Edwin B. Forsythe National Wildlife Refuge
Habitat Management Plan
December, 2013

Cover Photo: Piping plover (*Charadrius melodus*) on nest. Photo by USFWS

The National Wildlife Refuge System, managed by the U.S. Fish and Wildlife Service, is the world's premier system of public lands and waters set aside to conserve America's fish, wildlife and plants. Since the designation of the first wildlife refuge in 1903, the System has grown to encompass more than 150 million acres, 557 national wildlife refuges and other units of the Refuge System, plus 37 wetland management districts.

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CHAPTER 1: INTRODUCTION

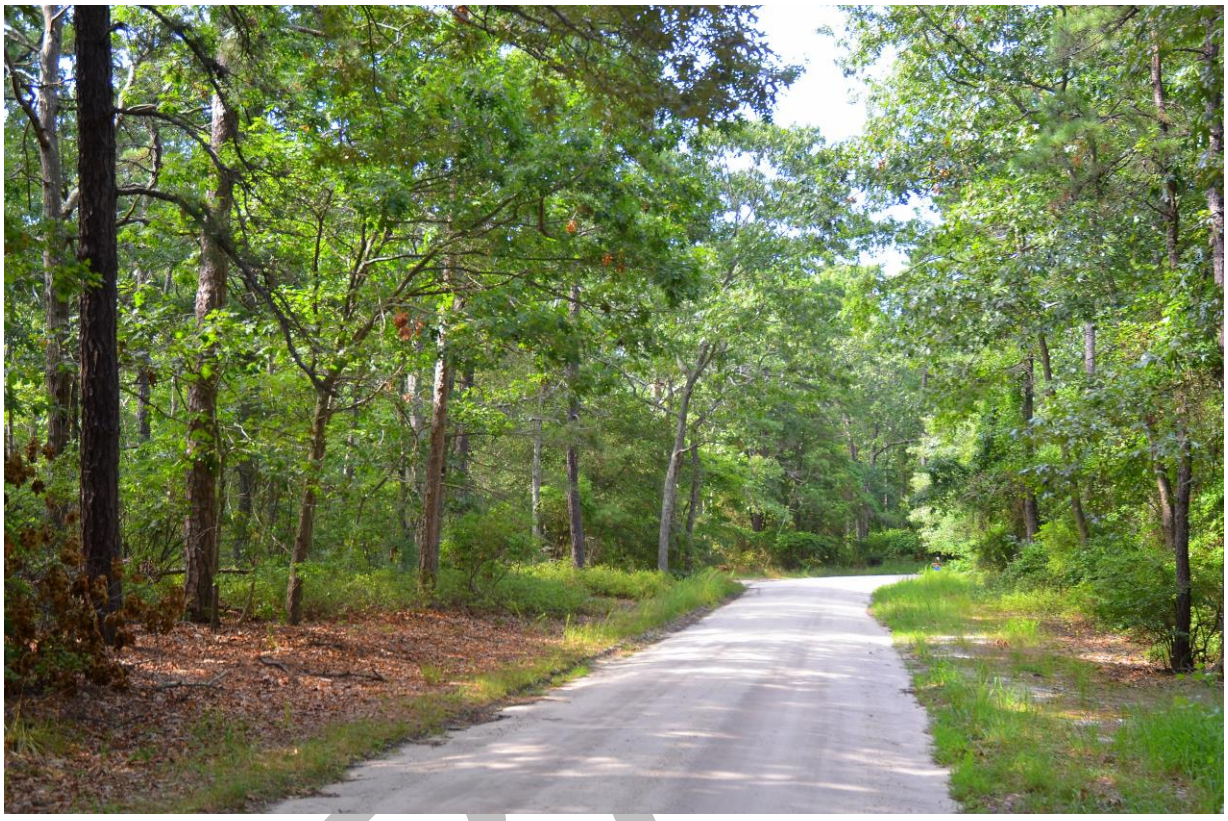

Image: Pine-oak woodland along Wildlife Drive. **Photo by Don Freiday**

1.1 Scope and Rationale
1.2 Legal Mandates and Refuge Purposes
1.3 Refuge Vision
1.4 Relationship to Other Plans

1.1 SCOPE AND RATIONALE

This Habitat Management Plan (HMP) for the Edwin B. Forsythe National Wildlife Refuge (Refuge) is a dynamic working document providing a decision-making process and guidance for managing Refuge habitat. The HMP defines a long-term vision, affording continuity and consistency for habitat management on Refuge lands. This HMP will be used in conjunction with the approved 2004 Comprehensive Conservation Plan (CCP) (USFWS 2004). The HMP lifespan is 15 years (2014-2029). It will be reviewed every five years using adaptive management to assess and modify management activities as monitoring and priorities dictate.

This plan documents the following processes:

1. Identification and prioritization of resources of concern;
2. Consideration of biological integrity, diversity, and environmental health;
3. Development of habitat goals, objectives, management strategies and prescriptions; and
4. Consideration of other factors such as collecting and analyzing available biological information, applying sound biological principles to the decision-making process, achieving the Refuge's purpose, and meeting the mission of the National Wildlife Refuge System (Refuge System).

The Refuge is managed as part of the Refuge System, whose mission is "to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States (U.S.) for the benefit of present and future generations of Americans." The Refuge spans almost 50 miles of the New Jersey coastal estuaries, from the Metedeconk River in Ocean County to Reeds Bay in Atlantic County. Over 47,000 acres of coastal beach/dune, salt marsh, freshwater wetlands, wetland forest, upland forest, pitch pine barrens, early successional habitats, and managed wetland impoundments comprise the Refuge. The Refuge's approved acquisition boundary encompasses 60,082 acres.

During the HMP planning effort it was important to ensure consistency with other conservation plans such as threatened and endangered species recovery plans, U.S. Fish and Wildlife Service (Service) ecosystem plans, the North American Waterfowl Management Plan, the New Jersey Wildlife Action Plan, and others to attain the goals and objectives of those conservation efforts to the extent practicable. This plan describes the potential contribution of this Refuge to ecosystem and landscape scale wildlife and biodiversity conservation goals. Federal, state, and local government agencies, conservation organizations, and individuals provided valuable input to this HMP.

1.2 LEGAL MANDATES AND REFUGE PURPOSES

Statutory authority for preparing HMPs is derived from the National Wildlife Refuge System Administration Act of 1966 (Refuge Administration Act), as amended by the National Wildlife Refuge Improvement Act of 1997 (Refuge Improvement Act), 16 U.S.C. 668dd - 668ee. The Refuge Improvement Act paved the way for a renewed vision for the future of the System where:

- Wildlife comes first
- Refuges are anchors for biodiversity and ecosystem-level conservation
- Lands and waters of the System are biologically healthy
- Refuge lands reflect national and international leadership in habitat management and wildlife conservation

The Refuge was created on May 22, 1984 by combining the former Brigantine and Barnegat National Wildlife Refuges (98 Stat. 207). The Refuge was named in memory of the late conservationist Congressman from New Jersey, Edwin B. Forsythe, through a Congressional Joint Resolution (H.J. Res. 537).

Brigantine National Wildlife Refuge was established on January 24, 1939 by the Migratory Bird Conservation Commission, under the authority of the Migratory Bird Conservation Act (16 U.S.C. section 715d). Congress designated 6,603 acres of the Brigantine National Wildlife Refuge as the Brigantine Wilderness (Wilderness Area) on January 3, 1975 (P.L. 93-632) to be managed under the Wilderness Act of 1964 (78 Stat. 890; 16 U.S.C. 1121 (note), 1131-1136). This designation has far-ranging impacts on the management of these portions of the Refuge. The Holgate Unit, Little Beach Island, and Mullica-Motts areas of unaltered beach and salt marsh comprise the Wilderness Area (see Appendix B, Map 1).

The Barnegat National Wildlife Refuge was established on June 21, 1967, under the authority of the Migratory Bird Conservation Act (16 U.S.C. section 715d).

The Reedy Creek Unit was established in 1991, under authority of the Emergency Wetlands Resources Act of 1968 (16USC 3901 (b). 100 Stat.3583).

The Refuge was established for the following purposes:

- For lands acquired under the Migratory Bird Conservation Act (16 U.S.C. §715-715r), as amended, "…for use as an inviolate sanctuary, or for any other management purpose, for migratory birds…." (16 U.S.C. §715d)
- "…the development, advancement, management, conservation, and protection of fish and wildlife resources…."(16 U.S.C. §742f(a)(4), Fish and Wildlife Act of 1956)
- "…the conservation of the wetlands of the Nation in order to maintain the public benefits they provide and to help fulfill international obligations (regarding migratory birds)…" (16 U.S.C. §3901(b), 100 Stat. 3583 Emergency Wetlands Resources Act of 1986)
- "…to secure for the American people of present and future generations the benefits of an enduring resource of wilderness." (78 Stat. 890:16 U.S.C. 1121 (note), 1131-1136, Wilderness Act of 1964)

Establishing Purposes for Brigantine National Wildlife Refuge:

- "…to preserve estuarine habitats important to the Atlantic brant (*Branta bernicla hrota)* and to provide nesting habitats for American black ducks (*Anas rubripes*) and rails (*Rallidae*)."

Establishing Purposes for Barnegat National Wildlife Refuge:

- "…the basic objective of preserving estuarine feeding and resting habitat for ducks and brant."

1.3 REFUGE VISION

The current vision for the Refuge is as follows:

Vision – To encourage a positive working environment in which we focus on high priority biological, visitor services, and resource protection work that supports our role in protecting and enhancing refuge resources while providing safe and educational opportunities to a diverse public. While we participate in a variety of projects throughout the year, the majority of each employee's work should support the following priorities:

- *Manage federally listed (Endangered or Threatened) species that occur on the refuge –*
  - *Piping Plover-continue to track bird use of refuge; develop project to better understand reasons for current survival rates*
  - *Swamp Pink-develop strategies to ensure protection of plant on refuge land and understand threats; manage against those threats*
  - *Seabeach Amaranth-work with the State and Conserve Wildlife Foundation to track plant, protect as needed*
- *Assess and manage impoundment systems to maximize habitat availability for a multitude of water-dependent birds and other wildlife-*
  - *Develop a Structure Decision-making process with the RO regarding long-term management of Brigantine system*
  - *Seek professional guidance about management of Brigantine and Barnegat complexes to maximize use by waterbirds*
  - *Seek opportunities for funding that completes carrying capacity research for brant and black ducks*
- *Understand and manage salt marsh habitat for priority species–*
  - *Collect salt marsh integrity data and understand how they relate to long-term resilience and persistence of our coastal habitats*
  - *Identify degraded areas of refuge marsh and work with partners to restore them*
  - *Work with partners on potential research projects that increase resiliency of marsh systems.*
- *Understand forest habitats on refuge–*
  - *Complete forest surveys and work with partners to assess forest health and resilience*
- *Understand and manage early successional habitat for priority species–*
  - *Maintain existing shrub and grassland areas*
  - *Set back habitat succession on over-mature areas*

- *Control invasive plants to that threaten native plant communities*

❖ *Welcome & Orient Visitors –*

- *Visitor Information Center – Keep the VIC and grounds well-maintained, staffed and projecting a positive image for the refuge and the NWRS*
- *Update new website – Ensure information is up-to-date and the site is easy to use*
    - *Continue to maintain Facebook page as best in Region 5*
    - *Expand use of Twitter*
- *Continue to respond promptly and accurately to public inquiries*
- *Improve directional signage on Route 9, Jimmie Leeds Road, and GSP*
- *Education and Outreach – Improve information we provide public*
    - *Continue to enhance environmental education program*
        - *Finalize lesson plans and train volunteers*
        - *Develop and print EE lesson brochure*
        - *Work with Stockton to lead Volunteer Master Naturalist program*
    - *Focus on Holgate, the Wildlife Drive, and deCamp Trail*
        - *Develop and install new welcoming and interpretive signage at Holgate*
        - *Revise Holgate Brochure*
        - *Continue to improve summer interpretive presence at Holgate*
        - *Update interpretive signage on WL Drive*
        - *Update self-guiding brochure to WL Drive*
        - *Develop and install new welcoming and interpretive signage at deCamp Trail*
        - *Make improvements at deCamp Trail*
        - *Foster partnership with locals to adopt deCamp Trail*
    - *Develop strategy to outreach to underserved communities focusing on Atlantic County area as a model to be used later in other areas of the refuge*
    - *Celebrate Brigantine 75th and Wilderness Act 50th Anniversary in 2014*
- *Wildlife-dependent Recreation –*
    - *Update Refuge deer hunt plan*
    - *Develop kayaking information/kayak trail*

❖ *Protect refuge resources and ensure public safety –*

- *Establish specific Law Enforcement Priority Zones on the refuge for the purpose of focused patrol, outreach/interpretation and maintenance.*
    - *7 Priority Areas/Activities*
        - *Reedy Creek*
            1. *F-Cove*

2. *deCamp Trail*

- *Forked River/Lacey Township*
  1. *Game Farm*
  2. *Murray Grove*
  3. *Lakes area/ Power Plant*
- *Oxycocus*
- *Holgate*
- *Headquarters/Wildlife Drive*
- *Waterfowl Hunting*
- *Deer Hunting*

o *Create a plan for each area with specific problems, a list of possible solutions and actions to be accomplished.*

➢ *Continue to work with Zone Officer to establish full NJ State jurisdiction to enforce State law.*

❖ *Engage in productive partnerships with organizations/individuals that enhance our stated vision –*

➢ *Barnegat Bay Partnership*
➢ *Relationships between Refuge and Municipalities*
➢ *Researchers*

❖ *Encourage development of refuge staff and work together to ensure good communication and teamwork –*

➢ *Support leadership training for all interested staff*
➢ *Ensure all Individual Development Plans are completed and that they are used as an opportunity for supervisors and staff to develop learning opportunities*
➢ *Develop and implement a pulse check for staff to provide feedback to station managers every few years*

1.4 RELATIONSHIP TO OTHER PLANS

Regional and National Plans

To ensure consistency with other plans, Refuge staff reviewed and considered the plans listed below to identify resources of concern, prioritize habitats and species, and evaluate the Refuge at a landscape level. Refuge staff will continue to work with state and regional partners in the conservation of trust resources by implementing the following plans and programs to the extent possible:

The Landscape Project, New Jersey Division of Fish and Wildlife (2012)

Beginning in 1994, the New Jersey Division of Fish and Wildlife began a landscape-level approach to protect New Jersey's biological diversity by maintaining and enhancing rare wildlife populations. (New Jersey Department of Environmental Protection. 2003). The plan identified and mapped areas of critical habitat for state and federally-listed threatened or endangered species using an extensive database that combines rare species location information with land cover data. Critical areas are ranked and prioritized.

New Jersey Wildlife Action Plan (revised 2008)

Congress established a "State Wildlife Grants" program to provide funds to state wildlife agencies for the conservation of fish and wildlife and their habitats in 2001. Each state was charged with developing a Comprehensive Wildlife Conservation Plan or Strategy by October 2005. State fish and wildlife agencies evaluated species and habitats in the greatest need of conservation while also considering the needs of all native wildlife.

The New Jersey Wildlife Action Plan was completed in 2008 and provides a statewide perspective, including all of New Jersey's wildlife diversity and habitats, in a comprehensive approach to long-term wildlife and habitat conservation in New Jersey. The plan identifies Species of Conservation Concern that represent the full array of wildlife species in New Jersey.

U.S. Fish and Wildlife Service Recovery Plans

Current Refuge management is guided by three Federal Endangered Species Act Recovery Plans:

- Atlantic Coast Piping Plover (*Chadradius melodus*) Recovery Plan (USFWS 1995)
- Recovery Plan for Seabeach Amaranth (*Amaranthus pumilus*) (USFWS 1996)
- Northeastern Beach Tiger Beetle (*Cincindela dorsalis dorsalis*) Recovery Plan (USFWS 1994)
- Swamp Pink (*Helonias bullata*) Recovery Plan (USFWS 1991)

The Northeastern Beach Tiger Beetle is considered extirpated in New Jersey; however, annual surveys are conducted.

Regional Wetlands Concept Plan – Emergency Wetlands Resources Act (USFWS 1990)

In 1986, Congress enacted the Emergency Wetlands Resources Act to promote the conservation of our Nation's wetlands. The Act directs the Department of the Interior to develop a National Wetlands Priority Conservation Plan identifying the location and types of wetlands that should receive priority attention for acquisition by federal and state agencies. In 1990, the Northeast Region completed a Regional Wetlands Concept Plan to provide specific information about wetlands resources in the Northeast. The plan identifies nearly 850 wetland sites that warrant consideration for acquisition to conserve wetland values including three sites within the Refuge: Brigantine/Barnegat Wetlands, Manahawkin Lake, and Reedy Creek.

U.S. Fish and Wildlife Service North Atlantic Landscape Conservation Cooperative (LCC)

The Service's North Atlantic LCC is a self-directed science and conservation planning partnership of federal agencies, states, tribes, universities, non-governmental organizations, and other conservation partnerships, such as fish habitat partnerships and migratory bird joint ventures. The North Atlantic LCC is a forum for developing common goals, coordinating conservation efforts and jointly developing the science and tools required by resource managers. In the face of ever increasing threats, LCCs help ensure that the right science is in the right places to support the most effective conservation of America's resources. The geographic area covered by the North Atlantic LCC extends from southeastern Virginia north along the mid-Atlantic coast through New England to Nova Scotia and the Gaspe Peninsula of Quebec (see Appendix B, Map 2). The boundaries for this LCC include the entire Refuge. The LCC has identified representative species and habitats using existing information.

One of the major goals of this effort is to identify a list of representative species for designing conservation and management strategies that will most effectively sustain fish and wildlife populations at desired levels in the face of land use change, climate change, and other stressors occurring within the North Atlantic LCC.

Conserving the Future: Wildlife Refuges and the Next Generation (USFWS 2011a)

Service staff began charting the course for the System's next decade in 2010. Using the System's last strategic plan, *Fulfilling the Promise*, they updated the vision for the future of America's national wildlife refuges (USFWS 1999a). Much has changed since 1999, when *Fulfilling the Promise* was published. America has less undeveloped land, more invasive species and impacts from a changing climate. The actions in this HMP reflect the vision and direction for the Service in the future.

U.S. Fish and Wildlife Service Migratory Bird Program Strategic Plan (2004)

The 10-year (2004-2014) strategic plan outlines goals and strategies to sustain and restore bird migrations and natural systems (USFWS 2004a). Key themes for this plan are as follows:

- monitoring and management actions for migratory birds based on sound science
- learning how priority birds respond to anthropogenic threats and habitat restoration
- supporting migratory birds and habitats through partnerships

The Refuge can contribute to the goals and strategies of the Migratory Bird Program Strategic Plan by supporting research studies on the Refuge with partners, conducting biological monitoring that contributes to region-wide population or habitat assessments, and managing Refuge habitats and conducting activities to protect and enhance migratory birds habitats and populations.

U.S. Fish and Wildlife Service Birds of Conservation Concern (BCC) (2008)

The BCC identifies nongame migratory birds that, without strong conservation action, are likely to become candidates for listing under the federal Endangered Species Act (USFWS 2008). BCC status was used in prioritizing species in the HMP. The Refuge can contribute to the goals and strategies of the BCC report by supporting research studies on the Refuge with partners, conducting biological monitoring that contributes to region-wide population or habitat assessments, and managing Refuge habitats and conducting activities to protect and enhance BCC habitats and populations.

North American Waterfowl Management Plan (NAWMP) (revised 2012)

The NAWMP specifies population goals and habitat conservation strategies needed to restore and sustain waterfowl in partnership with Canada and Mexico. The first NAWMP established "joint venture" partnerships across the country (USFWS 1986) involving federal, state and provincial governments; tribal nations; local businesses; conservation organizations; and individual citizens focused on protecting habitat and species. NAWMP is updated periodically with input from the waterfowl conservation community. The latest revision was made in 2012. The 2012 NAWMP Revision represents a new call to action for the waterfowl conservation community. The integrated vision – 'People conserving waterfowl and wetlands' – outlines the need to manage adaptively with clear goals and integrated measurable objectives for populations, habitat and people. To achieve this integrated vision, three goals are identified in the 2012 NAWMP Revision: Goal 1: Abundant and resilient waterfowl populations to support hunting and other uses without imperiling habitat; Goal 2: Wetlands and related habitats sufficient to sustain waterfowl populations at desired level while providing places to recreate and ecological services that benefit society; and Goal 3: Growing numbers of waterfowl hunters, other conservationists, and citizens who enjoy and support waterfowl and wetlands conservation.

Migratory Bird Joint Ventures

The most recent Atlantic Coast Joint Venture (ACJV) Waterfowl Implementation Plan (ACJV 2005) identifies focus areas, i.e., habitat complexes that are priorities for waterfowl conservation. Portions of the Refuge fall within the Brigantine-Barnegat Wetlands focus area (23,400 acres), one of seven in the state. The Arctic Goose Joint Venture coordinates monitoring of and research on Atlantic population Canada geese (*Branta canadensis*), brant (*Branta bernicla),* and greater snow geese (*Chen caerulescens*). The Refuge attracts significant numbers of these species in winter. Additionally, saltmarsh habitats along the mid-upper Atlantic Coast have been identified by the Black Duck Joint Venture (BDJV) as critical habitat for wintering American black ducks (*Anas rubripes*). Both JVs have identified quantification of winter habitat carrying capacity as priority needs for conservation planning and habitat development. The Refuge has participated in several studies funded in part by these JVs to estimate the winter habitat carrying capacity of Refuge habitats for brant and black ducks.

North American Bird Conservation Initiative (NABCI)

NABCI ensures the long-term health of North America's native bird populations by integrating bird conservation efforts based on sound science and cost-effective management, benefiting all birds in all habitats. NABCI participants coordinate efforts such as monitoring, private lands issues, policy and legislative issues, international collaboration, conservation design, and federal and state agency support for bird conservation. Refuge conservation actions often contribute to the goals of multiple ABCI partners and plans.

Partners-in-Flight (PIF) Bird Conservation Plan for the Mid-Atlantic Coastal Plain (Physiographic Area 44)

PIF is a partnership of government agencies, private organizations, academic researchers, and private industry throughout North America focused on coordinating voluntary bird conservation efforts to benefit species at risk and their habitats. The Refuge is located within the Coastal Plain physiographic province area 44 (PIF 1999). Many of the PIF priority species are also priority species of Bird Conservation Region (BCR) 30 and Species of Conservation Concern within the New Jersey Wildlife Action Plan. These priorities guide management on a regional scale and are incorporated in the HMP.

Mid-Atlantic Coast Bird Conservation Region (BCR 30) Implementation Plan (2008)

The Implementation Plan for BCR 30 (Steinkamp 2008) combines regional plans, assessments, and research completed over the past two decades to develop continental-based bird conservation efforts. The Refuge is located within the New England/Mid-Atlantic Region BCR 30 and many of the BCR 30 priority species are also priority species in PIF 44 and Species of Conservation Concern within the New Jersey Wildlife Action Plan.

U.S. Shorebird Conservation Plan (2001, 2nd Edition) and North Atlantic Regional Shorebird Plan (2000)

Concerns about shorebirds led to the creation of the U.S. Shorebird Conservation Plan (Brown et al. 2001). Developed as a partnership with individuals and organizations throughout the U.S., the plan presents conservation goals for each U.S. region, identifies important habitat conservation and research needs, and proposes education and outreach programs to increase public awareness of shorebirds and threats to them.

In the Northeast, the North Atlantic Regional Shorebird Plan (USFWS 2004b) was drafted to step-down the goals of the continental plan to smaller scales to identify priority species, species goals, and habitats, and prioritize implementation projects, which provides guidance for the HMP.

North American Waterbird Conservation Plan (2002) and Mid-Atlantic/New England/Maritimes (MANEM) Waterbird Conservation Plan (2008)

The North American Waterbird Conservation Plan (Kushlan et al. 2002) provides a framework for conserving and managing colonial nesting water-dependent birds by facilitating continent-wide planning and monitoring, coordination, and local habitat protection and management. Sixteen waterbird planning regions were identified to allow for planning at a scale that is practical yet provides a landscape-level perspective. The Refuge falls within the MANEM region. To facilitate waterbird conservation, a partnership of organizations and individuals drafted a regional waterbird conservation plan for 2006-2010.

Atlantic Flyway Resident Population Canada Goose Management Plan (2011)

The goal of the Atlantic Flyway Resident Population Canada Goose Management Plan (Atlantic Flyway Council 2011) is to manage resident Canada geese to achieve a socially acceptable balance between the positive values and negative conflicts associated with these birds. The plan describes the status and value of Atlantic Flyway resident Canada geese, summarizes the management consensus of wildlife agencies, and provides direction and objectives for cooperative efforts. Specific management objectives include reducing resident Canada geese to 700,000 birds (spring estimate) by 2020, distributed in accordance with levels prescribed by individual states and provinces. In New Jersey, the goal is 41,000 resident geese - the current population is 87,000.

Management Plan for Greater Snow Geese in the Atlantic Flyway (2009)

This plan seeks to sustain the greater snow goose populations at a level that maximizes a balance between benefits to society and habitat integrity (Atlantic Flyway Council 2009). It sets a population objective for greater snow geese of 500,000 to 750,000 to optimize the balance between a healthy population that can easily recover from catastrophic events and one that does not negatively impact its natural habitats and associated biodiversity. The population objective is to minimize habitat and crop damage on staging and wintering areas, and maximize other human-related benefits such as recreational hunting opportunity and wildlife viewing.

Atlantic Flyway Mute Swan Management Plan (2003-2013)

The Atlantic Flyway Mute Swan Management Plan (Atlantic Flyway Council 2003) was developed to reduce mute swan (*Cygnus olor)* populations in the Atlantic Flyway to levels that will minimize negative ecological impacts to wetland habitats and native migratory waterfowl and to prevent further range expansion into unoccupied areas. Specific management objectives include increasing public awareness of mute swans, their status as an introduced and invasive species, and their impacts on native wetland ecosystems and other species of wildlife. Other objectives include reducing the population of mute swans to less than 3,000 birds by 2013 as measured by the Atlantic Flyway Mid-summer Mute Swan Survey by preventing mute swans from further expanding their range or establishing new breeding populations; developing and implementing guidelines and regulations for keeping captive mute swans; monitoring changes in mute swan numbers and distributions to evaluate the effectiveness of management actions; and

developing research programs to assess what effects these changes have on wetland habitats and other wildlife.

National Audubon Society Important Bird Areas (IBA) Program

The IBA Program is an international bird conservation initiative that aims to identify and conserve the most important habitats for birds. IBAs link global and continental bird conservation priorities to local sites that provide critical habitat for native bird populations. The program is overseen by a Technical Review Committee representing state and federal agencies, academic ornithologists, the birding community, and regional biologists. The Refuge is recognized as an Important Bird Area.

North American Monarch Conservation Plan (2008)

This international plan encompassing Canada, the U.S., and Mexico outlines threats and conservation actions for monarch butterfly (*Danaus plexippus*) breeding, flyway, and wintering areas (CEC 2008).

National - State Agency Herpetological Conservation Report (NHCR) (Draft 2004)

The NHCR is a summary report sponsored by Partners in Amphibian and Reptile Conservation (PARC 2004). Partners in Amphibian and Reptile Conservation were created in response to the increasing national declines in amphibian and reptile populations. The NHCR provides a general overview of each state wildlife agency's support for reptile and amphibian conservation and research, and includes lists of the amphibian and reptile species of concern for each state. The latest draft NHCR plan was used in developing Appendix C.

Trust for Public Land Century Plan (1995)

The Trust for Public Land is a national nonprofit conservation organization dedicated to preserving land of recreational, ecological, and cultural value for public enjoyment. Its primary mission is to protect open space for public benefit. The Trust's Barnegat Bay Initiative is a long-term protection strategy involving land acquisition, public education, and scientific research on the region's remaining outstanding natural resources. Its goal is to collaborate with other non-profit and civic groups as well as local, state, and federal government agencies to establish a powerful and united coalition working to preserve the Barnegat Bay watershed. Barnegat Bay is within the National Estuary Program.

The Century Plan (Trust for Public Lands 1995) is a guide for future action to preserve the Barnegat Bay watershed in Ocean County, New Jersey and heighten public awareness about the Bay's landscape and ecological importance. It lists 100 unique conservation and public access sites of long-term importance to protecting Barnegat Bay as an ecosystem and a treasured public resource. Of these 100 sites, about half are partially or totally within the approved acquisition boundary of the Refuge.

Governor's Action Plan for Barnegat Bay (2010)

In December 2010, NJ Governor Chris Christie established a comprehensive plan to address the health of Barnegat Bay. Areas of the plan in which the Refuge may contribute include acquiring land in the watershed, educating the public, producing more comprehensive research, and reducing water craft impacts, where appropriate (New Jersey Department of Environmental Protection, 2010).

Barnegat Bay Partnership Strategic Plan (BBP) (2012)

Refuge staff are active members in the BBP and helped develop the 2012 Strategic Plan. Some Refuge actions in this HMP are directly related to priorities of the BBP, particularly projects related to land acquisition, education, and habitat protection.

Refuge Plans

Comprehensive Conservation Plan (June 2004)

The 1997 Refuge Improvement Act requires completion of a CCP for all Refuges by 2012. The 2004 CCP for E. B. Forsythe NWR (USFWS 2004) guides all biological and public use actions on the Refuge for a 15-year period. Habitat goals and objectives developed in this HMP are based on Refuge goals in the CCP, but also consider more recent developments, such as emerging climate change information and Hurricane Sandy impacts.

Refuge Annual Performance Plan

Each refuge prepares a Refuge Annual Performance Plan that includes a review of the habitat management activities from the previous year, an evaluation of monitoring programs, and recommendations for habitat management strategies and prescriptions for the coming year. The work plan documents specific habitat and wildlife management strategies for a specific work year. Adaptive management practices are incorporated by evaluating success of specific management strategies and prescriptions on an annual basis.

Annual Habitat Work Plans

Annual Habitat Work Plans (AHWP) review habitat management activities from the previous year, evaluate monitoring programs, and make recommendations for habitat management strategies and prescriptions for the coming year. The AHWP incorporates adaptive management practices by evaluating success of management programs on an annual basis.

Step-down Plans

A number of other plans specific to Refuge programs have provided guidance either in their draft or final format, including but not limited to:

- Habitat and Species Inventory and Monitoring Plans

- Hunt Plans
- Predator Management Plans
- Wildlife Disease Surveillance and Contingency Plan
- Fire Management and Prescribed Burning Plans
- Public Use Plan
- Law Enforcement Plan
- Energy Management Plan
- Safety Plans

Partnerships

Threats to America's land, water, fish, wildlife, or cultural resources are greater than any single agency or program can handle. Threats such as land use change, water scarcity, and the changing climate not only affect a single species or an isolated place, but affect multiple species and resources across an entire landscape. The Refuge has worked with federal, state, county and local governmental agencies as well as universities and private conservation organizations to understand and manage the habitats on the Refuge. In recent years the Refuge has partnered with the University of Delaware and the NJ Division of Fish and Wildlife to study the demographics, distribution and density of saltmarsh sparrows, as well as other tidal marsh obligate breeding birds. The Refuge has also partnered with the University of Delaware, University of Rhode Island, NJ Division of Fish and Wildlife, BDJV and ACJV to study the winter food supply and demand of black ducks and brant. The Refuge partners with the NJ Division of Fish and Wildlife, FWS Office of Migratory Bird Management and private conservation organizations, such as NJ Audubon Society and the Manomet Bird Observatory, to conduct a number of bird surveys that inform habitat management.

The North Atlantic LCC is a forum for science and conservation planning of federal agencies, states, tribes, universities, non-governmental organizations, and other conservation partnerships such as fish habitat partnerships and migratory bird joint ventures. A list of representative species driven by the LCC process has been created and forms the basis for conservation efforts.

The Refuge will continue to work together with federal, state, county, and local partners in the conservation of natural resources through the development and implementation of plans, programs, research, and management.

CHAPTER 2: BACKGROUND

Image: Salt marsh with Atlantic City in background. **Photo by Don Freiday**

2.1 Location and Description
2.2 Climate, Climate Change, and Sea Level Rise
2.3 Physical Features
2.4 Historical Perspective
2.5 Current Refuge Conditions

2.1 LOCATION AND DESCRIPTION

The Refuge extends almost 50 miles along coastal southern New Jersey in Atlantic, Burlington, and Ocean Counties (see Appendix B, Map 3). The refuge is surrounded by other state, federal, and private conservation lands. It lies almost entirely east of the Garden State Parkway from Brick Township, Ocean County in the north to Galloway Township, Atlantic County in the south. Refuge headquarters is in Oceanville, 10 miles north of Atlantic City. The Philadelphia Metropolitan area lies 50 miles west. New York City is 40 miles north of the northern boundary of the Refuge. The Refuge covers over 47,000 acres with an approved acquisition boundary of 60,082 acres.

A portion of the Refuge lies within the Pinelands National Reserve (PNR), which encompasses approximately 1.1 million acres and covers portions of seven counties and 56 municipalities in New Jersey. The PNR was created by Congress under the National Parks and Recreation Act of 1978. The New Jersey Pinelands Commission administers the Pineland Comprehensive Management Plan that promotes orderly development of the Pinelands to preserve and protect their significant and unique natural, ecological, agricultural, archaeological, historical, scenic, cultural and recreational resources. It was designated a U.S. Biosphere Reserve by the United Nations and is recognized as an International Biosphere Reserve.

The Refuge's location in the Atlantic Flyway makes it an important link to other protected areas. The Refuge is located within the Mid-Atlantic Coast BCR 30, the PIF Physiographic Area 44, and the North Atlantic LCC. Its value for the protection of wildlife and their habitat continues to increase as New Jersey's development increases.

2.2 CLIMATE, CLIMATE CHANGE, AND SEA LEVEL RISE

Climate

The Refuge is within the New Jersey coastal weather zone (Sandy Hook, Long Branch, Atlantic City, and Cape May weather stations). The ocean moderates the continental climate. Average monthly temperatures are 35°F in January, the coldest month of the year; and 75°F in July, the hottest month of the year. The growing season (average temperature of 43°F or more) for the Refuge is 255 days. Average annual precipitation is 42.6 inches, distributed fairly evenly throughout the year with slightly more in July and August, and less in February (USFWS 2004).

Climate Change and Sea Level Rise

According to Smerline et al. (2005) global climate change has already had an observable impact in the Northeastern U.S. The Intergovernmental Panel on Climate Change (IPCC) documented a worldwide sea level rise of 4.8 to 8.8 inches during the last century (IPCC 2007). The historic trend for sea level rise at the Refuge as measured at the Atlantic City tide gauge is 0.157 inches per year; about twice the global average for the last 100 years.

According to a 2009 review by researchers at the Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, state-of-the-art climate models predict that the sea level off New York City will rise about 8 inches more than the global average this century. A new U.S. Geological Survey study suggests that sea level in the northeastern United States is already rising faster than

the global average. Global and regional rates of sea level rise are expected to accelerate further as ice sheets and glaciers melt and warmer oceans expand. The Intergovernmental Panel on Climate Change's 2007 projections of between 8 and 24 inches of global sea level rise this century, are widely viewed by scientists as likely underestimates, with some researchers projecting more than a 4-foot rise.

A recent analysis by the Princeton-based nonprofit Climate Central found that 140,000 people in New Jersey live within 3 feet of the high-tide line. When the 4-foot storm surge associated with a once-in-50-years storm is taken into account, a 3-foot sea level rise would place the homes of 400,000 New Jersey citizens at risk (Climate Central 2012). Hurricane Sandy made landfall on the coast of New Jersey on October 29, 2012. The storm surge and flooding affected a large swath of the state. Over two million households in the state lost power, 346,000 homes were damaged or destroyed, and 37 people were killed.

Tidal marshes are among the most susceptible ecosystems to climate change, particularly accelerated sea level rise (Clough and Larsen 2008). The IPCC Special Report on Emissions Scenarios, cited in Clough and Larsen (2008), suggested that global sea levels will increase by 11.8 to 39.4 inches by 2100. Rahmstorf (2007) suggests that this range may be too conservative and that the feasible range by 2100 could be 19.7 to 55.1 inches. Pfeiffer et al. (2008) calculated that a 78.7 inch rise in sea level by 2100 is at the upper end of plausible scenarios due to physical limitations on glaciological conditions. Rising sea level may result in tidal marsh submergence (Moorhead and Brinson 1995) and habitat migration as salt marshes transgress landward and replace tidal freshwater and irregularly flooded marsh (Park et al. 1991). Additionally, during strong east winds, salt water droplets might be carried further inland, damaging salt-intolerant plants.

To assess the potential effects of sea level rise on refuges, the Service used the Sea-level Affecting Marshes Model (SLAMM) (Clough and Larsen 2008) for most Region 5 refuges. Under most scenarios of this model, the Refuge will be greatly impacted by sea level rise. The loss of irregularly flooded marsh, which constitutes roughly half of the Refuge, is predicted to be severe, particularly in the northern portion of the Refuge, which has the smallest tidal range. SLAMM predicts that the Refuge will be seriously threatened by all sea level rise scenarios, and even in the most conservative (15.3 inches) scenario half of the irregularly flooded marsh is lost by 2100. The southern half of the Refuge is not impacted as much, but is still predicted to have significant loss of marshes.

2.3 PHYSICAL FEATURES

Air Quality

New Jersey is the most densely populated state in the country and has the highest density of roads and traffic impacting air quality (USFWS 2004). The greatest adverse impact seems to be elevated levels of low-altitude ozone. Ozone levels exceed Environmental Protection Agency thresholds set for the state. Investigations at the Refuge indicate that the low-altitude ozone levels are high with resulting damage to vegetation (Davis 1995). The Interagency Monitoring of Protected Visual Habitats began in 1992 on the Refuge. The National Atmospheric Deposition Program began in 1998 and the New Jersey Department of Environmental Protection monitoring

began in 2007. Ozone, sulfur dioxide, fine particulates, light attenuation, visibility and mercury are monitored.

The Wilderness Area is a Class I Air Quality Area. This is the highest level of protection, giving it special protection under the Clean Air Act. Congress charged the Service with the responsibility of protecting air quality and air quality-related values, including vegetation, wildlife, soils, water quality, visibility, odors, and cultural and archaeological resources of the area from manmade pollution (USFWS 2004).

Despite this protection, air pollution is impacting the Wilderness Area (USFWS 2004). The area lies in a highly industrialized air shed with air pollution coming from many sources, including industry, automobiles, and power plants. Surveys conducted from 1993 to 1996 indicated that certain plant species exhibited typical symptoms of ozone injury (e.g., stippling and chlorosis, the yellowing of leaf tissue due to a lack of chlorophyll) (USFWS 2004). Higher CO_2 levels might result in lower pH acid rain or fog.

In addition to these documented effects, there is concern that other effects may be occurring. Rainfall throughout the area is acidic; rainfall pH at sampling locations in New Jersey is often less than 5.0 (USFWS 2004). As is the case in most of the eastern U.S., visibility in the Wilderness Area is affected by pollution-caused haze. Also, inshore waters of the Wilderness Area may be at risk from atmospheric nitrogen pollution. Research along the Atlantic Coast has demonstrated that atmospheric nitrogen (primarily from power plant and automobile emissions) contributes to nutrient level increases of inshore waters, with subsequent algae blooms, loss of sea grass beds, and deterioration of fish and wildlife habitat (USFWS 2004).

Soils

The Refuge is in the outer coastal plain, which consists of sedimentary deposits dating from the tertiary period. Refuge elevations range from sea level to 50 feet above mean sea level. Topography is nearly level to gently sloping. Uplands slope gradually to a wide band of salt marsh and shallow bays. These bays are separated from the ocean by barrier islands or spits.

The major soil series in the Refuge are Sulfaquents-Sulfihemists, Manahawkin-Atsion-Berryland, Tidal Marsh-Coastal Beach and Downer-Hammonton-Sassafras association (USFWS 2004). Soils survey data and maps are available from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) website http://soildatamart.nrcs.usda.gov/manuscripts/NJ001/0/atlantic.pdf. Pleistocene and Recent Age deposits overlay the Kirkwood-Cohansey formations and contain sand, gravel, silt, peat, and organic muck. The effect of sea level rise on soils adjacent to salt marshes has yet to be determined.

Hydrology

Kirkwood-Cohansey is the major aquifer underlying the Refuge. The Kirkwood Formation is chiefly sand, silt, and clay. The Cohansey Sand is chiefly unconsolidated quartz sand with some gravel and many clay beds. This aquifer system provides most of the domestic water to the area. Several aquifers underlie the Kirkwood-Cohansey system and are tapped to a lesser extent for public and domestic supply.

The Refuge contains both tidal and non-tidal surface waters. Non-tidal waters include marshes, bogs, fens, ponds, creeks, artificial impoundments, and seasonally flooded forests. Tidal waters include salt and fresh marshes, ponds, creeks, ditches, tidally restored impoundments, coves, bays, rivers, and inlets. Numerous creeks flow through salt marshes connecting estuarine waters with uplands. Higher sea levels will increase marine transgression, causing salt water to intrude into freshwater areas and aquifers. Upstream development along streams and creeks continues to degrade Refuge hydrology and habitat quality. Much of the development is comprised of single family homes, but recently a large shopping mall development was constructed upstream of a site containing endangered swamp pink. Increases in nutrients, oils, road salts and tars, sediment, garbage and higher coliform counts often occur after development.

The tide cycle on the Refuge includes two high and two low tides each day. The rotation of the earth, gravitational pull, relative alignment of the moon, and sun cause tide times and heights to vary in a monthly cycle. The greatest inundation occurs during new and full moons, however tides are also effected by wind speed and direction as well as barometric pressure. These variations in tide as well as slight elevation differences in marshes result in some areas being flooded more or less frequently. Coastal geomorphology also affects tidal height and duration. The flooding regime is the primary determinant of the type of plant community found on a particular area of salt marsh.

Environmental Contaminants

The Service collected sediments, mummichogs, and fiddler crabs to determine baseline contamination in and adjacent to the Refuge in 1996. Sediments were collected at 25 locations; mummichogs and fiddler crabs from 10 of the 25 locations. Samples were analyzed for trace metals, organochlorine pesticides, polychlorinated biphenyls (PCBs), and butyltin compounds (USFWS 1998).

The Service analyzed the samples for 19 trace metals: aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium, and zinc. All of these trace metals were detected in the sediment samples. None of the sediment samples contained metal concentrations exceeding severe toxic effects guidelines for sediment (USFWS 2004). Many sediment trace metal concentrations exceeded lower toxic effects guidelines, but these concentrations were not notably greater than background levels within New Jersey. Fiddler crabs contained higher mean metal concentrations than mummichogs for all detected metals except zinc.

There was no strong relationship between the sediment concentrations of metals and those in crabs. Inorganic contaminant concentrations in Refuge biota were not notably greater than reference levels and were less than levels measured in areas known to be polluted. The whole body concentrations of inorganic contaminants in both fish and crabs were not sufficient to cause acute or sublethal effects to piscivorous birds and predatory fish.

Several organic contaminants, dichlorodiphenyl-dichloroethane (DDD), dichlorodiphenyl-dichloroethylene (DDE), total PCBs, and PCB 77, were detected in measurable quantities in all sediment samples. Levels of several organic contaminants, particularly the metabolites of dichlorodiphenyltrichloroethane (DDT), DDD and DDE, were greater than available reference

concentrations from other areas within southern New Jersey. Some of the highest sediment concentrations of these organic contaminants were detected at sampling stations located just downstream of inactive cranberry farms. One farm yielded a DDD concentration of significant ecotoxicological concern. A few other sampling stations also contained levels of DDE and total chlordane that exceeded severe toxic effect sediment guidelines.

Detectable levels of p, p1-DDD, p, p1-DDE, dieldrin, heptachlor epoxide, oxychlordane, and total PCBs were found in all crab and fish samples analyzed. Unlike the inorganic contaminant result, crabs did not contain higher organic contaminant levels than fish. Organic contaminant concentrations in Refuge biota were not notably greater than reference levels and were less than levels measured in areas known to be polluted. Body burdens of organic contaminants in mummichogs did not indicate that these fish should be suffering physiological impairment. The whole body concentrations of organic contaminants in both fish and crabs were not sufficient to cause acute or sublethal effects to piscivorous birds and predatory fish.

The New Jersey Field Office (NJFO) recently investigated sediment organochlorine pesticide contamination in several local abandoned cranberry bogs under Service ownership in Ocean County, New Jersey (USFWS 2005, USFWS *in prep*). All bogs sampled in those investigations had elevated sediment levels of total-DDT (sum of all six DDD, DDE, and DDT isomers) ranging from 0.7 to 25.5 ug/g (dry weight). The DDT isomer composition in bog sediments was unusually dominated by DDD rather than DDE, and the concentrations of the various DDT isomers frequently exceeded levels correlated with severe adverse effects to benthic macroinvertebrates. It is recommended that these bogs are prioritized for sediment contaminant characterization to support informed decision making and management options and that habitat management options should include allowing the bogs to revert to stands of Atlantic white cedar.

Preliminary data collected by NJFO during summer 2011 from bats and several passerine species near Refuge headquarters and along Absecon Creek, which is approximately 8 km southwest of the Refuge Headquarters, indicates substantial exposure and bioaccumulation of mercury at levels that may be correlated with adverse biological effects. There are several potential sources of mercury identified that require further evaluation - global distillation of mercury as a potential source has not been ruled out.

Contaminant levels in the majority of sediment and biota from the Refuge were found to be low and of little concern with regard to the potential for adverse effects on resident biota or their predators. Exceptions were limited to seven sampling stations where the concentrations of DDD, DDE, or total chlordane exceeded severe toxic effects sediment guidelines. Two of these stations were located at the surface water outfalls of the inactive Oxycoccus and Commerce cranberry farms. Unfortunately, biota was not collected from these two stations. It is reasonable to suspect even greater concentrations of organic contaminants exist inside the abandoned cranberry farms themselves. Inactive cranberry farms that used DDT in the past may be a serious threat to federal trust resources (USFWS 2004).

2.4 HISTORICAL PERSPECTIVE

Pre-European Settlement

Human occupation of the New Jersey coast began with the arrival of Native American hunter-gatherer bands approximately 10,000 BCE (Before the Common Era). Human population on the coast seems to have increased somewhat after 5000 BCE as the climate warmed. The locations and contents of archaeological sites reflect a diverse mix of hunting and gathering of upland, wetland, and aquatic resources that varied with the seasons (USFWS 2004). Sea level change moderated around 2000 BCE, and the extensive coastal wetlands that developed provided rich hunting, shell fishing, and plant gathering environments (USFWS 2004). Greater resource reliability supported a larger and more stable human population.

The Lenni Lenape tribe inhabited the area (USFWS 2004) establishing permanent villages, but also used temporary camps for short term activities, such as fishing or hunting. Villages were most likely located along waterways used for transportation. Native Americans were primarily farmers - major crops were corn, squash, and beans. These crops were supplemented with fish, wild game, berries, nuts, herbs, and roots. Fires were set to move deer to hunters. Large fires of unknown causes were observed by Dutch explorers as early as 1632 (Foreman 1979).

European Settlement

Permanent settlement of the Refuge area by Euro-Americans began in the second quarter of the 18th century. This was preceded by a long period of contact with Native American Lenape through offshore fishing and the fur trade. By the middle of the century, the Lenape were severely diminished by European diseases and moved to a reservation. By 1801, almost all Lenape had left New Jersey (Foreman 1979).

According to Foreman (1979), by 1765 European settlement concentrated on the outer coastal plain. Primary activities were fishing, whaling, lumbering, and hunting and gathering. Settlement within the Pine Barrens remained sparse. Throughout the eighteenth and nineteenth century forests were exploited for lumber, pitch-tar, turpentine, and charcoal to support the iron, glass, and brick industry (Boyd 1991).

Colonial towns on the New Jersey shore were generally established at estuaries with suitable harbors for fishing and trade, such as the Mullica River. The New York Road linked these communities along the shore. Ore from bogs and charcoal from the Pine Barrens provided raw materials for an ironworks at Batsto that produced munitions for the American Revolution. Limited by shallow and small harbors, these shore community's experienced slow economic and population growth during the 19th century (USFWS 2004).

Many upland areas on the Refuge generally consist of former farmland associated with historic period settlement. Cranberry production started between 1825 and 1840 mostly in the Pine Barrens (Boyd 1991). Historic archaeological sites are rare except in a few settings, such as present or former landing areas. Some remains of landing wharves and sunken small craft may exist in the marshes. A lifesaving station site near Brigantine City is one of the few documented historic archaeological sites at the Refuge (USFWS 2004). There are currently no standing historic structures on the Refuge.

Except for a handful of studies prior to Refuge construction projects, Refuge lands have never been surveyed for archaeological sites. Prehistoric site potential is high, but site discovery is complicated by major changes in sea level over the last 12,000 years (USFWS 2004). Much of the Refuge is tidal marsh, and archaeological sites/artifacts in this setting are logistically difficult to locate and study. In exposed areas, they have often been lost to erosion. Upland portions of the Refuge have generally high potential for prehistoric sites, as much of this land adjoins wetland resources used by their inhabitants (USFWS 2004).

Wildlife and Habitat Changes

Human impact to the Pine Barrens of New Jersey has been severe (Foreman 1979). Forest cutting, agriculture, mining for iron ore and glass sands, subdivision, and other real estate development have removed forest cover and increased the abundance of disturbance-adapted species. The greatest human impacts to the Pine Barrens are currently wildfire control and forest fragmentation.

According to Little (in Foreman 1979), Pine Barrens forests were modified and shaped by Native American burning resulting in upland sites dominated by large pines with little undergrowth or small scattered pines with blueberry/huckleberry understories. Sites were most likely maintained by frequent and light fires. Fire intensity was probably low as most anthropogenic fires occurred primarily in fall and winter. Large fire events after settlement occurred in 1755 (30 miles in length) and in 1895 (125,000 acres). In 1900 and 1930, fires burned 129,500 and 172,855 acres respectively. In 1963, 183,000 acres burned and in 1995 one wildfire burned 19,225 acres in Ocean County (NJDEP 2012). Fire is the single most important factor in shaping vegetation in the Pine Barrens. Today prescribed burning is used to decrease the start and spread of wildfire. Continued wildfire suppression, and the use of low-temperature, cold-season controlled fires, may change the composition of some Pine Barrens forests by favoring oaks for dominance of the forest (Boyd 1991).

Early farms along the salt marsh altered adjacent pine forests for timber products and agricultural lands (Harshberger 1916). Woodlands were exploited for lumber, wood, charcoal, turpentine, and other forest products. Atlantic white cedar was cut for lumber and shingles. Forest removal favored wildlife preferring successional habitats, such as American woodcock (*Scolopax minor*), northern bobwhite (*Colinus virginianus*), and prairie warbler (*Dendroica discolor*).

In the 1900s, salt marshes were ditched for mosquito control. Large-scale parallel-ditching continued through the 1930s (Burger et al. 1979). Approximately 6,000 acres of salt marsh on the Refuge is not ditched. Lathrop et al. (2010) reported Barnegat Bay has lost more than one quarter of its tidal salt marshes over the past century due to filling and development, and that a large proportion of the bay's remaining salt marshes are ditched for mosquito control.

Approximately 45 percent of the total length of the bay is bulkheaded and more than 70 percent of the adjacent upland shores are developed, causing the loss and alteration of vital shoreline and shallow-water habitats (Lathrop 2010). Some Barnegat Bay sub-watersheds have over half of the riparian zone altered by impervious surfaces (highways, parking lots, buildings), and have degraded riparian buffers (straightened and/or ditched channels without a vegetated buffer). As

sea levels rise, 29 percent of potential tidal marsh retreat area is presently limited by developed features, such as housing, commercial development, and roads (Lathrop 2010).

One-third (270 species) of the vascular plants in the Pine Barrens are non-native (Foreman 1979). Introduced mammals, birds, a reptile, fish, and insects are common. Some native species such as wolf (*Canis lupus*), cougar (*Puma concolor*) (Harshberger 1916), and heath hen (*Tympanuchus cupido cupido*) are no longer found in New Jersey.

2.5 CURRENT REFUGE CONDITIONS

Natural Community Types

The Refuge System uses the National Vegetation Classification System (NVCS) developed by The Nature Conservancy and the Natural Heritage Network as a standard for classifying plant communities (NatureServe 2009). The classification contains hierarchical levels of community specificity. The narrowest level within the classification is the Association. Vegetation community classification and mapping using a combination of aerial photo interpretation and on-the-ground field assessment was conducted for this project. NVCS and mapping to the NVCS association level was used, wherever possible. Vascular plant species nomenclature within the report follows the nationally standardized list from the PLANTS 3.5 Database (USDA NRCS 2006). The various communities were grouped into the following 8 major habitat types (also see Appendix B, Map 4).

Coastal Habitats

Beach/Dune comprises 1,574 acres and includes:

- *Northern Bayberry Dune Shrubland and Central Coast Beach-Heather Dune Shrubland Communities*: maritime dune shrubland, often dwarf, characterized by bayberry (*Morella* spp.) and beach plum (*Prunus maritima*) or woolly beach heather (*Hudsonia tomentosa*) with a sparse herbaceous layer including American beachgrass (*Ammophila breviligulata*), seaside goldenrod (*Solidago sempervirens*), and coastal panicgrass (*Panicum amarum).*
- *Northern Beachgrass, Mid-Atlantic Coast Backdune and Overwash Dune Grassland Communities*: maritime grassland dunes with variable cover (25-50%) dominated by American beachgrass, coastal panicgrass, bluestem broomsedge (*Andropogon virginicus*)**,** shore little bluestem (*Schizachyrium littorale*), and sparse to variable, often monotypic stands of saltmeadow cordgrass (*Spartina patens*), and other associated species including beach pea (*Lathyrus japonicas)*, seaside goldenrod, field sagewort (*Artemisia campestris*), purple sandgrass (*Triplasis purpurea*), and American searocket (*Cakile edentula*) (closer to the tidal zone), and sparse shrubs of bayberry and wax myrtle (*Morella cerifera*) (away from the tidal zone).
- *Beach Strand Communities*: characterized by sparsely vegetated annuals and biennials, including American searocket, seaside sandmat (*Chamaesyce polygonifolia*), and spear saltbush (*Atriplex patula*).
- *Maritime Forest Communities*: dense tall-shrub thickets to open woodlands dominated by eastern red cedar (*Juniperus virginiana*), mixed with pitch pine (*Pinus rigida*), post oak

(*Quercus stellata*), black oak (*Quercus velutina*), black cherry (*Prunus serotina*), common serviceberry (*Amelanchier arborea*), American holly (*Ilex opaca*), or common hackberry (*Celtis occidentalis*); a variable shrub layer of bayberry, groundsel tree (*Baccharis halimifolia*), or beach plum, and a patchy herbaceous cover.
- *Northern Tall Maritime Shrubland Communities*: variable community with a canopy of common serviceberry, black cherry, sassafras (*Sassafras albidum*), blackgum (*Nyssa sylvatica*), and red maple (*Acer rubrum*), a subcanopy layer of bayberry, *Photopia* spp., and *Viburnum* spp., and a sparse herbaceous layer.

Salt Marsh comprises 33,358 acres and includes:

- *North Atlantic Low Salt Marsh Communities*: monotypic tall grassland dominated by smooth cordgrass (*Spartina alterniflora*) in regularly flooded intertidal zones with very low species richness.
- *North Atlantic High Salt Marsh Communities*: patch mosaic generally dominated by a single graminoid species, saltmeadow cordgrass (*Spartina patens*), saltgrass (*Distichlis spicata*), or saltmeadow rush (*Juncus gerardii*).
- *Tidal Phragmites Marsh Communities*: often dominated by monotypic stands of invasive *Phragmites (australis),* and with few or no other vascular plants present.
- *Salt Panne and Pool Communities:* tidally flooded hypersaline flats or very shallow depressions (pannes) dominated by variable cover of Virginia glasswort *(Salicornia depressa*), dwarf saltwort (*Salicornia bigelovii*), slender grasswort (*Salicornia maritima*), and permanently or semi-permanently flooded salt pools or pannes with widgeongrass (*Ruppia maritima*) and sago pondweed (*Stuckenia pectinata*) herbaceous vegetation.
- *North Atlantic Coast Estuarine Intertidal Mudflats Communities*: unvegetated saline mudflats exposed between the highest high tide and the lowest low tide with a low-diversity but a highly productive benthic invertebrate community.
- *Transitional Tidal Marsh* and *Brackish Meadow Communities*: dominated by colonies of chairmaker's bulrush (*Schoenoplectus americanus*) (40 to 75% total cover) or switchgrass (*Panicum virgatum*) and co-dominant with saltmeadow cordgrass, and associated with sweetscent (*Pluchea odorata*), smooth cordgrass, goldenrod (*Solidago* spp.), and saltgrass.
- *Salt Shrub Scrub Communities*: transition from salt marsh to upland dominated by maritime shrubs, including maritime marsh elder, and with common associates of groundsel tree, bayberry, switchgrass, and saltgrass, rosemallow (*Hibiscus moscheutos*), poison ivy (*Toxicodendron radicans*), and red fescue (*Festuca rubra*).

Freshwater Wetland

Freshwater Wetland comprises 593 acres and includes:

- *Eastern Reed Marsh Communities*: often dominated by monotypic stands of invasive *Phragmites,* and with few or no other vascular plants, to native freshwater marsh vegetation.

- *Lily Pond Communities*: hydromorphic coastal plain pond community with a muck substrate and characterized by American white water-lily (*Nymphaea odorata*) and Robbins' spikerush (*Eleocharis robbinsii*) herbaceous vegetation.
- *Eastern Cattail Marsh Communities*: tall emergent marsh dominated with graminoid vegetation including narrowleaf (*Typha angustifolia*) and broadleaf cattail (*T. latifolia*) and a shrub layer (<25% cover) of sweetgale (*Myrica gale*), common winterberry (*Ilex verticillata*), and white meadowsweet (*Spiraea alba*).
- *Northeastern Leafy Forb Marsh Communities*: emergent marshes dominated by broad-leaved plants including pickerelweed (*Pontederia cordata*), green arrow-arum (*Peltandra virginica*), and broadleaf arrowhead (*Sagittaria latifolia*) herbaceous vegetation.
- *Northern Peatland Sedge Coastal Plain Pond Communities*: Coastal Plain depression wetland community dominated by Walter's sedge (*Carex striata*) on sand and gravel, and sometimes organic muck, substrate.
- *Blueberry Wetland Thicket Communities*: a tall-shrub swamp where the dominant shrubs include highbush blueberry (*Vaccinium corymbosum*), common winterberry, coastal sweet pepperbush (*Clethra alnifolia*), and swamp azalea (*Rhododendron viscosum*), and variable herbaceous layer with *Sphagnum* spp.
- *Swamp Loosestrife Shrub Swamp Communities*: flooded shrubland border where swamp loosestrife (*Decodon verticillatus*) forms dense, often monotypic tangles to provide breeding, nesting, and migratory bird habitat, and habitat for other species of greatest conservation need.
- *Pine Barrens Bog Communities*: shallow, circular depressions and swales, or margins of intermittent ponds and stream sides with dense leatherleaf (*Chamaedaphne calyculata*) interspersed with swamp loosestrife, cranberry (*Vaccinium macrocarpon*), and huckleberry (*Gaylussacia* spp.) over a carpet of *Sphagnum* spp., and scattered Walter's sedge.
- *Sea Level Fen Communities*: small patch communities with diverse species composition of estuarine and palustrine species, including smooth sawgrass (*Cladium mariscoides*), water sundew (*Drosera intermedia*), beaked spikerush (*Eleocharis rostellata*) in association coastal sedge (*Carex exilis*), common spikerush (*Eleocharis palustris*), brownfuit rush (*Juncus pelocarpus*), and swamp rose (*Rosa palustris*).
- *Pine Barrens Riverside Shrub Savanna Communities*: woody herbaceous community with an open canopy (10-25%) of Atlantic white cedar, pitch pine, dwarf huckleberry (*Gaylussacia dumosa*) and woody associates including inkberry (*Ilex glabra*), sheep laurel (*Kalmia angustifolia*), bayberry spp., and bristly dewberry (*Rubus hispidu*s), and herbaceous associates including chainfern (*Woodwardia* spp.).

Wetland Forest

Wetland Forest comprises 10,842 acres and includes:

- *Southern Red Maple-Blackgum, Red Maple-Sweetgum, Red Maple Sedge Swamp Forest, and Successional Sweetgum Forest Communities*: seasonally flooded open to closed forests with a canopy of red maple, blackgum, green ash (*Fraxinus pennsylvanica*), and sweetgum (*Liquidambar styraciflua*)with an occasional American holly, sassafras, sweetbay (*Magnolia virginiana*), tuliptree (*Liriodendron tulipifera*), and willow oak

(*Quercus phellos*) with a variable shrub layer including highbush blueberry, coastal sweet pepperbush, huckleberry, swamp azalea, swamp doghobble (*Eubotrys racemosa*), and common winterberry, and a sparse herbaceous layer to a graminoid and fern dominated layer in the Sedge Swamp community.

- *Lowland Pitch Pine Forest Communities*: mixed deciduous-evergreen to deciduous canopy of pitch pine, red maple, blackgum, and sweetgum and a subcanopy of sweetbay and American holly with a shrub layer of coastal sweet pepperbush, swamp doghobble, huckleberry, and blueberry, and herbaceous layer of cinnamon fern (*Osmunda cinnamomea*), eastern teaberry (*Gaultheria procumbens*), and various sedges.
- *Coastal Plain Atlantic White Cedar-Red Maple Swamp and Atlantic White Cedar Swamp Communities*: canopies dominated by Atlantic white cedar or mixed with red maple, a shrub layer of blueberry, coastal sweet pepperbush, inkberry, and a sparse to moderate herbaceous layer of cinnamon fern, *Carex* spp., and S*phagnum* spp. mosses.
- *Atlantic White Cedar Bog Communities*: open canopy of stunted Atlantic white cedar in association with red maple, pitch pine, and sweetbay with a dense low shrub layer dominated by heath shrubs, leatherleaf and sheep laurel, and a dwarf shrub mat herbaceous layer of cotton grass (*Eriophorum* spp.), and chainfern with a continuous *Sphagnum* spp. moss layer.
- *Pine Barrens Riverside Bog Asphodel Savanna Communities*: diverse wet meadow community of Atlantic white cedar, bog asphodel (*Narthecium americanum*), purple pitcherplant (*Sarracenia purpurea*)-threadleaf sundew (*Drosera filiformis*) and *Sphagnum* spp.

Upland Forest

Upland Forest comprises 4,893 acres and includes:

- *Oak, Oak-Pine, and Pine Oak Upland Forest Communities*: open to closed canopy forest of pitch pine mixed with scarlet (*Quercus coccinea*), southern red (*Q. falcata*), white and black oak (*Q. velutina*) or of mixed oaks including southern red, willow, white (*Q. alba*), scarlet, swamp chestnut (*Q. michauxii*), and black oak with a sub canopy of American holly, sassafras, mountain laurel (*Kalmia latifolia*), red maple, blackgum, or dogwood (*Cornus* spp.), a shrub layer of huckleberry, blueberry, common serviceberry, or American hazelnut (*Corylus americana*), and a sparse to variable herbaceous layer.
- *Successional Upland Forest Communities*: mix of overstory species including scarlet and red oaks, red maple, tuliptree, and loblolly pine (*Pinus taeda*) with a variable shrub cover of *Rubus* spp., deerberry (*Vaccinium stamineum*), and spicebush (*Lindera benzoin*), and a variable herbaceous cover. These communities are fire adapted with fire as natural disturbance.

Pitch Pine Barrens Forest

Pitch Pine Barrens Forest comprises 1,368 acres and includes:

- *Pitch Pine Barrens Upland Forest Communities*: open canopy forests with an overstory of pitch pine, a very low cover of deciduous trees, when present, may include post oak (*Quercus stellata*) and black oak, an understory dominated by blackjack oak (*Quercus*

marilandica), a low heath shrub layer of blueberry and huckleberry, and a variable herbaceous layer. This community is fire-dependent.

Early Successional Habitat

Early Successional Habitat comprises 832 acres and includes:

- *Northeastern Successional Shrubland Communities*: varying from open fields with scattered tall and short shrubs of gray dogwood (*Cornus racemosa*), blackhaw (*Viburnum prunifolium*), and *Rhus* spp., covering 25% of the field, with herbaceous vegetation, including *Solidago* spp., bentgrass (*Agrostis* spp.), bromegrass (*Bromus* spp.), and clovers (*Trifolium* spp.) in the interstices, to dense "closed-canopy" tall shrubland with a canopy of eastern red cedar, gray birch (*Betula populifolia*), chokecherry (*Prunus virginiana*), red maple, and black cherry and a sparse ground layer vegetation.
- *Old Field Eastern Red Cedar Communities*: broadly spaced woodland of dense and nearly impenetrable thickets with an eastern red cedar dominated canopy layer with scattered pines. Maples, oaks, cherry, and a variable shrub cover dependent on canopy closure, with the most forested stands having little or no shrub cover and with exotic shrubs such as silverberry (*Elaeagnus commutata*) and multiflora rose (*Rosa multiflora*).
- *Northeastern Modified Successional Shrubland Communities*: shrubby old fields dominated by thickets of gray dogwood, blackhaw, multifora rose, and smooth sumac (*Rhus glabra*) with patches of herbaceous vegetation among the shrubs and short shrubs, including Japanese barberry (*Berberis thunbergii*), *Rhus* spp. and in some fields, blueberry and huckleberry with occasional small trees, including eastern red cedar, gray birch, chokecherry and red maple with <25% cover, and a variable herbaceous layer typical of old fields, grasslands, and agricultural sites.
- *Northeastern Old Field Communities*: grassland comprised of mid-height (1-3 feet tall) grasses and forbs, with occasional scattered shrubs with variable species composition resulting from early succession in pastures and post-agricultural fields with largely non-native cool-season grasses and herbs (generally of European origin).

Managed Impoundments and Ponds

On the Refuge there are approximately 2,500 acres of water and wetland areas created by dams or dikes impounding water flow. When impoundments are properly managed as ephemeral freshwater wetlands, they have high carrying capacity for waterbirds and increase biodiversity (Fredrickson and Taylor. 1982). Coastal impoundments require significant maintence to remain functional. Accelerated sea level rise is expected to increase the cost of maintence and the risk of breaching, necessitating re-evaluation and adaptation. Two large, managed impoundments are important features of the southern part of the Refuge and are popular wildlife viewing areas. The Northwest and Southwest Pools, comprising approximately 800 acres, are fed by Lily Lake, Doughty Creek and springs. These two impoundments have been managed as one since the dike separating them failed. This impoundment is managed as a moist-soil unit for migrating shorebirds and wintering waterfowl.The adjacent East Pool (536 acres) receives tidal flow from the four open tide gates and is managed as a salt marsh habitat for waterfowl, shorebirds and piscivorous migratory birds. Several small ponds near the impoundments were excavated during construction of the dikes.

Four other impoundments are located on the Refuge. Barnegat Pool 1 is managed as a deep water reservoir and provides water to Pools 2 and 3, which are managed as medium-depth reservoirs that feed Pool 4. Pool 4 is managed as moist soil for migrating shorebirds and wintering waterfowl. The Barnegat Pools total about 350 acres. There are other smaller impoundments at Forked River, Murray Grove/Stouts Creek and Oak Island that would need significant repair before the water in them could be controlled and managed. Freshwater ponds exist on the Oxycoccus, Commerce Bank, and Headquarters properties.

Wildlife

New Jersey coastal wetlands have long been wintering and migration habitat for brant and American black ducks. Located along the Atlantic Flyway, Refuge salt marsh and wetland habitats are of significant importance to many species of waterfowl, shorebirds, and songbirds during the spring and fall migratory periods. Refuge beaches provide nesting and migration habitat for shorebirds, gulls, terns and skimmers. Forested habitats support varied and abundant populations of resident and migratory wildlife including more than 300 species of birds and a variety of mammals, reptiles, amphibians, insects, and plants.

Migratory Birds

The coastal wetlands of New Jersey are of international importance to wintering waterfowl. In 2011, 37% of the Atlantic Flyway black duck population, 41% of the brant population, and 22% of the greater snow goose (*Chen caerulescens*) population were recorded in New Jersey during the Service's mid-winter inventory (USFWS 2012). Refuge wetlands are one of only 26 sites in the U.S. classified as a Wetlands of International Importance under the Ramsar Convention.

The Refuge provides important migrating and wintering habitat for snow geese, brant, American black duck and northern pintail *(Anas acuta).* The 2012 Midwinter Waterfowl counts for the Refuge included 6,060 snow geese, 5,480 brant, and 20,335 black duck (USFWS 2012).

Many marsh and water birds use the Refuge. The most common include great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), black-crowned night-heron (*Nycticorax nycticorax*), glossy ibis (*Plegadis falcinellus*), and cattle egret (*Bubulcus ibis*). Herons and egrets nest on or near the Refuge, frequently foraging in the salt marshes, streams, ponds, and impoundments. Black rail (*Laterallus jamaicensis*), clapper rail (*Rallus longirostris*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola),* and sora (*Porzana carolina*) are found in Refuge marshes. Songbird species utilizing the marshes include marsh wren (*Cistothorus palustris),* saltmarsh sparrow (*Ammodramus caudacutus*), and seaside sparrow *(Ammodramus maritimus*). Seaside sparrows occur primarily in natural salt marshes (Burger et al. 1982).

Common shorebird spring migrants include dunlin (*Calidris alpina*), sanderling (*Calidris alba*), semipalmated sandpiper (*Calidris pusilla*), semipalmated plover (*Charadrius semipalmatus*) and short-billed dowitcher (*Limnodromus griseus*). In fall, common migrants include black-bellied plover (*Pluvialis squatarola*), red knot (*Caladris canutus*), sanderling, semipalmated sandpiper, and semipalmated plover (Refuge files). Other species utilizing the Refuge include greater yellowlegs (*Tringa melanoleuca*), least sandpiper (*Caladris minutilla*), lesser yellowlegs (*Tringa flavipes*), piping plover, ruddy turnstone (*Arenaria interpres*), whimbrel (*Numenius phaeopus*),

spotted sandpiper (*Actitis macularia*) and pectoral sandpiper (*Calidris melanotos*). More shorebirds species are found in fall migration than in spring. Shorebird migration peaks in May and August (Refuge files).

Important beach nesting birds on Holgate and Little Beach Island are the American oystercatcher (*Haematopus palliatus*), black skimmer (*Rynchops niger*), piping plover, and least tern (*Sternula antillarum*). From 1993 to 2011, piping plover production (chicks fledged) averaged 0.8 chicks per nesting pair (Refuge files). During the same period black skimmer and least tern nesting numbers and production varied greatly. No black skimmer or least tern fledglings have been documented in recent years, though there have been a few attempts at nesting.

Many raptors breed on the Refuge, including red-tailed hawk (*Buteo jamaicensis*), turkey vulture (*Cathartes aura*), sharp-shinned hawk (*Accipiter striatus*), broad-winged hawk (*Buteo platypterus*), osprey (*Pandion haliaetus*), red-shouldered hawk (*Buteo lineatus*), northern harrier (*Circus cyaneus*), great horned owl (*Bubo virginianus*), common barn owl (*Tyto alba*), and barred owl (*Strix varia*). Wintering and resident foraging raptors include bald eagle (*Haliaeetus leucocephalus*), northern harrier, and red-tailed hawk. Many other raptors may be seen during migration; including, American kestrel (*Falco sparverius*), sharp-shinned hawk, and Cooper's hawk (*Accipiter cooperii*).

Avifauna of the Pine Barrens has been described as "not rich" (Boyd 1991) or "remarkably simple" (Foreman 1979) because of a lack of habitat diversity and edge (Boyd 1991, 2008). Common bird species include the American kestrel, common nighthawk (*Chordeiles minor*), eastern towhee (*Pipilo erythrophthalmus*), northern bobwhite, pine warbler (*Dendroica pinus*), and whip-poor-will (*Caprimulgus vociferus*).

Oak and oak-pine forests provide better nesting habitat, are richer in food resources and provide for a greater diversity of birds than Pine Barrens (Boyd 2008). Species utilizing these forests include black-and-white warbler (*Mniotilta varia*), downy woodpecker (*Picoides pubescens*), ovenbird (*Seiurus aurocapilla*), red-eyed vireo (*Vireo olivaceus*), hairy woodpecker (*Picoides villosus*), and wood thrush (*Hylocichla mustelina*).

Wetland forests and Atlantic white cedar swamp birds include Acadian flycatcher (*Empidonax virescens*), gray catbird (*Dumetella carolinensis*), eastern wood-pewee (*Contopus virens*), northern parula (*Parula americana*), worm-eating warbler (*Helmitheros vermivorus*), and wood thrush.

Freshwater wetlands, including bogs, fens, and shrub swamps represent a small portion of Refuge habitats and provide habitat for belted kingfisher (*Megaceryle alcyon*), green heron (*Butorides irescens*), marsh wren, tree swallow (*Tachycineta bicolor*), and wood duck (*Aix sponsa*).

Current bird sightings for the Refuge can be found at the following website: http://www.fws.gov/refuge /Edwin_B_Forsythe/visit/ebird.html.

Mammals

No systematic inventory of mammalian species has been conducted at the Refuge, but over 30 species of mammals, characteristic of the Mid-Atlantic coastal communities occur on the Refuge. Forest species include red fox (*Vulpes vulpes*), grey fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), white-tailed deer (*Odocoileus virginianus*), grey squirrel (*Sciurus carolinensis*), red squirrel (*Tamiasciurus hudsonicus*), eastern chipmunk (*Tamias striatus*), white-footed mouse (*Peromyscus leucopus*), red-backed vole (*Clethrionomys gapperi*), pine vole (*Microtus pinetorum*), masked shrew (*Sorex cinereus*), short-tailed shrew (*Blarina brevicauda*), and eastern mole (*Scalopus aquaticus*) (Refuge files).

Shrubland and grassland species of mammals include the meadow vole (*Microtis pennsylvanicus*), meadow jumping mouse (*Zapus hudsonius*), woodchuck (*Marmota monax*), eastern cottontail (*Sylvilagus floridanus*) and several of the forest and wetland species. Mammals associated with wetlands include mink (*Mustela vison*), river otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), meadow vole, southern bog lemming (*Synaptomys cooperi*), and least shrew (*Cryptotis parva*) (Boyd 2008). Many species of nesting, migrating, or wintering raptors are dependent on the availability of small mammal populations.

Year around species of bats include little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), northern long-eared bat (*Myotis septentrionalis*), eastern small-footed bat (*Myotis leibii*) and tri-colored bat (*Perimyotis subflavus*). Bats occur in forested habitat types during the summer breeding season and forage in forest openings. A number of other migratory bat species, hoary bat (*Lasiurus cinereus*), red bat (*Lasiurus borealis*), and silver-haired bat (*Lasionycteris noctivagans*) probably pass through southern New Jersey during migration. Bat counts conducted by the Conserve Wildlife Foundation of New Jersey and the New Jersey Endangered and Nongame Species Program indicate that roost sites in New Jersey have decreased by 41% from 2008 or earlier compared to 2010 (CWFNJ 2010). Little research has been done on bats in the vicinity of the Refuge.

Marine mammals, such as harbor porpoise (*Phocoena phocoena*) and bottle-nosed dolphin (*Tursiops truncatus*) are observed in waters off Refuge lands. Harbor seals (*Phoca vitulina*) and gray seals (*Halichoerus grypus*) use the Refuge beach and salt marshes as haul out areas during winter months. Marine mammals are managed by the National Oceanic and Atmospheric Administration.

Reptiles and Amphibians

The most commonly observed amphibian observed in Refuge uplands is Fowler's toad (*Anaxyrus fowlerii*) and less frequently eastern spadefoot toad (*Scaphiopus holbrookii*) and wood frog (*Lithobates sylvatica*). Pine Barrens treefrog (*Hyla andersonii*) is mostly restricted to cedar and sphagnum bogs and swamps in the Pine Barrens (Boyd 2008). Other upland reptiles found on the Refuge include northern fence lizard (*Sceloporus undulatus*), northern pine snake (*Pituophis melanoleucus*), and eastern box turtle (*Terrapene carolina*).

Wetlands provide habitat for salamanders including, red-backed salamander (*Plethodon cinereus*), slimy salamander (*Plethodon glutinosus*), and marbled salamander (*Ambystoma opacum*) (Foreman 1979). Spring peeper (*Hyla crucifer*) and southern gray treefrog (*Hyla chrysoscelis*) are known for their chorus of distinctive mating calls. Other turtles include snapping turtle (*Chelydra serpentina*), eastern mud turtle (*Kinosternon subrubrum*), and redbelly turtle (*Pseudemys rubriventris*).

Northern diamondback terrapin (*Malaclemys terrapin*) utilize coastal marshes, estuaries, coves, tidal flats, and inner edges of barrier beaches in New Jersey (Gessner and Stiles 2001) and select flat locations in high dunes in New Jersey for their nests (Burger and Montevecchi 1975). Overall, 19 species of reptiles and amphibians can be found on the Refuge (Refuge files).

Fish

Salt marshes, streams, ponds, bays, and rivers comprising the estuaries of the Refuge are critical and provide the foundation for sport and commercial fisheries, as well as food base for many birds and mammals. Refuge lands are bordered by and hydrologically connected to these estuarine habitats. Fishery resources are of significant importance to Refuge wildlife species and fish and invertebrates are bio-indicators of habitat change. The Refuge relies on partnerships with other agencies and groups to conserve these resources.

Mummichog (*Fundulus heteroclitus*) and sheepshead minnow (*Cyprinodon variegatus*) are abundant in salt marshes where they are most frequently found in shallow water environments such as marsh ponds and small intertidal creeks. Estuarine habitats are important nursery areas for a number of important recreational and commercial species including summer flounder (*Paralichthys dentatus*), striped bass (*Morone saxatilis*), white perch (*Morone americana*), and northern weakfish (*Cynoscion regalis*).

Upland Refuge streams and ponds are high in acidity tannins and dissolved iron content, but low in nutrients (Boyd 2008). Characteristic species include blackbanded sunfish (*Enneacanthus chaetodon*), banded sunfish (*E. obesus*), bluespotted sunfish (*E. gloriosus*), pirate perch (*Aphredoderus sayanus*), swamp darter (*Etheostoma fusiforme*), and chain pickerel (*Esox niger*).

Invertebrates

A wide variety and number of invertebrates are of biological importance. Numerous aquatic invertebrates provide an important food source for fish and bird species. For example, grass shrimp (*Palaemonetes* spp.) remain in salt marsh pools of water after tides have receded and are an important food source for Refuge birds. Other invertebrates such as chironomids or midges are the focus of freshwater impoundment management because of their high value for feeding shorebirds.

According to Boyd (2008), there are over 10,000 species of arthropods in the Pine Barrens alone. Refuge beach habitat is considered of medium restoration potential for the federally threatened northeastern beach tiger beetle (*Cicindela dorsalis*), which is considered extirpated in New Jersey (USFWS 1994, USFWS 2004).

The monarch butterfly utilizes Refuge landscapes during fall migration. Other butterfly species include the bronze copper (*Lycaena hyllus*), checkered white (*Pontia protodice*), and Hessel's hairstreak (*Mitoura hesseli*). Insect pollinators on the Refuge are not well documented.

Important marine bivalves found in nearby waters include blue mussel (*Mytilus edulis*), Coquina clam (*Donax variabilis*), eastern oyster (*Crassostrea virginica*), quahogs (*Mercenaria mercenaria*), razor clam (*Ensis directus*), ribbed mussel (*Modiolus demisus*), soft shell clam (*Mya arenaria*), and surf clam (*Spisula solidissima*). Other important invertebrates include blue crab (*Callinectes sapidus*), fiddler crab (*Uca* spp.), and horseshoe crab (*Limulus polyphemus*).

Invasive Species

Federal management of invasive plant species is guided by planning efforts outlined in Executive Order 13112 requiring the development of a National Invasive Species Management Plan every two years. The Executive Order defined an invasive species as a non-native species to the ecosystem whose introduction will cause (or is likely to cause) economic or environmental harm. The Plan focuses on those non-native species that cause or may cause significant negative impacts and that do not provide an equivalent benefit to society.

One report estimates the economic cost of invasive species in the U.S. at $137 billion annually (Pimentel et al. 2000). Up to 46 percent of the plants and animals federally listed as endangered species have been negatively impacted by invasive species (National Invasive Species Council 2001, Wilcove et al. 1998). Nonindigenous plants documented in New Jersey number between 1,288 and 1,363 and are as much as 62 percent of the state's total vascular flora. Most have been introduced into New Jersey from continents other than North America, mostly from Europe and Asia (Snyder and Kaufman 2004).

Inventories have identified a minimum of 30 invasive plant species on the Refuge (Table 2-1) Annual control techniques include chemical, hand pulling, and mowing. Inventory and mapping are ongoing efforts.

TABLE 2-1. INVASIVE PLANT SPECIES AT E.B. FORSYTHE NWR

Common Name	**Scientific Name**
Asiatic sand sedge	*Carex kobomugi*
Autumn/Russian olive	*Elaeagnus umbellata, E. angustifolia*
bamboo	*Bambusa, Phyllostachys, Psuedosassa*
black locust	*Robinia pseudoacacia*
Bradford pear	*Pyrus calleryana*
butterfly bush	*Buddleia davidii*
Chinese/Japanese wisterias	*Wisteria sinensis, W. floribunda*
common reedgrass	*Phragmites australis*
English ivy	*Hedera helix*
Chinese silvergrass	*Miscanthus sinensis*

ditch lily	*Hemerocalis fulva*
honeysuckle spp.	*Lonicera* spp.
Japanese barberry	*Berberis thunbergii*
Japanese knotweed	*Fallopia japonica*

Asiatic sand sedge is restricted to sea beaches and primary and secondary sand dunes. Planted for erosion control and sand stabilization, the sedge forms dense mats that crowd out indigenous dune species. The sedge is lower growing than the native dune grasses and leaves dunes vulnerable to shifting sands and blowouts, changing the dune profile dramatically (Virginia NHP1998). Asiatic sand sedge may form dense monocultures up to 65 feet across, effectively excluding most native species. This species is found on the Holgate Unit of the Refuge. In summer 2012, an aggressive eradication program to eliminate the plant was initiated.

Since 2001, southern pine beetle (*Dendroctonus frontalis*) populations in New Jersey have remained largely confined to the southern portions of the state. In 2008, southern pine beetles crossed the Egg Harbor River and entered the pine forests of Atlantic County. In 2010, it continued north and west and now is found in the New Jersey Pinelands (NJDEP 2012a). During March 2012, Refuge biologists accompanied by a forester from the U.S. Forest Service (USFS) surveyed for the beetles on the southern boundary of the Refuge and found evidence of infestation on private property near Great Creek Road. The New Jersey Department of Environmental Protection, Bureau of Forest Management and the USFS continue to monitor for southern pine bark beetles throughout southern New Jersey.

A number of other invasive species, such as the mute swan and European starling (*Sternus vulgaris*), can be found on the Refuge. Detailed and updated information on invasive species in New Jersey can be found on the USDA National Invasive Species Information Center for New Jersey and New Jersey Department of Environmental Protection, New Jersey Invasive Species Council websites (http://www.invasivespeciesinfo.gov/unitedstates/nj.shtml, http://www.nj.gov/dep/njisc/).

Wildlife Surveys

Refuge staff conducts a variety of inventories to estimate wildlife usage and make management decisions. Inventories may vary based on data needs and availability of staff and funding. A Service-wide inventory and monitoring initiative was undertaken in 2009. Its purpose is to collect and synthesize information that supports management at multiple geographic scales and informs decisions at all organizational levels. Information contained in this HMP will be utilized as the Refuge prepares its own inventory and management plan. Results of that plan will be important to implement the objectives and strategies discussed in this HMP. The inventory and monitoring plan will be targeting monitoring efforts toward species that will result in meaningful data to evaluate management actions.

Threatened, Endangered, Recovered and Rare Species

Piping plover, a federally threatened bird species, occur on the Refuge. Swamp pink, a federally threatened plant species, is found on the Refuge and the Refuge is within the historic range of the federally endangered, American chaffseed (*Schwalbea americana*) plant, and the federally threatened plant, Knieskern's beaked-rush (*Rhynchospora knieskernii*). A number of federally endangered marine mammals and sea turtles are found in the nearby Atlantic Ocean and Delaware Bay waters.

CHAPTER 3: RESOURCES OF CONCERN

Image: American black ducks (*Anas rubripes*). Photo by Nick Kontonicolas

3.1 Potential Resources of Concern
3.2 Biological Integrity, Diversity, and Environmental Health
3.3 Priority Resources of Concern
3.4 Representative Species
3.5 Conflicting Habitat Needs
3.6 Adaptive Management

3.1 POTENTIAL RESOURCES OF CONCERN

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

Trust resources for which the Service has full responsibility include migratory birds, endangered species, certain marine mammals, inter-jurisdictional fish, and the land and waters administered by the Service for the management and protection of these resources. Additionally, each refuge has an establishment purpose(s) to guide management goals and objectives. The New Jersey Wildlife Action Plan (2008) identifies wildlife species in the state that are the highest priority for conservation. These federal and state lists received emphasis in developing the Refuge's resources of concern.

Given the multitude of purposes, mandates, policies, and regional and national plans that can apply to the Refuge (see Chapter 1.2 and 1.3), there is a need to prioritize those resources on which the Refuge is best suited to focus management objectives. This chapter documents the process used to identify priority Refuge resources of concern, priority habitats, and representative species. The first step of developing a habitat management strategy is to define the Refuge resources of concern by referencing mandates, policies, purposes, and applicable regional/national plans.

The results of this process are summarized in Appendix C, which contains a matrix of potential Refuge resources of concern based on occurrence, habitat availability, and population trends. Species in Appendix C are of local, state, regional, or national conservation concern whose range and habitat requirements are found in the Refuge.

In May 2011, a meeting of technical experts from federal, state and local agencies, along with other Service program areas helped define habitats and species of concern. Review of numerous conservation plans and documents focusing on the Mid-Atlantic Region and New Jersey assisted this process. Refuge surveys, databases, studies, and reports provided substantial information.

3.2 BIOLOGICAL INTEGRITY, DIVERSITY, AND ENVIRONMENTAL HEALTH

The National Wildlife Refuge System Improvement Act of 1997 states that in administering the System, the Service shall "… ensure that the biological integrity, diversity, and environmental health of the System are maintained…" (USFWS 2003). The Service defines these terms as:

- *Biological Integrity:* Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities.

- *Biological Diversity:* The variety of life and its processes, including the variety of living organisms, the genetic differences between them, and the communities and ecosystems in which they occur.
- *Environmental Health:* Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment.

In addition to providing habitat for trust species, refuges support other elements of biodiversity including invertebrates, rare plants, unique natural communities, and ecological processes (USFWS 1999a). Where possible, refuge management restores or mimics natural ecosystem processes or functions and thereby maintains biological diversity, integrity, and environmental health. Given the continually changing environmental conditions and landscape patterns of the past and present (e.g., rapid development, climate change, sea level rise), relying on natural processes is not always feasible nor is it always the best management strategy for conserving wildlife resources. Uncertainty about the future requires that the Refuge manage within a natural range of variability rather than emulating an arbitrary point in time. This maintains mechanisms that allow species, genetic strains, and natural communities to evolve with changing conditions rather than trying to maintain stability.

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

To assess the historical condition, site capability, current regional landscape conditions, and Biological Integrity, Diversity, and Environmental Health (BIDEH) data pertinent to the Refuge, the following resources were utilized:

- Archaeological and historical accounts
- Maps and associated data on site history and capabilities
- Landscape vegetation classification schemes, Nature Serve, TNC, USFS
- Species conservation plans and assessments including the New Jersey Wildlife Action Plan, BCR 30 Plan, the Service's Species of Conservation Concern 2008, North Atlantic LCC Representative Species, NAWMP, and others (see Chapter 1.3)
- Status and trend information for potential species of concern as documented in regional and state assessments and reports
- Literature review and scientific publications
- Status and trend information from Refuge surveys and other research
- Meeting and review with Refuge partners

A list of habitats that contain naturally-occurring elements of BIDEH was developed from the above effort to determine those habitats that contain the most ecological and biological integrity (Table 3-1).

TABLE 3-1. SUMMARY OF THE BIDEH FOR E.B. FORSYTHE NWR			
Habitat (plant communities) that Represent Existing BIDEH	**Habitats and Potential Conservation Species**	**Natural Processes Responsible for These Conditions**	**Limiting Factors**
Beach/Dune	Beach/Dune communities span from just above mean high tide to back dunes beyond the influence of most storm tides. Community complexity and cover increase further and higher from the shoreline. Plant communities include: Beach Strand, Overwash Dune Grassland, Mid-Atlantic Coast Backdune Grassland, Northern Beachgrass Dune, Central Coast Beach Heather Dune Shrubland, and Northern Bayberry Dune Shrubland (NatureServe 2009). ***Potential Conservation Species:*** *American oystercatcher, black skimmer, common tern, least tern, marbled godwit, piping plover, red knot, royal tern, ruddy turnstone, sanderling, semipalmated sandpiper, seabeach amaranth, northeastern beach tiger beetle, and monarch butterfly.*	Tidal currents, shifting sand transport by water and wind, salt spray, low substrate moisture, salt water, summer heat, storm events, and periodic tidal overwash.	Climate change, sea level rise, subsidence, shoreline stabilization (jetties, shoreline hardening, etc.), recreation, mammalian/avian predation, coastal storms, and invasive species.
Salt Marsh	Salt Marsh is an estuarine, intertidal, emergent marsh within lagoon systems behind barrier islands and along the shorelines of major bays and estuaries extending to the lower reaches of major tributaries. Ultimately gives way to brackish and tidal fresh wetlands within lower salinity waters. Plant communities include: Salt Scrub Shrub, Eastern Tidal Salt Shrub, Reed Tidal Marsh, Transitional Tidal Marsh, Brackish Meadow, North Atlantic Low Salt Marsh, North Atlantic High Salt Marsh, Salt Panne, Salt Panne Pool, North Atlantic Coastal Estuarine Intertidal Mudflats, Northern Tall Maritime Shrub, and Maritime Red-cedar Woodland (NatureServe 2009). ***Potential Conservation Species:*** *American black duck,*	Elevation, diurnal tides, regular and irregular tidal inundation, flooding, sediment deposition, and storm events.	Climate change, sea level rise, subsidence, marsh dieback, urban and industrial development, eutrophication, mosquito ditching, haying, dredge and fill, pollution, and invasive species.

	American bittern, American oystercatcher, bald eagle, black-crowned night-heron, black rail, black skimmer, brant, bufflehead, canvasback, clapper rail, common tern, dunlin, least bittern, least tern, marsh wren, northern harrier, saltmarsh sparrow, seaside sparrow, sedge wren, semipalmated sandpiper, snowy egret, tricolored heron, whimbrel, white-rumped sandpiper, willet, yellow-crowned night-heron, river otter, diamond-backed terrapin, and monarch butterfly.		
Permanently Flooded Freshwater Wetland	Diverse freshwater wetlands occurring in both tidal and non-tidal areas. Tidal freshwater wetlands are located directly inland of salt marshes in areas where water movement is influenced by tidal fluctuations. Plant communities include: Eastern Reed Grass, Lily Pond, Eastern Cattail Marsh, Northern Peatland Sedge Coastal Plain Marsh, Blueberry Wetland Thicket, Swamp Loosestrife Shrub Swamp, Pine Barrens Bog, Sea Level Fen, Pine Barrens Riverside Shrub Savanna, and Pine Barrens Riverside Bog Asphodel Savanna (NatureServe 2009). ***Potential Conservation Species:*** *American bittern, American black duck, bald eagle, black-crowned night-heron, green heron, glossy ibis, king rail, least bittern, little blue heron, marsh wren, sedge wren, sora, wood duck, river otter, eastern painted turtle, eastern tiger salamander, spotted turtle, southern leopard frog, and bronze copper.*	Elevation, water table, seasonal flooding, ground water discharge, silt deposition, beaver, and old channel oxbows.	Drainage and filling, eutrophication, sedimentation, altered chemical and hydrologic alteration, impoundment/dike construction, invasive species, salt water intrusion, sea level rise, and recreational activities.
Wetland Forest	Closed canopy forested wetland communities dominated by deciduous tree species. Plant communities include: Coastal Plain Atlantic White Cedar-Red Maple Swamp, Atlantic White Cedar Swamp, Atlantic White Cedar Bog, Southern Red Maple-Blackgum Swamp, Red Maple-Sweetgum Swamp, Lowland Pitch Pine Forest, and Red Maple Sedge Swamp (NatureServe 2009). ***Potential Conservation Species:*** *black-and-white warbler, eastern whip-poor-will, Kentucky warbler, Louisiana*	Windthrow, ice storms, beaver, tree senescence, insect outbreaks, pathogens. Groundwater seepage in sandy soils, seasonal flooding, or perched water table. Variable hydrologic regimes from saturated	Logging, conversion to agriculture and urban development, drainage and filling, deer browsing, fragmentation,

	waterthrush, mallard, northern flicker, red-shouldered hawk, rusty blackbird, wood duck, wood frog, wood thrush, worm-eating warbler, yellow-throated vireo, eastern red bat, hoary bat, silver-haired bat, marbled salamander, wood frog, Hessel's hairstreak, and swamp pink.	throughout growing season to dry by midseason. Atlantic white cedar occurs in basins overlying sand and gravel deposits with saturated peat over mineral sediments with standing water present for at least half the growing season, and with nutrient-poor soils, especially low in nitrogen and phosphorus, and high in iron.	invasive species, altered chemical and hydrologic regimes, impoundment/dike construction, salt water intrusion, and sea level rise.
Upland Forest	Upland Forest includes mixed hardwood species dominated by oak. Plant communities include: Scarlet Oak-Pitch Pine Forest, Mixed Oak-Pine/Pine-Mixed Oak, Mixed Oak-Pine/Holly Forest, Pitch Pine-Oak Forest, Mesic Mixed Oak Forest, Southern Red Oak/Heath Forest, Northeastern Coastal Oak-Heath Forest, and Coastal Oak Laurel Forest (NatureServe 2009 ***Potential Conservation Species:*** *brown thrasher, chimney swift, eastern whip-poor-will, eastern wood-pewee, Kentucky warbler, northern flicker, ovenbird, rusty blackbird, scarlet tanager, wood thrush, worm-eating warbler, yellow-throated vireo, hoary bat, little brown bat, silver-haired bat, northern pine snake, and eastern box turtle.*	Elevation, windthrow, ice storms, variable fire frequency in some communities, tree senescence, insect outbreaks, pathogens, droughty soils to moist and well-drained sites.	Logging, conversion to agriculture and urban development, fire suppression, deer browsing, fragmentation, and invasive species.
Pitch-Pine Barrens Forest	Pine Barrens dominated by pitch pine with very low cover of deciduous trees. Plant communities include: New Jersey Pitch Pine/Scrub Oak Barrens, Coastal Plain Mesic Pine Barrens, and Pitch Pine/Pennsylvania Sedge Woodland (NatureServe 2009). ***Potential Conservation Species:*** *brown thrasher, eastern kingbird, eastern towhee, eastern whip-poor-will, northern bobwhite, prairie warbler, wood thrush, corn snake, northern*	Fire and soil dependent and well-drained to xeric sands.	Logging, conversion to agriculture and urban development, fire suppression, deer browsing,

	pine snake, and pine barrens tree frog.		fragmentation, and invasive species.
Early Successional Habitat	Transitional habitats dominated by shrub and small trees persisting up to 20 years depending on site potential with variable species composition representing the particular site. This habitat probably occurred in a patchy distribution reflecting natural disturbances and aboriginal use of fire prior to European times. Plant communities include: Old Field Eastern Red Cedar Forest, Northeastern Modified Successional Forest, Northeastern Successional Shrubland, Successional Heath Shrubland, and Northeastern Old Field (NatureServe 2009). ***Potential Conservation Species:*** *American woodcock, blue-winged warbler, brown thrasher, eastern kingbird, eastern meadowlark, eastern towhee, eastern whip-poor-will, field sparrow, northern bobwhite, northern harrier, prairie warbler, short-eared owl, white-eyed vireo, willow flycatcher, checkered white, and monarch butterfly.*	Windthrow, ice storms, fire, beaver, tree, senescence, insect outbreaks, pathogens, and forest edge.	Conversion to agriculture and urban development, deer browsing, and invasive species.
Managed Wetland Impoundments	Common impoundment species include: dwarf spike rush (*Eleocharis parvula*), smartweed (*Polygonum* spp.), fleabane (*Pluchea odorata*), swamp rose mallow (*Hibiscus moscheutos*), American three-square (*Scirpus americanus*), umbrella-grass (*Fuirena pumila*), *Bacopa monnieri*, inland saltgrass (*Distichlis spicata*), beggartick (*Bidens* spp.), cattail (*Typha* spp.), and eastern baccharis (*Baccharis halimifolia*) ***Potential Conservation Species:*** *American black duck, brant, black-bellied plover, Canada goose, dunlin, greater yellowlegs, green-winged teal, northern pintail, snow goose, semipalmated plover, semipalmated sandpiper, short-billed dowitcher, and monarch butterfly.*	Freshwater inflows, tidal currents, salt water, summer heat, storm events. Naturally would occur on flats having small depressions where rainwater/tidal overwash and/or high groundwater table create brackish wetlands inhabited by plants with limited salt tolerance.	Climate change, sea level rise, subsidence, recreation, mammalian/avian predation, coastal storms, and invasive species, water management capabilities, high maintenance and management needs

3.3 PRIORITY RESOURCES OF CONCERN

The Priority Resources of Concern listed Table 3-2 contains federal or state endangered or threatened species and priority species identified in various regional landscape level plans. Species were prioritized by considering the vegetative communities, the species using those habitats in the landscape, and how the Refuge can make the greatest contribution to state/regional/national priorities. To guide this process, the following concepts were considered:

- Indicator species can be used as a representative of BIDEH. Indicator species presence, absence, abundance, or relative well-being in a given habitat niche serves as a marker of overall health of its required habitat type.
- The BCR 30 plan ranks and prioritizes all birds and their habitats relative to their conservation concern and priority of needs.
- The PIF Mid-Atlantic Coastal Plain Bird Conservation Plan (Physiographic Area 44) ranks and prioritizes land birds and habitats of management and conservation concern.
- The North Atlantic LCC identifies representative species.
- Refuge habitat conditions may limit the capability or practicality of support or management for some potential species of concern. Site-specific factors evaluated are:
    - Patch size
    - Habitat connectivity
    - Incompatibility or conflict with surrounding land uses
    - Specific life history needs
    - Use of natural processes to maintain habitat conditions within a natural range of variability suitable to the representative species
    - Use of adaptive management (flexibility and responsiveness) to changing environmental conditions (e.g., climate change)
- The likelihood that a potential species of concern would have a positive reaction to management strategies.
- The ability of natural processes to maintain suitable habitat conditions within a natural range of variability.
- The ability to use adaptive management (flexibility and responsiveness of the Refuge and habitats) in the face of changing environmental conditions (e.g., climate change).

TABLE 3-2. PRIORITY RESOURCES OF CONCERN FOR E.B. FORSYTHE NWR			
Habitat	Class	Species	Season Used By Species
Beach/Dune	birds	American oystercatcher	Y
		black skimmer	M, B
		common tern	M, B
		least tern	M, B
		migrating shorebirds	M
		piping plover	M, B
		red knot	M, W
		sanderling	M, W
		willet	M, B
	invertebrates	monarch butterfly	M
	reptiles	northern diamondback terrapin	Y
	plants	seabeach amaranth	Y
Salt Marsh	birds	American bittern	M, B
		American black duck	Y
		American oystercatcher	Y
		bald eagle	Y
		black skimmer	M, B
		brant	M, W
		bufflehead	M, W
		canvasback	M, W
		clapper rail	Y
		common tern	M, B
		least tern	M, B
		marsh wren	Y
		migrating and wintering waterfowl	M, W
		northern harrier	Y
		saltmarsh sparrow	Y
		semipalmated sandpiper	M
		short-billed dowitcher	M, W
		snowy egret	M, B
		whimbrel	M
		willet	M, B
	invertebrates	monarch butterfly	M, B
	reptiles	northern diamondback terrapin	Y

Permanently Flooded Freshwater Wetland	birds	American bittern	M, B
		American black duck	Y
		bald eagle	Y
		black-crowned night-heron	Y
		green heron	M, B
		king rail	M, B
		least bittern	M, B
		marsh wren	Y
		migrating landbirds	M
		sedge wren	M
		wood duck	M, B
	invertebrates	bronze copper	Y
	reptiles	eastern painted turtle	Y
	amphibians	southern gray treefrog	Y
Wetland Forest	birds	bald eagle	Y
		black-and-white warbler	M, B
		eastern whip-poor-will	M, B
		Kentucky warbler	M ,B
		migrating landbirds	M
		red-shouldered hawk	M
		wood duck	M, B
		wood thrush	M, B
		worm-eating warbler	M, B
	mammals	eastern red bat	M
		hoary bat	M
		silver-haired bat	M
	amphibians	marbled salamander	Y
		wood frog	Y
	invertebrates	Hessel's hairstreak	Y
	plants	swamp pink	Y
Upland Forest	birds	bald eagle	Y
		black-and-white warbler	M, B
		brown thrasher	M, B
		eastern whip-poor-will	M, B
		eastern wood-pewee	M, B
		Kentucky warbler	M, B
		migrating landbirds	M
		ovenbird	M, B
		wood thrush	M, B
		worm-eating warbler	M, B

		yellow throated vireo	M
	mammals	hoary bat	M
		little brown bat	M
		silver haired bat	M
	reptiles	eastern box turtle	Y
		northern pine snake	Y
	amphibians	wood frog	Y
Pitch Pine Barrens	birds	black-and-white warbler	M, B
		brown thrasher	M, B
		eastern towhee	M, B
		eastern whip-poor-will	M, B
		northern bobwhite	Y
		prairie warbler	M, B
		wood thrush	M, B
	reptiles	corn snake	Y
		northern pine snake	Y
	amphibians	pine barrens tree frog	Y
Early Successional Habitat	birds	American woodcock	Y
		brown thrasher	Y
		eastern meadowlark	M, B
		eastern towhee	Y
		eastern whip-poor-will	M, B
		migrating landbirds	M
		northern bobwhite	Y
		northern harrier	Y
		prairie warbler	M, B
	invertebrates	checkered white	Y
		monarch butterfly	M
Managed Wetland Impoundments	birds	American black duck	Y
		black-crowned night-heron	Y
		colonial waterbirds (tricolored and little blue heron, glossy ibis, snowy egret)	M, B
		least bittern	M,B
		migrating and wintering waterfowl	M, W
		migrating shorebirds	M

B=Breeding season, M= Migration season; W=Wintering season, Y=Year round

3.4 REPRESENTATIVE SPECIES

Representative species represent groups that are closely associated with important habitat attributes and are selected to represent the needs of a group of species that use the same habitat and respond to management similarly. The Potential Resources of Concern Table (Appendix C) contains a large number of species with a broad array of habitat needs. Prioritizing those species and their habitats is necessary to determine where to focus Refuge management strategies, where Refuge species and habitats can make the greatest contribution to the System, its surrounding landscape, and state/regional/national priorities, and where the Refuge may use its resources with the greatest efficacy. Using representative species simplifies the development of goals, objectives, and strategies while at the same time addressing important components of functional, healthy ecosystems (USFWS 2008a). Achieving Refuge purposes and managing for trust resources, as well as BIDEH, can be addressed through the habitat requirements of representative species or species that may represent guilds that are associated with important attributes or conditions within habitat types (Table 3-3).

Achieving Refuge purposes and managing for trust resources as well as BIDEH can be addressed through the habitat requirements of "representative species" or species that may represent guilds that are highly associated with important attributes or conditions within habitat types. Landscape conservation plans, like the North Atlantic LCC, BCR Plans (BCR 30), PIF Plans, New Jersey Wildlife Action Plan, and others (see Chapter 1.3) have been very effective at ranking and prioritizing migratory birds and other species of conservation need and focus.

TABLE 3-3. REPRESENTATIVE SPECIES, ASSOCIATED HABITAT REQUIREMENTS, AND OTHER BENEFITTING SPECIES – E.B. FORSYTHE NWR

Representative Species	Habitat Type	Habitat Structure and Life History Requirements	Other Benefiting Species
American Oystercatcher	Beach/Dune (1,574 acres)	Habitat includes sand or shell beaches, dunes, and salt marsh. Nesting habitat includes upland dune, higher sandy areas, part of a primary or secondary dune system, above mean high water and beach, flat open sand areas with little or no vegetation, and small residual dunes in periodically flooded areas. Typically feeds in intertidal mud or sand flats, or on shellfish beds; roosts on adjacent beaches, dunes, or marsh islands (Nol and Humphrey 1994). Utilizes Refuge habitats for breeding, migration, and wintering.	Other benefiting species include: black-bellied plover, black-skimmer, common tern, dunlin, Forster's tern, least tern, marbled godwit, red knot, ruddy turnstone, sanderling, semipalmated sandpiper, willet, northern diamondback terrapin, and northeastern beach tiger beetle
Migrating Shorebirds		Undisturbed beach habitats provide feeding and resting sites for shorebirds to replenish their fat reserves and meet energetic demands of migration. Feed in the wrack line in the morning on low to rising tides (Burger et al. 1979a). Will utilize the nearby habitat mosaic that provides shallow water and/or mud flat habitats with sparse vegetation, undisturbed roosting areas, and abundant invertebrate food resources.	
Piping Plover		Nests on sparsely vegetated open sand, gravel, or cobble beaches, frequently adjacent to sand dunes. Areas with access to ephemeral pools, salt-pond, or bay habitat preferred and may result in increased fledging success for beach nesting birds (Loegering and Fraser 1995). Utilizes Refuge habitats for breeding and migration.	
Seabeach Amaranth		Found on overwash flats at accreting ends of coastal islands, lower foredunes, and upper strands of non-eroding beaches, landward of the wrack line (USFWS 1996). Utilizes Refuge habitat year-around.	
American Black Duck	Salt Marsh (33,358 acres)	Utilizes salt, brackish, and freshwater marshes. Breeds in salt marshes, coastal islands and meadows, brackish and freshwater impoundments, and riverine marshes. Nest sites are very diverse; uses salt marsh, islands, wooded swamps, and marshes. Forages in salt marsh, mudflats, impoundments, as well as shallow margins of lakes, streams, bays, and open waters (Frazer et al. 1990). Utilizes Refuge habitats for breeding, migration, and wintering.	Other benefiting species include: American bittern, bald eagle, black-crowned night-heron, black rail, black skimmer, bufflehead, canvasback, common tern, dunlin, Forster's tern, glossy ibis, greater scaup, greater and lesser yellowlegs, least sandpiper, least tern, marbled godwit, marsh wren, monarch
American Oystercatcher		Uses salt marsh islands, surrounded by intertidal marsh or mud flats, with a sand, tide wrack substrate and dredge spoil areas, usually flat and nearly level elevated areas of various substrates. Typically feeds in intertidal mud or sand flats, or on shellfish beds; roosts on adjacent beaches, dunes, or marsh islands (Nol and Humphrey 1994). Utilizes Refuge habitats for breeding and migration.	
Brant		Overwinter on mudflats and in shallow waters sheltered coastal bays and estuaries behind barrier beaches, with extensive cordgrass marshes in upper intertidal area and eelgrass and sea-lettuce (*Ulva lactuca*) beds near the lower reaches (Reed et al. 1998). Utilizes Refuge habitats for migration and wintering.	

Clapper Rail		Breeding habitats in New Jersey are natural and ditched short-form salt marsh cordgrass (most preferred), tall-form salt marsh cordgrass, and salt meadow cordgrass (least preferred) (Mangold 1974). Presumably uses similar salt and brackish marshes during migration (Eddleman 1998). Utilizes Refuge habitats for breeding and migration.	butterfly, short-billed dowitcher, tricolored heron, white-rumped sandpiper, whimbrel, and yellow-crowned night-heron.
Northern Harrier		Use of marshes and open fields in fall migration in Cape May suggests that fall habitat selection is similar to summer and winter habitats (Niles et al. 1996). Forages over open habitats. Habitat use frequency appears related to a combination of prey biomass and vegetative cover. Hunts low <15 feet over ground (Smith et al.2011). Utilizes Refuge habitats for breeding, migration, and wintering.	
Saltmarsh Sparrow		Breeding is restricted to salt marsh edges along the Atlantic Coast. Nests typically placed within grass column with sides supported by vegetation. Bottom of nest usually elevated a few centimeters above substrate or water in salt marshes. Breeding success limited by storms and spring tides, which often flood nests (Greenlaw and Rising 1994). Utilizes Refuge habitats for breeding and migration.	
Semipalmated Sandpiper		Feeds along water's edge in water less than 1.2 inches deep (Wilds 2007). Feeds by pecking and probing for macroinvertebrates or "slurping" biofilm. Utilizes Refuge habitats for migration.	
Snowy Egret		In New Jersey usually breeds in mixed species rookeries in shrubs and trees. Uses shallow estuarine sites for feeding including salt-marsh pools, tidal channels, and shallow bays (Parsons and Master 2000). Utilizes Refuge habitats for breeding and migration.	
Willet		In Mid-Atlantic states, found in salt marsh habitat mosaic of shallow puddles and salt pannes with cordgrass, rarely found in freshwater habitats during breeding season (Lowther et al. 2001). Utilizes Refuge habitats for breeding and migration.	
Northern Diamondback Terrapin		Only estuarine turtle found in coastal, brackish marshes and their tributaries, bays, inlets, and tidal portions of coastal rivers. Shallow tidal creeks and tidal mudflats are the most important feeding areas. Feed primarily on marine invertebrates, such as fish, crustaceans, bivalves, and worms (Sierra and Burke 2007). Along saltmarsh creeks on Cape May Peninsula in southern New Jersey, Yearicks et al. (1981) found adults hibernating below the surface in banks and shallow depressions along creek bottoms. Utilizes Refuge habitats year-round.	
Green Heron	Permanently Flooded Freshwater Wetland (1,368 acres)	Thick vegetation along creeks and wetlands for feeding and trees (32.5 to 65 feet) or bushes on islands usually on or over water for nesting (ground level to 65 feet). Utilizes Refuge habitats for breeding and migration.	Other benefiting species include: American black duck, American bittern, bald eagle, black-crowned night-heron, dunlin, Forster's tern, glossy ibis, gull-billed tern, king rail, least bittern, least tern, little blue heron, sedge
Marsh Wren		Marsh wrens use a diversity of vegetation to support their nests including cattail, bulrush, and *Phragmites*. Utilizes tall marsh grasses; prefers high grass (>6.5 ft.) in narrow strips along tidal creeks and rivers and moderately high grass (3-5 ft.) in adjacent marsh (Kroodsma and Verner 1997). Utilizes Refuge habitats for breeding and migration.	

Eastern Painted Turtle		Occur in aquatic habitats with permanent water, aquatic vegetation, soft substrate, and basking sites. Hibernation occurs in water under logs and stumps, and in muskrat and beaver lodges. Occasionally found on land during dispersal or nesting (Mitchell 1994, Wilson 1995). In fragmented habitats considerable annual mortality may result from vehicular traffic (Mitchell 1994). Utilizes Refuge habitats year-around.	wren, sora, wood duck, Wilson's phalarope, northern gray treefrog, eastern spadefoot toad, southern gray treefrog, and bronze copper.
Red-shouldered Hawk	Wetland Forest (10,842 acres)	Requires large areas of contiguous forest (Dykstra et al.2008). Extensive bottomland hardwood, riparian areas, and flooded deciduous forest stands of mature to old-growth canopy trees with variable amounts of understory with a generally open subcanopy (Dykstra et al.2008). Utilizes Refuge habitats for breeding and migration.	Other benefiting species include: bay-breasted warbler, black-and-white warbler, brown thrasher, chimney swift, eastern whip-poor-will, Kentucky warbler, mallard, northern waterthrush, prairie warbler, scarlet tanager, wood duck, worm-eating warbler, yellow-throated vireo, eastern red bat, hoary bat, silver-haired bat, eastern spade-foot toad, Fowler's toad, eastern tiger salamander, marbled salamander, and Hessel's hairstreak.
Wood Thrush		Utilizes interior and edges of deciduous and mixed forests, especially well-developed, upland, and mesic sites. Key elements include: trees >52 feet height, high variety deciduous tree species, moderate subcanopy and shrub density, shade, fairly open forest floor, moist soil, and decaying leaf litter. Area sensitive and seems to favor forests greater than 250 acres with few roads and bordered by narrow unpaved roads or power line corridors rather than paved roads (Robbins et al.1989, Rich et al.1994). Poorly documented in fall, probably uses second-growth and forest-edge habitats with fruit (Evans et al. 2011). Utilizes Refuge habitats for breeding and migration.	
Migrating Landbirds		Utilize closed canopy forested wetland communities dominated by tree species including red maple, Atlantic white cedar, sweetgum, and pine. Other trees and shrubs include American holly, magnolia, sassafras, huckleberries, rhododendron, swamp doghobble, and pepperbush with a variable herbaceous layer. Fruit producing shrubs and trees, such as American holly and cherry, provide high energy fruit for migrating foraging birds. Utilizes Refuge habitats for migration.	
Wood Frog		Wood frogs are typically found in or near moist woods and breed in shallow ponds or pools. Pond hydroperiod must be at least 85 days to ensure adequate time for complete metamorphosis (Bagdonas and Pettus 1976, Haynes and Aird 1981). Favor wooded swamps and bogs (preferably closed canopy) with emergent vegetation, still water and shallow, sloping shorelines with moist grassy meadows, willow bogs, or forests with moderate to thick leaf litter within 325 feet of the shoreline (Muths et al.2005). Utilizes Refuge habitats year-round.	
Swamp Pink		Over half of the known populations are found in New Jersey. Is an obligate wetland species that occurs in forested wetlands, including those bordering meandering streamlets, headwater wetlands, sphagnous Atlantic white cedar swamps, and spring seepage areas. Occurrence is limited to perennially saturated areas with the water table near or at the surface, fluctuating slightly during spring and summer months (USFWS 1991). Is a shade-tolerant plant and has been found in wetlands with canopy closure varying between 20-100 percent. Observations at Atlantic white cedar dominated sites indicate that it is associated with emergent portions of in-stream and stream bank hummocks under a relatively open tree canopy (Laidig and Zampella 2009). Primary threats are the indirect effects of off-site activities and developments that	

		change groundwater and surface water hydrology.	
Eastern wood-pewee	Upland Forest (4,893 acres)	Breeds in wooded communities, including both deciduous and coniferous forest. Usually associated with forest clearings and edges (McCarty 1996). In eastern deciduous forest habitats, found in more open sites with low-density canopy cover. Absent in areas of closed canopy (Hespenheide 1971). Size of forest fragments does not appear to be an important factor in habitat selection (Robbins et al. 1989). Uses edge and suburban habitats, including a variety of habitats with trees and shrubs, edge, early successional clearings, and primary and secondary forest for migration. Forestry practices that maintain large tracts of intermediate aged forest with closed canopy and limited clear cuts (≤25acres), along with thinning to remove mature trees and woody growth <3 inches in diameter at breast height, should provide adequate habitat (Stauffer and Best 1980) Impacts of white-tailed deer deserve further attention (deCalesta 1994).	Other benefiting species include: bay-breasted warbler, brown thrasher, chimney swift, Kentucky warbler, northern waterthrush, prairie warbler, rusty blackbird, scarlet tanager, worm-eating warbler, yellow-throated vireo, hoary bat, silver haired bat, eastern spade-foot toad, northern gray treefrog, eastern tiger salamander, and wood frog.
Eastern Whip-poor-will		Utilize dry deciduous or mixed forests with little or no underbrush. Openness in forest understory appears more important than composition (Wilson 1985). Absent from areas of extensive closed forest canopy. Little migration habitat information available; probably occurs in same forests used for breeding (Cink 2002). Nests and young broods inhabit young to mid-age forest interspersed with openings; older broods found where tree basal area greater with a sparser mature tree composition. Absent from areas of extensive closed forest canopy. Utilizes Refuge habitats for breeding and migration.	
Ovenbird		Utilize mature, large, contiguous tracts of deciduous or mixed deciduous/coniferous closed-canopy forest with heights of 52–72 feet and canopy closure from 60 - 90 percent in contiguous blocks of 250 to 2,200 acres for breeding (Porneluzi 2011). Utilizes Refuge habitats for breeding and migration.	
Migrating Landbirds		Utilize mixed hardwood forest species dominated by various oak trees and shrubs, including huckleberries, or a mix of oak trees, pine trees, and shrubs, including huckleberries. Fruit producing shrubs and trees, such as American holly and cherry, provide high energy fruit for migrating foraging birds. Utilize Refuge habitats for migration.	
Eastern Box Turtle		Found in open canopied woodlands and meadows with areas of dense ground cover. Utilizes Refuge habitats year-round.	
Northern Pine Snake		Found in well-drained and pliable sandy soils in upland pine and pine-oak forests with open areas of loose sandy soil and little vegetation (NJDEP 2009). Nest burrows are in large clearings with less than 10% tree cover (Zappalorti et al.1983). Threats are population fragmentation through habitat loss and fragmentation, road mortality, limited dispersal, and fire suppression (NJDEP 2009). Utilizes Refuge habitats year-round.	
Eastern Towhee	Pitch Pine Barrens (1.368 acres)	Edge-associated generalist occupying habitats characterized by dense shrub–small tree cover near ground and well-developed litter. Dense, low cover may be interspersed with patches of more open ground. Overstory trees may or may not be present, and if present, open-canopy (woodland) situations are favored (Greenlaw 1996). Utilizes Refuge habitats for breeding and	Other benefiting species include: black-and-white warbler, brown thrasher, Kentucky

		migration.	warbler, northern flicker, scarlet tanager, wood thrush, worm-eating warbler, yellow-throated vireo
Eastern Whip-poor-will		Utilize dry deciduous or mixed forests with little or no underbrush. Openness in forest understory appears more important than composition (Wilson 1985). Absent from areas of extensive closed forest canopy. Little migration habitat information available; probably occurs in same forests used for breeding (Cink 2002). Nests and young broods inhabit young to mid-age forest interspersed with openings; older broods found where tree basal area greater with a sparser mature tree composition. Absent from areas of extensive closed forest canopy. Utilizes Refuge habitats for breeding and migration.	
Migrating Landbirds		Utilize pitch pine forests with mixed hardwood forest species dominated by various oak trees and shrubs, including huckleberries, or a mix of oak trees, pine trees, and shrubs, including huckleberries. Fruit producing shrubs and trees, like American holly and cherry, provide high energy fruit for migrating foraging birds. Utilize Refuge habitats for migration.	
Northern Bobwhite		In forest habitats, the best opportunities for management exist in well-drained upland pine and mixed pine-hardwood stands. Maintaining tree canopy cover at <50% to create open, park-like conditions is essential. Fifty to 75 % of understory vegetation should be burned annually during late winter to early summer in small, patchy mosaics (Brennan 1999). Utilizes Refuge habitats year-round.	
Prairie Warbler		Nest in areas of mixed pine-oak forest, especially where tall pines and or shrub undergrowth are found (Foreman 1979) and maintained by fire (Nolan et al.1999). Utilizes Refuge habitats for breeding and migration.	
Northern Pine Snake		Found in well-drained and pliable sandy soils in upland pine and pine-oak forests with open areas of loose sandy soil and little vegetation (NJDEP 2009). Nest burrows are in large clearings with less than 10% tree cover (Zappalorti et al.1983). Threats are population fragmentation through habitat loss and fragmentation, road mortality, limited dispersal, and fire suppression (NJDEP 2009). Utilizes Refuge habitats year-round.	
Pine Barrens Tree Frog		Acidic habitats, carpeted with dense mats of sphagnum moss are required. Breeding ponds are typically isolated, shallow, dilute, and acidic (pH 3.74 - 4.69). Structural characteristics include an open canopy, a dense shrub layer, and heavy ground cover. Soil types include sands and muck. Utilize temporary, early successional pond-like habitats dominated by shrub and herbaceous vegetation (Bunnell 2011). Utilizes Refuge habitats year-round.	
American Woodcock	Early Successional (832 acres)	Habitat change across American woodcock range is the suspected cause of region-wide declines in abundance. Habitat quality and probably quality is decreasing as the rate of change of farm land into young growth forests slows (Dobell 1977). Requires young forest and with forest openings to provide display areas. Adjacent young hardwoods and mixed woods with shrubs provide moist ground for daytime feeding. Overstory canopy cover 53–64 percent in diurnal sites may vary daily and seasonally. Shrub canopy cover generally high (75–8 7 percent). Nests and young broods inhabit young to mid-age forest interspersed with openings	Other benefiting species include: American kestrel, blue grosbeak, blue-winged warbler, eastern towhee, gray catbird, eastern kingbird, golden-

		1-10 acres in size; older broods found where tree basal area is greater with a sparser mature tree composition. Loss of even-aged forest management (low variation tree age structure, often initiated by large scale natural disturbances (fire, insects or clearcut harvesting) may discriminate against this species (Keppie and Whiting 1994). Spring and autumn migration habitat similar: moist, young hardwoods with shrubs. Utilizes Refuge habitats for breeding and migration.	winged warbler, great crested flycatcher, indigo bunting, northern harrier, prairie warbler, short eared owl, white-eyed vireo, eastern whip-poor-will, willow flycatcher, eastern spade-foot toad, and Fowler's toad.
Brown Thrasher		Uses a wide variety of habitats and reaches highest densities in shrub or mid-successional stages of forests. Habitat suitability index model variables: suitability peaked when density of woody stems ≥39 inches tall was 4,000–12,000/acre, percentage of canopy cover of trees was 10–30%, and percentage of ground surface covered by litter ≥0.4 in deep was >80% (Cavitt and Haas 2000). Not found breeding in New Jersey woodlots <2 acres in size and rare in woodlots of <10 acres (Foreman et al. 1976). Utilizes Refuge habitats for breeding and migration.	
Eastern Meadowlark		Favor habitats with good grass and litter cover. Ground nests are well concealed, often in a shallow depression and usually in fairly dense vegetation (Lanyon 1995). Utilizes Refuge habitats for breeding and migration.	
Northern Bobwhite		Requires an abundance of seed producing plants and green succulent vegetation for feeding adults as well as abundant insects for feeding young in a mosaic of small patches (1.25 to 6.25 acre) of early successional habitats (Brennan 1999). Utilizes Refuge habitats year-round.	
Wintering and Migrating Landbirds		Scattered shrubs and small trees less than 15 feet are used for security, roosting, and feeding. Fruit-producing shrubs and trees, such as American holly and cherry, provide high energy fruit for migrating foraging birds. Migrating bird abundance is highest in this habitat in New Jersey (McCann et al. 1993). Utilizes Refuge habitats for migration.	
American Black Duck	Managed Wetland Impoundments (1,736 acres)	Managed wetland impoundments are used for foraging, loafing, thermal cover, and protection from anthropogenic disturbances. Utilizes Refuge impoundment habitats for breeding, migration, and wintering.	Other benefiting species include: black-crowned night-heron, glossy ibis, least bittern, and little blue heron.
Northern Pintail		Managed wetland impoundments provide shallow flooded (<12" water depth) areas and seed-producing moist soil vegetation that provides important habitat for feeding, loafing, thermal cover and protection from anthropogenic disturbances. Utilizes Refuge impoundments for migration and wintering.	
Migrating Shorebirds		Managed wetland habitats provide a mix of shallow water (<4 inches water depth) and mudflat habitat with sparse to no vegetation (<15% cover) at the time of peak migration (late May and late August) to provide arthropods, amphipods, and insects. Utilizes Refuge impoundments for migration and wintering.	
Snowy Egret		Forages in shallow (<8 in) pools along the water edge where foot-stirring, striking, and captures were most prevalent; larger pools (>2.5 acres) visited more frequently than small ones (Parsons and Master 2000). Utilizes Refuge impoundments habitats during the breeding season and for migration.	

3.5 CONFLICTING HABITAT NEEDS

Given the diversity of goals, purposes, mandates, past management priorities, and conservation priorities for the Refuge System, conflicting management priorities may exist at the Refuge. Conflicting habitat or management decisions will require a conflict resolution process, such as Structured Decision Making. Potential conflicts include:

Impoundment Management

Refuge impoundments alter natural processes and habitats to provide high-productivity managed wetlands that are used extensively by wildlife and for wildlife viewing by the public. Climate change and sea level rise will present management and maintenance challenges in the future. Management and maintenance will likely become more difficult and expensive. Conversely, the value of managed impoundments may increase as salt marsh is negatively impacted by sea level rise. Decisions concerning the future of impoundments will be challenging and will have direct impacts on wildlife and visitors. Refuge managers and staff will work with their partners and the public to determine future actions concerning impoundment management. Refuge managers and staff will utilize the Region 5 Coastal Impoundment Structured Decision Making process for impoundment management.

Forest Habitat Management

A variety of species utilize forest habitat and the different successional stages that may occur from fire, storm events, or management actions. Different forest age classes provide habitat for various wildlife species and will require tradeoffs between species as management actions are implemented. The reduction of forest fuels along the wildland urban interface (WUI) to protect adjacent properties has the potential to compromise Refuge objectives.

Prescribed burning, cutting, or thinning to maintain early successional forest habitats must consider undesirable effects of forest fragmentation or risk to adjoining properties. Forest management, which includes providing early successional habitats, will require a careful balance to achieve wildlife objectives, to provide healthy forests, and to manage the WUI.

Mosquito Management

Several species of mosquitoes found in coastal New Jersey are important vectors of potentially lethal diseases, including Eastern Equine Encephalitis and West Nile Virus. Refuge staff are striving to responsibly address risks to public health and safety and to protect trust resources from mosquito borne diseases as well as the impacts of pesticides and Open Marsh Water Management on wildlife and the ecosystem. Refuge staff, Regional staff and mosquito control agencies are working to develop new strategies for mosquito control with appropriate National Environmental Policy Act (NEPA) compliance. The public will have the opportunity to review and comment on the proposed strategies before they are implemented.

3.6 ADAPTIVE MANAGEMENT

Adaptive management is a deliberate, science-based process for decision making in the face of uncertainty. This approach treats management actions as experiments, and uses the outcomes of those experiments to inform and improve future actions. Adaptive management relies on an iterative cycle of monitoring, assessment, and decision making to clarify the relationships among management actions, habitat response, and wildlife use. Since it is based on a continual learning process, adaptive management improves long-term management outcomes.

Refuge managers and staff will use adaptive management to assess and to modify management strategies and prescriptions as necessary and to achieve habitat goals and objectives. The adaptive approach recognizes management performance can be optimized if management strategy effects can be predicted with certainty. Adaptive management provides a framework for making objective decisions in the face of uncertainty. Management faces four fundamental sources of uncertainty:

- Environmental variation/stochasticity – the temporal and spatial variation in weather conditions and other key features of wildlife habitat.
- Partial controllability – the outcome of and species response to habitat manipulation cannot be controlled or predicted with certainty due to natural variation, climate change, contaminants, invasive species, or other factors.
- Partial observability – the ability to estimate key attributes only within the precision afforded by existing monitoring programs.
- Structural uncertainty – an incomplete understanding of biological processes.

CHAPTER 4: HABITAT GOALS, OBJECTIVES, MANAGEMENT STRATEGIES AND PRESCRIPTIONS

Image: Forsythe personnel spraying invasive plants from airboat Photo by Don Freiday

4.1 Introduction
4.2 Goal 1: Coastal Habitat
4.3 Goal 2: Freshwater Wetland Habitat
4.4 Goal 3: Upland Habitat
4.5 Goal 4: Managed Wetland Impoundment Habitat

4.1 INTRODUCTION

The goals and objectives identified in this chapter were developed through collaboration among managers and biologists from the Refuge after examination of other conservation plans as described in Chapter 1 and consultation with federal, state, and local government agencies, conservation organizations, and individuals with knowledge of Refuge resources. The potential of this Refuge to contribute to ecosystem and landscape scale wildlife and biodiversity conservation goals was considered. The goals were generally consistent with the existing 2004 CCP, but were also written with an eye towards the next CCP revision. These goals and objectives will be re-evaluated during the CCP revision process with additional federal, state, local, university, and conservation organizations, and public involvement.

To develop habitat objectives, Refuge staff conducted a comprehensive analysis of habitat requirements for each priority resource of concern (Table 3-2). To facilitate management, all priority resources of concern were grouped into habitat types. Representative species, limiting factors and threats to each habitat type were determined (Table 3-3).

The Service requires habitat objectives be developed using the SMART criteria (objectives should be Specific, Measurable, Achievable, Result-oriented, and Time-fixed). Rationale is provided for each habitat objective to summarize scientific information, expert opinion, and professional judgment used to formulate each objective.

This chapter also outlines management strategies and prescriptions to address the habitat management goals and objectives. Management strategies identify the tools and techniques (e.g. mowing, burning, water level manipulation, etc.) utilized to achieve the habitat objectives. Prescriptions provide the details behind the specific means by which the strategies will be implemented (e.g. timing, frequency, duration, and location). After reviewing available literature the identified treatments were selected in consultation with other Refuge biologists, managers, and practitioners to ensure their effectiveness. Many environmental factors including wildlife population size and migration, as well as weather and habitat conditions, affect the selected prescriptions and the ability to achieve objectives from year to year. As such, many prescription details will be identified in future Annual Habitat Work Plans.

The natural world contains myriad complex and dynamic systems. This is especially true at the Refuge, which contains an array of different habitats that support thousands of plant and wildlife species in a relatively small area. It is important to acknowledge as land stewards and habitat managers that one can never fully understand each aspect of these continually changing systems. Despite the planning efforts undertaken within this HMP, there will undoubtedly be the need to address changes to physical, ecological, social, political, and financial factors that influence biodiversity and its conservation. For example, Hurricane Sandy changed the physical structure of some Refuge habitats. In addition, the resulting Debris Cleanup and Resilience funding changed what it will be possible for managers to accomplish and the Congressional, Public, and Partner expectations of Refuge management.

The work outlined within this HMP is intended to be feasible, yet extensive, given the available workload of Refuge staff, funding, and community support. As such, additional biological

technicians and other staff may help in achieving these management objectives. The prescriptions outlined here represent a comprehensive effort to guide management over the next 15 years. However, it is impossible to predict the full suite of management strategies and prescriptions required over this period. Some additional strategies may need to be added while others listed here may not be utilized. There are a number of management strategies and prescriptions common to all habitats.

Management Strategies and Prescriptions Common to All Objectives

Inventory and Monitoring Plan

Within two years, prepare an Inventory and Monitoring Plan to survey and develop quantitative goals for representative species. Conduct appropriate monitoring and survey programs, as funding and staffing permit, to measure success with respect to achieving objectives.

Invasive Species Management

Prevent new invasions of non-native species from becoming established by utilizing Early Detection Rapid Response (EDRR) that detects newly established invasive species and immediately addresses those populations through appropriate control measures. This strategy involves plant identification and inventory, maintaining updates of new invasive species present in the region, as well as knowing appropriate management techniques prior to conducting control efforts. It is desirable to work with neighboring landowners experiencing similar issues.

Participate in and adopt the region-wide Adaptive Management Project for invasive species so that treatments are monitored and evaluated for effectiveness. Refuge managers and staff will be using an integrated approach to *Phragmites* control, which will consider restoration of natural processes, herbicides, prescribed burning, biological control, and other as yet developed tools.

A number of invasive plants out-compete native species in disturbed sites. Whenever plant succession is set back to provide habitat for early successional species, particular attention will be paid to monitoring and controlling invasive plants at those sites.

Public Use

Ensure that Refuge lands are signed properly to guard against trespass (pedestrian and motorized) and resulting damage.

Continue patrols by Law Enforcement personnel and target problem areas.

Conduct education and outreach programs to educate pedestrians and those in motorized vehicle users about how to reduce their disturbance impact on birds. For example, teach visitors to walk around flocks of shorebirds and observe wildlife from a distance, or provide updated information to off-road vehicle (ORV) users on bird usage at Holgate.

Continue annual litter clean-up events with partners.

4.2 GOAL 1: COASTAL HABITAT

Maintain and restore, where possible, the biological integrity, diversity, and environmental health of Coastal Habitats to sustain native plants and wildlife, federal trust resources, and species of conservation concern.

Objective 1.1 Beach/Dune Habitat

Annually maintain and protect naturally occurring wilderness-designated Beach/Dune habitat on Holgate Beach and Little Beach Island to provide the following habitat attributes (Maslo et al. 2010) for American oystercatcher, migrating shorebirds, piping plover and seabeach amaranth:

- backshore vegetative cover of less than 10%
- primary dune vegetative cover of less than 13%
- shell/pebble cover of 17–18%
- dune height of less than or equal to 1.1 m
- dune slope of less than 13%
- less than five percent invasive species
- nearby (< 0.5 km) ephemeral pools, salt ponds, or bay habitat

For the Beach/Dune objective utilize the following metrics:

- Maintain an average piping plover productivity ≥ 1.2 fledged chicks per pair averaged over a 10-year period (U.S. Fish and Wildlife Service 2009). Reevaluate piping plover management strategies and prescriptions should the 10-year running average fledging rate drop below 1.0 chick per pair.
- Maintain an average of 10% nest success for American oystercatchers.
- Increase the number of seabeach amaranth plants, based on the 5-year average.
- Provide migration habitat for shorebird species (family Scolopacidae). Each year, maintain mean counts per survey that are greater than or equal to the threshold listed below (Table 4-1). If the mean count per survey falls below the threshold for three or more consecutive years, management review will be implemented.

TABLE 4-1. SHOREBIRD (SCOLOPACIDAE) COUNTS AS ESTIMATED BY THE INTERNATIONAL SHOREBIRD SURVEY (ISS) ON FORSYTHE NWR (HOLGATE AND LITTLE BEACH). HOLGATE DATA IS FROM 2005-2012 (SPRING) AND 2004-2012 (FALL), WHILE LITTLE BEACH DATA IS FROM 2009-2012 (SPRING) AND 2004, 2009-2012 (FALL). SEASONS ARE DEFINED AS: SPRING = APRIL – JUNE AND FALL = JULY – NOV.

Location (Season)	All years of available data		Threshold
	Mean count (±1 standard error) per survey	95% Confidence Interval	Lower Bound of 95% Confidence Interval
Holgate (Spring)	1,304 ± 169	972 – 1,636	972
Holgate (Fall)	1,297 ± 161	980 – 1,614	980
Little Beach (Spring)	1,841 ± 541	781 – 2,902	781
Little Beach (Fall)	1,155 ± 153	857 – 1,455	857

Rationale

The piping plover is a federally listed threatened species and a New Jersey endangered species. The least tern is a species of high conservation priority in BCR 30 and a New Jersey threatened species. The American oystercatcher is a species of highest conservation priority in BCR 30. Both the piping plover and least tern are LCC representative species. These species nest on Beach/Dune habitats on the Refuge and require similar habitat management actions.

Predation is a major limiting factor for piping plover (USFWS 1995) and other Beach/Dune habitat nesting species. Primary predators include red fox, skunk, raccoon, crows, gulls, grackles, and feral cats. Increases in red foxes and raccoons on Virginia barrier islands from 1977 to 1998 resulted in declines in numbers and colonies of five species of terns (Erwin et al. 2001).

Landscape-wide habitat loss from urban development, public beach use during nesting periods, ORV travel, shoreline stabilization, and dune modification along barrier islands and beaches has significantly reduced shorebird habitats along the Atlantic Coast. Pedestrian and ORV travel negatively affect shorebird foraging during critical periods and may contribute to the lack of long distance migration success (Harrington and Drilling 1996).

The Piping Plover Recovery Plan established a region-wide goal of 1.5 chicks fledged per breeding pair (USFWS 1995). Analysis of trends in abundance and productivity from 1986-2009 indicates the breeding productivity within New Jersey was 1.18 chicks per pair (Hecht and Melvin 2009). An HMP fledge rate objective of 1.2 fledged chicks per pair is a more realistic objective based on Hecht and Melvin's more recent analysis of 1989-2006 region-wide productivity data and is slightly higher than the New Jersey 23-year average of 1.18 chicks per

pair. While consistent with average New Jersey productivity, the goal is still higher than the actual productivity of 0.65 observed from 1993 to 2011 on the Refuge (Table 4-2).

The Refuge-wide average piping plover fledge rate is below the current recovery objective, the New Jersey average, and the revised objective within this HMP. Storm events, predation, human disturbance, climate change, and sea level rise are likely contributing factors. As per the HMP's direction, we are re-evaluating current management strategies through consultation with USFWS Ecological Services NJFO, the Region 5 piping plover specialist, state NJ Division of Fish and Wildlife partners and USGS researchers.

TABLE 4-2. NUMBER OF PIPING PLOVER NESTING PAIRS AND PRODUCTIVITY ON E.B. FORSYTHE NATIONAL WILDLIFE REFUGE, 1993 TO 2011.

Year	Nesting Pairs	Plover Chicks Fledged	Fledging Rate (Chicks/Pairs)
1993	18*	4*	0.22*
1994	31	9	0.29
1995	9*	8*	0.89*
1996	35	13	0.37
1997	22	6	0.27
1998	31	26	0.84
1999	33	39	1.18
2000	30	29	0.97
2001	36	29	0.81
2002	35	20	0.57
2003	34	32	0.94
2004	38	8	0.21
2005	32	8	0.25
2006	30	10	0.33
2007	39	16	0.41
2008	25	1	0.04
2009	17	24	1.41
2010	26	31	1.19
2011	24	27	1.13
Mean	28.68	17.89	0.65

*- Holgate Beach only

American oystercatchers and least terns also nest on Refuge beaches, but nesting success has been variable. From 2005 to 2010, only three least tern fledglings were documented (Refuge files) even though least terns bred successfully on Refuge beaches in the past. American oystercatcher nest success is also variable. Between 2009 and 2011, no oystercatchers hatched nests at Holgate while nest success was 21 percent on Little Beach Island during the same time period. We will also evaluate management for these species during the piping plover review.

Migrating shorebirds are sensitive to human disturbance. Higher levels of human activity on Virginia beaches increased time in flight and maintenance behaviors, and reduced time spent roosting (Forgues 2010). Disturbed sanderlings spent 177 percent more time in maintenance behaviors, 151 percent more time in flight, and 42 percent less time resting than did undisturbed sanderlings. Sanderlings flushed more frequently in response to pedestrians than vehicles. Increasing levels of pedestrian traffic decreased the likelihood of sanderling occurrence by as much as 45 percent (Morton 1996). The abundance of black-bellied plover, ruddy turnstone, sanderling, whimbrel, and willet declined significantly during spring and fall migration in Maryland and Virginia with higher ORV frequency (Forgues 2010).

Seabeach amaranth, a federally listed threatened species, is endemic to Atlantic Coast beaches and barrier islands (USFWS 1996) and historically found from Nantucket, Massachusetts to Folly Beach, South Carolina. By 1987, the plant was extirpated from nearly three-fourths of its earlier range (Hancock 2003). The seabeach amaranth recovery objective is to have 75 percent of the sites with suitable habitat occupied for 10 consecutive years (USFWS 1996).

Seabeach amaranth is a pioneer plant species found on the dynamic foredune habitat of the Atlantic Coast The primary habitat is overwash flats at the accreting ends of islands, lower foredunes, and upper strands of non-eroding beaches (landward of the wrack line). The species is occasionally found in small temporary populations in sound-side beaches, foredune blowouts, inter-dune areas, and on sand and shell material deposited for beach replenishment or as dredge spoil. Seabeach amaranth usually grows on a nearly pure sand substrate, with occasional shell fragments mixed in at elevations from eight inches to five feet above mean high water.

Threats to seabeach amaranth include beach stabilization (beach armoring, sand fences, sea walls, groins, jetties, and riprap), mechanical beach raking, dune modification, ORV use, intense public use, and invasive species, like Asiatic sand sedge.

Beach/Dune Management Strategies and Prescriptions

Continue:

- Holgate beach closures from April 1st to August 31st to provide disturbance-free habitat for threatened beach nesting bird species.
- Little Beach Island year-round beach closure to provide disturbance-free habitat for threatened beach nesting bird species and migrating shorebirds.
- Conducting predator control to increase American oystercatcher and piping plover nest and fledge success.
- Placing exclosures over piping plover nests after the second egg is laid.
- Employing protective strategies, such as signage, fencing or area closure to public as needed, when seabeach amaranth is found.

Monitoring Elements:

- Monitor the following habitat attributes using LiDAR and vegetative cover data:
    - backshore vegetative cover of less than 10%
    - primary dune vegetative cover of less than 13%

    - shell/pebble cover of 17–18%
    - less than five percent invasive species
    - nearby (< 0.5 km) ephemeral pools, salt ponds, or bay habitat
    - dune height of less than or equal to 1.1 m
    - dune slope of less than 13%
- Conduct both one-dimensional (1D) beach shoreline survey and two-dimensional (2D) surveys of the beach profile during the fall and spring to track the change in shoreline, dune/beach face and elevation.
- Annually monitor piping plover and other beach nesters on Holgate and Little Beach Island to provide protective measures and determine numbers, nest success and fledging rate.
- Annually monitor for the presence of seabeach amaranth at Holgate and Little Beach Island.
- Annually monitor for invasive Asiatic sand sedge and eliminate if found.
- Conduct the International Shorebird Surveys (ISS) during spring and fall migration. If the mean count per survey falls below the thresholds (Table 4-1) for three or more consecutive years, management review will be implemented.

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics, the abiotic factors affecting this habitat and its representative species.
- Investigate the feasibility of establishing seabeach amaranth through plantings.

Objective 1.2 Salt Marsh Habitats

Maintain, protect, and restore 33,358 acres of Salt Marsh to provide high quality habitat for American black duck, American oystercatcher, clapper rail, saltmarsh sparrow, snowy egret, willet, brant, northern harrier, semipalmated sandpiper and northern diamondback terrapin by targeting/maintaining the following mix of salt marsh cover types:

- high salt marsh approximately 25%
- low salt marsh approximately 60%
- pannes approximately 5%
- ponds approximately 10%

Specific objectives include the following:

- Manage 6,603 acres as federally designated wilderness by maintaining wilderness character.

- Provide breeding, wintering, and migrating habitat for representative species.

During the breeding season, maintain the running three-year mean densities of American black ducks, American oystercatchers, snowy egrets and northern harriers shown below, as measured by the NJ Division of Fish and Wildlife Breeding Waterbird Population Surveys (Table 4-3). Thresholds are the mean ± one standard error of all years of available data, and we will maintain

or exceed the threshold ranges. If the running three-year mean falls below the thresholds for three or more consecutive years, management review will be implemented.

TABLE 4-3. AMERICAN BLACK DUCK, AMERICAN OYSTERCATCHER, SNOWY EGRET AND NORTHERN HARRIER COUNTS AND DENSITIES AS ESTIMATED BY THE NJ DIVISION OF FISH AND WILDLIFE BREEDING WATERBIRD POPULATION SURVEYS ON FORSYTHE NWR (PLOTS SM34, SM36, SM38, SM44, SM50, SM52, SM54, SM56, SM60, SM62, SM64, SM 66, SM70, SM72 AND SM76). AMERICAN BLACK DUCK DATA IS FROM 2005-2012, WHILE AMERICAN OYSTERCATCHER, SNOWY EGRET AND NORTHERN HARRIER DATA IS FROM 2005-2011. THRESHOLDS ARE THE MEAN ± 1 STANDARD ERROR OF ALL YEARS OF AVAILABLE DATA FOR EACH SPECIES.

Species	All years of available data		Thresholds	
	Mean count (±1 standard error) per year	Mean density per km^2 (±1 standard error)	Three-year running mean count	Three-year running mean density per km^2
American black duck Total Indicated Pairs	42.0 ± 8.0	2.8 ± 0.6	36 – 50	2.2 – 3.4
American black duck Total Indicated Birds	102.1 ± 17.3	6.8 ± 1.2	84.8 – 119.4	5.6 – 8.0
American oystercatcher	40.9 ± 6.4	2.7 ± 0.4	34.5 – 47.3	2.3 – 3.1
Snowy egret	22 ± 6.4	1.5 ± 0.4	15.6 – 28.4	1.1 – 1.9
Northern harrier	0.9 ± 0.3	0.06 ± 0.02	0.6 – 1.2	0.04 – 0.08

During the wintering season, maintain the running three-year mean densities of American black ducks, brant, American oystercatchers, and northern harriers shown below, as measured by the FWS Office of Migratory Bird Mid-Winter Survey (Table 4-4). Thresholds are the mean ± one standard error of all years of available data, and we will maintain or exceed the threshold ranges. If the running three-year mean falls below the thresholds for three or more consecutive years, management review will be implemented.

TABLE 4-4. AMERICAN BLACK DUCK, BRANT, AMERICAN OYSTERCATCHER AND NORTHERN HARRIER COUNTS AND DENSITIES AS ESTIMATED BY THE FWS OFFICE OF MIGRATORY BIRD MID-WINTER SURVEY SEGMENTS 7-13, WHICH FALL ON THE REFUGE AND COVER AN AREA OF 974.2 KM^2. THRESHOLDS ARE THE MEAN ± 1 STANDARD ERROR OF THE 2006-2012 DATA FOR EACH SPECIES.

	2006 – 2012		Thresholds	
Species	Mean count (±1 standard error) per year	Mean density per km^2 (±1 standard error)	Three-year running mean count	Three-year running mean density per km^2
American black duck	34, 955.7 ± 4,085.8	35.2 ± 4.5	30,869.9 – 39,041.5	30.6 – 39.7
Brant	9,781.4 ± 979.8	10.0 ± 1.0	8,801.6 – 10,761.2	9.0 – 11.0
American oystercatcher	1.4 ± 0.9	0.002 ± 0.001	0.5 – 2.3	0.007 – 0.003
Northern harrier	9.9 ± 3.0	0.008 ± 0.003	6.9 – 12.9	0.006 – 0.012

Rationale

Salt marsh comprises the largest Refuge vegetative community, making up about 78 percent of the Refuge landscape (see Appendix B, Map 4), and is divided into 23 management units (see Appendix B, Map 5). Much of the Refuge salt marsh was grid-ditched during the early 20th century for mosquito control. However, 6,603 acres of un-ditched salt marsh exist within the Brigantine Wilderness Area on Little Beach Island**,** the Holgate Unit, and between Motts Creek and the Mullica River.

The American black duck is a Refuge representative species, a BCR 30 highest conservation priority species and a LCC representative species. Black ducks are a species in decline according to the North American Breeding Bird Surveys (BBS) from 1966 to 2010 (Sauer et al. 2011); Atlantic Flyway Mid-winter Waterfowl Survey numbers decreased 27 percent from 2001 to 2011 (USFWS 2011). Estuarine complexes and bays that occur between barrier beaches and the mainland are critical to wintering and migrating waterfowl and support approximately 65 percent of the total wintering American black duck population in the Atlantic Flyway (Steinkamp 2008). Salt marshes, coastal islands and meadows, brackish and freshwater impoundments, and riverine marshes are used for breeding. The Refuge contains a significant proportion of the American black ducks and brant wintering in New Jersey (Table 4-5).

Brant are a Refuge representative species and a BCR 30 highest conservation priority species. Since 1978, numbers have fluctuated from about 45,000 in 1978–1979 and 1979–1980 to 185,000 in 1991–1992 (Reed et al. 1998). Atlantic Flyway Mid-winter Waterfowl Survey numbers in 2011 were 148,935, a slight increase from 145,261 in 2001 (USFWS 2011).

TABLE 4-5. WINTERING AMERICAN BLACK DUCK AND BRANT COUNTED IN STRATUM, NJ 7-13 (FORSYTHE NWR) DURING USFWS ANNUAL MID-WINTER WATERFOWL SURVEY, 2006-2012.				
Year	American Black Duck Count	Brant Count	Percent of NJ Black Duck Counted on Refuge	Percent of NJ Brant Counted on Refuge
2012	39,165	7,535	40.7	10.8
2011	20,335	5,480	32.7	9.0
2010	25,405	10,625	34.0	19.1
2009	29,370	12,945	37.2	17.5
2008	51,370	9,460	37.6	10.7
2007	35,275	10,250	39.8	15.2
2006	43,770	12,175	48.0	19.3

Other representative species using salt marsh include American oystercatcher, clapper rail, saltmarsh sparrow, snowy egret, willet, northern harrier, semipalmated sandpiper and northern diamondback terrapin. All are BCR 30 conservation priority species and LCC representative species. Saltmarsh sparrow, a BCR 30 highest conservation priority, is also New Jersey Species of Conservation Concern and USFWS Special Concern breeding bird. Forty-four species of mammals, birds, reptiles and amphibians listed as Species of Conservation Concern in the New Jersey Wildlife Action Plan are found in salt marsh habitat. The American black duck, clapper rail, northern pintail, and willet are declining species in the North American BBS (Sauer et al. 2011).

Salt marsh management has been primarily custodial with invasive species management, mosquito control, monitoring, and public use management being the primary activities. Funding from the Department of the Interior for resilience planning has greatly increased the scope and amount of salt marsh work that is possible in the future. Based on current projections, sea level rise will be the largest challenge for future salt marsh management.

Salt Marsh Management Strategies and Prescriptions

Continue:

- Working with partners to implement the Barnegat Bay Partnership Plan to reduce nutrient loading and address other issues negatively impacting the bay.
- Working with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat.
- Working with partners to conduct studies to better understand the demographics and carrying capacity of representative species.
- Using data such as NVCS, National Wetland Condition Assessment (NWCA), Mid-Atlantic Coastal Wetland Assessment (MACWA), and Salt Marsh Integrity (SMI) to characterize salt marsh vegetative communities.
- Using Light Detection and Ranging (LiDAR), surface elevation tables (SETs), Feldspar layers, and other techniques to measure salt marsh accretion.

- Working with partners to assess the effect of Open Marsh Water Management (OMWM) on salt marsh accretion/persistence.
- Working with partners to restore tidal habitat at the Cedar Bonnet Island Unit as part of a NJ Department of Transportation mitigation project.
- Working with partners to identify, prioritize and implement habitat restoration projects. Potential projects include lands developed prior to refuge establishment, dredge spoil sites, former salt-hayed farms, parallel-ditched marshes, and other salt marshes that are unable to keep pace with sea level rise. Take advantage of opportunities as they arise.
- Participation in a regionally-driven structured decision making process regarding OMWM to address concerns regarding persistence of managed marshes.
- Assessing the extent and change in area of Salt Marsh habitat. Compare with SLAMM model predictions and refine model assumptions.
- Determination of the feasibility of restoration of formerly managed impoundments, which are now open to restricted tidal flow, within 15 years of approval of this HMP.

Monitoring Elements:

- Implementation of Salt Marsh Integrity monitoring protocols on all salt marsh units within 5 years of HMP approval. Collect and analyze data on an annual basis. When adequate data exist, set quantitative objectives for additional representative species, such as saltmarsh sparrow and clapper rail, and other SMI attributes.
- Continue working with the NJ Division of Fish and Wildlife and the FWS Division of Migratory Bird Management to conduct the spring Waterbird Survey and Mid-winter Waterfowl Survey to collect and receive data to assess the density of representative species. If the running three-year mean falls below the thresholds (Tables 4-3 and 4-4) for three or more consecutive years, management review will be implemented.

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.

4.3 GOAL 2: FRESHWATER WETLAND HABITAT

Maintain and restore, where possible, the biological integrity, diversity, and environmental health of Wetland Habitats to sustain native plants and wildlife, federal trust resources, and species of conservation concern.

Objective 2.1 Permanently Flooded Freshwater Wetland Communities

Maintain, protect, and restore 593 acres of Permanently Flooded Freshwater Wetland Communities, with less than 15 percent overall cover of invasive plants, to provide habitat for green heron, marsh wren, and eastern painted turtle.

Rationale

Freshwater Wetland Communities provide nesting and migration habitat for bird species listed in regional conservation plans, including BCR 30, PIF 44 (Partners in Flight 1999) and the New Jersey Wildlife Action Plan (NJDEP 2008), as well as international plans such as Saving Our Shared Birds and Partners in Flight's Tri-National Vision for Landbird Conservation. Twenty-seven priority bird species listed in both BCR 30 and PIF 44 implementation plans are found in Freshwater Wetland Communities.

Freshwater Wetland Communities representative species include green heron, marsh wren, and painted turtle. The bird species are BCR 30 conservation priority species and New Jersey Species of Conservation Concern. The green heron is a declining species in the North American BBS (Sauer et al. 2011).

A number of globally significant and rare vegetation communities occur in this habitat. Sea Level Fens (G1) are small areas (<5 acres) of freshwater seepage adjacent to salt marshes. All twelve occurrences are probably less than fifteen acres total on the Refuge. Threats include upland development and altered hydrology. Other unique communities include Pine Barrens Riverside Asphodel Savanna (G2) and Lily Pond, Chain fern (G2) communities that have 100-150 occurrences range wide and are threatened by hydrological changes.

Permanently Flooded Freshwater Wetland Management Strategies and Prescriptions

Continue:

- Working with partners to reduce nutrient loading and address other issues negatively impacting Freshwater Wetland Communities.

Within 10 years:

- Work with partners to determine the feasibility of restoring disturbed wetland communities (e.g., former cranberry farms) within five years of HMP approval. If feasible, implement prioritized habitat restoration projects. Take advantage of opportunities as they arise.
- Investigate freshwater wetland impacts due to public use at the Bon Segway area (north of Oyster Creek Nuclear Generating Station).

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.
- Work with partners to identify, prioritize and implement habitat restoration projects.
- Work with partners to develop a monitoring and protection strategy for sea level fens.

Objective 2.2 Wetland Forest Communities

Manage, protect and restore 10,842 acres of Wetland Forest Communities in large contiguous forested blocks with diversity of age classes and forest structure, minimal forest edge and minimal fragmentation with less than 15 percent overall cover of invasive plants to provide habitat for red-shouldered hawk, wood thrush, migrating land birds, wood frog, and swamp pink.

Rationale

Wetland Forest Communities provide nesting and migration habitat for bird species listed by regional conservation plans, including BCR 30, PIF 44, and the New Jersey Wildlife Action Plan, as well as international plans such as Saving Our Shared Birds and PIF's Tri-National Vision for Landbird Conservation. Twenty-five priority bird species listed in both BCR 30 and PIF 44 implementation plans are found here. Representative species include migrating land birds, red-shouldered hawk, wood thrush, swamp pink, and wood frog.

The red-shouldered hawk, wood thrush, and wood frog are LCC representative species. The red-shouldered hawk is a New Jersey endangered species and the wood thrush is a New Jersey Species of Conservation Concern. The wood thrush is a declining species on the North American BBS (Sauer et al. 2011).

Wetland Forest Communities have a well-developed, variable forest composition and structure with canopy and sub-canopy trees, understory shrubs, and diverse ground cover. Frequency, duration, and severity of flooding vary seasonally and yearly, and contribute to a rich diversity of species, vertical and horizontal structure, and ground cover due to age, soils, elevation and slope, and disturbance frequency. Isolated local events impact small areas or individual trees and result in downed trees, snags, and broken branches. Freshwater Wetland Communities are found intermingled within this community. Upland forest communities are often found in a mosaic with wetland forests. Almost 1,800 acres of Atlantic White Cedar Swamp occur on the Refuge. This community is limited to the Atlantic Coastal Plain and only 2,500 to 7,500 acres occurs range-wide (NatureServe 2009). Atlantic White Cedar Bog (G3G4) an oligotrophic basin peat land dominated by heath shrubs with an open canopy of stunted Atlantic white cedar is found here.

Forests are increasingly fragmented and altered compared with the forests of the late 1800's and early 1900's. Landscape changes such as roads, rights-of-way, and subdivisions are likely to be permanent. Different species require different sized forests. Wood thrush prefer forests larger than 250 acres (Robbins et al. 1989, Rich et al. 1994), while a breeding pair of red-shouldered hawks require 250-625 acres to be successful (MDNR 2000).

Swamp pink, a federally listed threatened species, is an obligate wetland plant species occurring in forested wetlands with canopy closure varying between 20-100 percent, including those bordering meandering streams, headwater wetlands, sphagnums, Atlantic white cedar swamps, and spring seepage areas. Swamp pink requires perennially saturated areas with the water table near or at the surface, fluctuating slightly during spring and summer months (USFWS 1991). Observations at Atlantic white cedar-dominated sites indicate swamp pink is associated with emergent portions of in-stream and stream bank hummocks under a relatively open tree canopy

(Laidig and Zampella 2009). Primary threats to swamp pink are indirect effects of off-site activities and development affecting groundwater and surface water hydrology. Over half of the known populations are found in New Jersey.

Forested Wetland Management Strategies and Prescriptions

Continue:

- Working with the Service's New Jersey Field Office to annually monitor swamp pink populations.
- Working with partners to complete the Forest Survey and analyze the results.
- Working with federal and state partners to monitor, and if necessary, respond to forest pest infestations, such as southern pine beetle.

Within two years:

- Evaluate the restoration potential of the Oxycoccus property in Manahawkin.
- Complete an inventory Refuge Atlantic white cedar habitat, including detection of swamp pink, bog asphodel, and curly grass fern.
- Develop a strategy to manage beavers within Atlantic white cedar swamps, if warranted

Within 10 years:

- Develop an Atlantic white cedar forest management and restoration plan.

Within 15 years:

- Assess anthropogenic alterations to natural hydrology and sea level rise. Determine if mitigation or restoration is required.

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.
- Work with partners to identify, prioritize and implement habitat restoration projects.

4.4 GOAL 3: UPLAND HABITAT

Maintain and restore, where possible, the biological integrity, diversity, and environmental health of Upland Habitat to sustain native plants and wildlife, federal trust resources, and species of conservation concern.

Objective 3.1 Upland Forest Communities

Manage, protect, and restore 4,839 acres of Upland Forest Communities to provide the following habitat attributes (Bakermans et al. 2012) for eastern wood-pewee, eastern whip-poor-will, ovenbird, and migrating land birds, as well as eastern box turtle and northern pine snake:

- forest blocks greater than 500 acres

- square or rectangular shape to minimize edge
- minimal fragmentation within and among blocks; however, allow for 10-15% canopy gaps of greater than 40 m^2
- less than 15% invasive species

Rationale

Upland Forest Communities provide nesting and migration habitat for bird species listed by regional conservation plans, including BCR 30, PIF 44, and the New Jersey Wildlife Action Plan, as well as international plans such as Saving Our Shared Birds and PIF's Tri-National Vision for Landbird Conservation. Thirty priority bird species listed in both BCR 30 and PIF 44 implementation plans are found on the Refuge.

Upland Forest Communities are comprised of mesic deciduous and dry oak-pine forests. Mesic deciduous forests typically are an assortment of hardwoods in moist habitats, while dry oak-pine forests typically are found on more droughty, sandy soils. Upland forest communities have a well-developed, variable forest composition and structure with canopy and sub-canopy trees, understory shrubs, and diverse ground cover. A rich diversity of species, vertical and horizontal structure, and ground cover result from age, soils, elevation and slope. Structural diversity is facilitated by isolated local events that impact small areas or individual trees and result in downed trees, snags, and broken branches, which allows sunlight to penetrate the canopy.

Upland Forests, like Wetland Forests, haves experienced fragmentation and landscape changes compared with forests in the late 1800's and early 1900's and changes are likely to be permanent. Ovenbirds prefer mature forests and are sensitive to forestry practices, including single tree selection and timber stand improvement, and impacts extend 325 feet beyond clearcuts. Several recent studies have estimated territory density on the breeding grounds in relation to fragmentation, edge, and forest harvest. In fragmented landscapes, a minimum habitat area of 1,250 acres with 90 percent core area appears necessary to support ovenbird populations (Porneluzi et al. 2011). Likewise, wood thrush prefer forests larger than 250 acres (Robbins et al. 1989, Rich et al. 1994).

Eastern wood-pewee, eastern whip-poor-will, ovenbird, eastern box turtle and northern pine snake are LCC representative species. The northern pine snake is a New Jersey endangered species and the eastern wood-pewee, eastern whip-poor-will, eastern box turtle, and northern pine snake are New Jersey Species of Conservation Concern. The eastern whip-poor-will is a declining species in the North American BBS (Sauer et al. 2011).

Upland Forest Communities Management Strategies and Prescriptions

Continue:

- Working with federal and state partners to monitor, and if necessary, respond to forest pest infestations, such as southern pine beetle.
- Working with partners to complete the Forest Survey and analyze the results.

Monitoring Elements:

- Resume or develop monitoring for representative species in cooperation with federal and state partners.

Within 15 years:

- Explore use of LiDAR to measure canopy height and canopy closure.
- Work with partners to develop forest management and restoration plans to provide habitat conditions for representative species, utilizing forest management practices, including fire, thinning, planting, and other techniques to restore, maintain, and manage upland forests.
- Consider the interrelationships of WUI, invasive species mitigation, early successional habitat, and its associated species.

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.
- Work with partners to identify, prioritize and implement habitat restoration projects.

Objective 3.2 Pitch Pine Barrens Forest Communities

Manage, protect, and restore 1,368 acres of Pitch Pine Barrens Forest Communities in large contiguous forested blocks with a diversity of age classes, minimal forest edge and fragmentation and with less than 15 percent overall cover of invasive plants. Pitch Pine Barrens Forest would consist of an open canopy forest strongly dominated by pitch pine with very low cover of deciduous trees and a variable herbaceous layer depending on fire frequency and intensity, and would provide habitat for eastern towhee, eastern whip-poor-will, migrating land birds, prairie warbler, and northern bobwhite, as well as northern pine snake, and pine barrens tree frog.

Rationale

Pitch Pine Barrens Forest Communities provide nesting and migration habitat for bird species listed by regional conservation plans including BCR 30, PIF 44, and the New Jersey Wildlife Action Plan, as well as international plans such as Saving Our Shared Birds, and PIF's Tri-National Vision for Landbird Conservation. Thirty priority bird species listed in both BCR 30 and PIF 44 implementation plans and a New Jersey threatened snake and frog are found here.

These forests are part of the New Jersey Pine Barrens and are found on well-drained nutrient-poor sandy soils. The open Pitch Pine canopy with very low cover of deciduous trees is fire-maintained with a maritime influence. Representative species include eastern towhee, eastern whip-poor-will, migrating land birds, northern bobwhite, prairie warbler, northern pine snake, and Pine Barrens tree frog.

Eastern towhee, eastern whip-poor-will, northern bobwhite, and prairie warbler are BCR 30 conservation species. Eastern towhee, eastern whip-poor-will, and prairie warbler are New Jersey Species of Conservation Concern. Northern harrier and Pine Barrens tree frog are New Jersey endangered species and northern pine snake is a New Jersey threatened species. Eastern towhee, eastern whip-poor-will, and northern pine snake are LCC representative species. Eastern towhee, northern bobwhite, prairie warbler, and eastern whip-poor-will are declining species in the North American BBS (Sauer et al. 2011).

The Pine Barrens tree frog requires specialized acidic habitats, such as Atlantic white cedar swamps and pitch pine lowlands with dense mats of sphagnum moss. Structural characteristics of preferred habitats include an open canopy, a dense shrub layer, and heavy ground cover. Soil types include sands and muck. Temporary woodland ponds, Atlantic white cedar bogs, and seepage areas along tributaries of major rivers and streams serve as breeding ponds for the Pine Barrens tree frog. The primary threat is habitat destruction or alteration from residential, agricultural, and industrial development (Hammerson 2004).

The northern pine snake, a New Jersey threatened species, prefers well-drained, sandy, upland pine and pine-oak forests and is found only in the Pine Barrens. Northern pine snakes are isolated from all other pine snake populations throughout the country (NJDEP 2009). Pine snake nests are found almost exclusively in open areas with loose sandy soils and little vegetation (Burger and Zappalorti 1986).

Pitch Pine Barrens Forest Communities Management Strategies and Prescriptions

Continue:

- Working with partners to complete the Forest Survey and analyze the results.

Annually:

- Work with federal and state partners to monitor, and if necessary, respond to forest pest infestations, such as southern pine beetle.

Monitoring Elements:

- Resume or develop monitoring for representative species in cooperation with federal and state partners.

Within 15 years:

- Work with partners to initiate a forest inventory and restoration assessment.
- Work with partners to develop forest management and restoration plans to provide habitat conditions for representative species, utilizing forest management practices, including fire, thinning, planting, and other techniques to restore, maintain, and manage upland forests.
- Consider the interrelationships of WUI, invasive species mitigation, early successional habitat, and its associated species.

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.
- Work with partners to identify, prioritize and implement habitat restoration projects.

Objective 3.3 Early Successional Habitats

Manage, protect, and restore 832 acres of Early Successional Habitat for American woodcock, brown thrasher, eastern meadowlark, northern bobwhite, and wintering and migrating land birds. Managed habitats include grassland dominated by a mix of cool and warm season grasses, forbs, early successional shrubs and a few low trees, as well as scrub-shrub containing a mix of grasses, forbs, early successional native fruit-producing shrubs and trees, including blackberry, *Viburnum* spp., and cherry.

Rationale

Early Successional Habitat provides wintering and migrating habitat for bird species listed by regional conservation plans, BCR 30, PIF 44, and the New Jersey Wildlife Action Plan, as well as international plans such as Saving Our Shared Birds and PIF's Tri-National Vision for Landbird Conservation. Thirty-four priority bird species listed in both BCR 30 and PIF 44 implementation plans are found here, as well as a number of LCC representative species. American woodcock, brown thrasher, eastern meadowlark and northern bobwhite are BCR 30 species of conservation priority, New Jersey Species of Conservation Concern, Atlantic BCR 30 conservation priority species and/or LCC representative species. American woodcock, brown thrasher, eastern meadowlark and northern bobwhite are declining species in the North American BBS (Sauer et al. 2011).

The New Jersey Wildlife Action Plan identifies the protection, maintenance, enhancement, and/or restoration of grassland and scrub/shrub habitats to maintain viable populations of declining early successional species (NJDEP 2008). These habitats were also identified as migration habitat in other Atlantic Coastal Plain studies (McCann et al. 2003, Paxton and Watts 1999, Rothbart and Capel 2006). Early Successional Habitats are valuable for pollinators, particularly butterflies.

Early Successional Habitat Management Strategies and Prescriptions

Annually:

- Maintain, protect, and enhance existing early successional habitat around headquarters and adjacent to the Wildlife Drive.

Monitoring Elements:

- Resume or develop monitoring for representative species in cooperation with federal and state partners.

Within 15 years:

- Prepare an assessment of the condition, value, location, size, and composition to determine extent of future early successional habitats (could be more or less acreage over life of HMP) as part of the forest management plan cited in upland forest communities.

Because of logistics and security issues surrounding the large machinery used to set back succession, management of early successional habitats will likely focus on existing large early successional patches at the Forked River Game Farm site, near the Barnegat garage, and along the wildlife drive.

When Possible:

- Maintain, protect, and enhance existing early successional habitat around the Barnegat Maintenance Yard and former Forked River Game Farm site.
- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.
- Work with partners to identify, prioritize and implement habitat restoration projects.

4.5 GOAL 4: MANAGED WETLAND IMPOUNDMENT HABITAT

Manage Refuge Wetland Impoundments to sustain native plants and wildlife and federal trust resources with an emphasis on migrating and wintering birds and species of conservation concern. Consider other options to current management when conservation targets cannot be achieved or when it may be no longer viable to maintain impoundments due to sea level rise or other factors.

Objective 4.1 Managed Wetland Impoundment Communities – East Pool

Until a viable alternative for management as a freshwater system is developed, use daily tidal inundation to manage 536 acres in the East Pool as a functional estuarine/saltmarsh system containing a mix of open water, mudflat and vegetated saltmarsh habitats for American black duck, migrating shorebirds, northern pintail, and snowy egret. If any of these habitat components (open water, mudflat or vegetated saltmarsh) fall below 20 percent cover, management strategies and prescriptions would be evaluated. Maintain *Phragmites* at less than five percent cover to encourage native aquatic vegetative cover.

Maintain the running three-year mean counts per survey for American black duck, northern pintail, snowy egret, and spring and fall migrating shorebirds shown below, as measured by the Refuge's Weekly Waterbird Survey (Table 4-6). Thresholds are the mean ± one standard error of all years of available data, and we will maintain or exceed the threshold ranges. If the running three-year mean falls below the thresholds for three or more consecutive years, management review will be implemented.

TABLE 4-6. AMERICAN BLACK DUCK, NORTHERN PINTAIL, SNOWY EGRET, AND SPRING AND FALL MIGRATING SHOREBIRD MEAN COUNTS PER SURVEY IN THE EAST POOL AS ESTIMATED BY THE REFUGE'S WEEKLY WATERBIRD SURVEY. THRESHOLDS ARE THE MEAN ± 1 STANDARD ERROR OF THE 2005-2012 SURVEYS.

Species	Survey Period	Mean count per survey (±1 standard error) 2005 – 2012	Threshold three-year running mean count per survey
American black duck	Nov – Mar	505 ± 32	474 – 537
Northern pintail	Oct – Mar	215 ± 23	192 – 238
Snowy egret	Jul – Oct	60 ± 9	51 – 69
Spring migrating shorebirds	Apr – May	932 ± 281	650 – 1,213
Fall migrating shorebirds	Jul – Nov	386 ± 118	268 – 504

We acknowledge the limitations of this dataset and recommend that alternative survey methods be considered for future monitoring. The Weekly Waterbird Survey is conducted by volunteers, who receive training in bird identification and survey methodology. The number of times the survey is conducted each month depends on volunteers' availability and, thus, the survey is less systematic than if it were conducted by a paid technician. The actual area surveyed has varied by an unmeasured amount since 2005 due to visual obstructions (i.e. vegetation) and lack of access to the center of the impoundment. The survey was amended several years ago to conform to the Integrated Waterbird Monitoring and Management (IWMM) Protocol; however, the fundamental shortcomings of this survey remain. Given these discrepancies, we report mean counts per survey in Table 4-6, rather than estimates of density. Future surveys could be designed to more-rigorously survey the entire pool area, or a subsample of known area, to produce density estimates.

Managed Wetland Impoundment Communities - East Pool Management Strategies and Prescriptions

Annually:

- Continue the Weekly Waterbird Survey for representative species. If the running three-year mean falls below the thresholds (Table 4-6) for three or more consecutive years, management review will be implemented.
- Determine and employ Integrated Pest Management strategies (i.e., chemical and prescribed burn treatments) to control invasive species, such as *Phragmites***.**
- Use herbicide or mechanical removal to eliminate woody vegetation from dikes.
- Monitor and assess vegetative composition using IWMM protocols.

Every 3 Years:

- Conduct a rigorous vegetative assessment to evaluate the efficacy of invasive plant management and monitor for sea-level-rise-induced changes.

When Possible:

- Work with partners to identify, prioritize and implement habitat restoration projects.
- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.

Objective 4.2 Managed Wetland Impoundment Communities – West Pool

Seasonally manage water levels on 850 acres in the West Pool for American black duck, migrating shorebirds, northern pintail, and snowy egret. Within 15 years of the approval of this HMP, reduce *Phragmites* to less than five percent cover to encourage native aquatic vegetative growth. Over a 10-year period, reduce salt marsh fleabane to less than five percent cover. Annually, provide moist soil conditions on 75 percent of the unit during the growing season to promote dense, high energy seed-producing annual plants and dwarf spikerush beneficial to American black ducks and northern pintail. Provide moist soil conditions on 50 percent of the unit to provide optimum foraging habitat for spring-migrating shorebirds. Provide access to food for summer-/fall-migrating shorebirds, American black duck and northern pintail on 85 percent of the unit through water level manipulation late August through December.

Maintain the running three-year mean counts per survey for American black duck, northern pintail, snowy egret, and spring and fall migrating shorebirds shown below, as measured by the Refuge's Weekly Waterbird Survey (Table 4-7). Thresholds are the mean ± one standard error of all years of available data, and we will maintain or exceed the threshold ranges. If the running three-year mean falls below the thresholds for three or more consecutive years, management review will be implemented.

TABLE 4-7. American black duck, northern pintail, and spring and fall migrating shorebird mean counts per survey in the West Pool as estimated by the Refuge's Weekly Waterbird Survey. Thresholds are the mean ± 1 standard error of the 2005-2012 surveys.			
Species	Survey Period	Mean count per survey (±1 standard error) 2005 – 2012	Threshold three-year running mean count per survey
American black duck	Nov – Mar	1,125 ± 122	1,003 – 1,248
Northern pintail	Oct – Mar	469 ± 111	158 – 580
Snowy egret	Jul – Oct	21 ± 7	13.6 – 29.0
Spring migrating shorebirds	Apr – May	678 ± 231	447 – 909
Fall migrating shorebirds	Jul – Nov	1,432 ± 403	1,029 – 1,834

Managed Wetland Impoundment Communities - West Pool Management Strategies and Prescriptions

Annually:

- Continue the Weekly Waterbird Survey for representative species. If the running three-year mean falls below the thresholds (Table 4-7) for three or more consecutive years, management review will be implemented.
- Determine and employ Integrated Pest Management strategies (i.e., chemical and prescribed burn treatments) needed to control invasive species, such as *Phragmites*.
- Use herbicide or mechanical removal to eliminate woody vegetation from dikes.
- Monitor and assess vegetative composition using IWMM protocols.
- Slowly drawdown West Pool beginning in late February or early March. To maximize the germination of beneficial plants throughout the impoundment, water levels will be drawn down slowly (i.e., 1 to 2 inches per week) with the target of a complete drawdown by May 1st. An early season drawdown will foster production of annual plants (e.g., smartweeds). The impoundment will remain in a saturated mudflat condition throughout the growing season.
- Commence a gradual re-flooding in September and reach objective water level of 2.0 feet msl by October 20. Full pool (2.8 feet msl) will be reached by December 1st.
- When necessary to control *Phragmites*, re-flood after the spring shorebird migration (mid-June) to eliminate air pockets in the soil that are critical to *Phragmites* rhizome respiration. This flooding should be combined with chemical application for maximum control. After one or two years of the control regime, return to the preferred scheme of managing for a longer drawdown period that provides habitat for both northbound and southbound migrating shorebirds.

Every three years:

- Conduct a rigorous vegetative assessment
- Update the water management plan.

When Possible:

- Work with partners to identify, prioritize and implement habitat restoration projects.
- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.

Objective 4.3 Other Managed or Potentially Managed Wetland Impoundment Communities – (Oak Island, Barnegat Pools, Forked River, Stouts Creek)

Within five years of HMP approval, evaluate these other potentially managed impoundments'value, potential, and contribution to achieving the Managed Impoundment Goal and supporting American black duck, migrating shorebirds, northern pintail, and snowy egret.

Other Managed or Potentially Managed Wetland Impoundment Communities - Management Strategies and Prescriptions

Annually:

- Continue the Weekly Waterbird Survey for representative species at the Barnegat Impoundments.

Within five years:

- Work with partners to identify, prioritize and implement habitat restoration projects by assessing the value, and potential contribution to achieving the Managed Impoundment Goal of all wetland impoundments.
- Determine and employ Integrated Pest Management strategies (i.e., chemical and prescribed burn treatments) needed to control invasive species, such as *Phragmites***.**
- Use herbicide or mechanical removal to eliminate woody vegetation from dikes.

When Possible:

- Work with partners to conduct studies to better understand habitat dynamics and the abiotic factors affecting this habitat and its representative species.
- Work with partners to conduct studies to better understand the demographics and carrying capacity of representative species.

Rationale

Managed wetland impoundments provide critical life cycle needs and habitat benefits for a variety of migratory waterfowl, wading birds, and shorebirds. By varying water levels seasonally, food resources can be provided for different groups of birds. Manipulating water or habitats and reducing disturbance, can increase carrying capacity above that of native habitats,

mitigating degradation or loss of these habitats. The resulting number and diversity of species provides public use benefits of wildlife viewing, wildlife photography and environmental education opportunities.

American black duck and northern pintail are LCC representative species and species of highest and medium conservation priority in BCR 30, respectively. Both are declining species in the North American BBS from 1966 to 2010 (Sauer et al. 2011) and both species have seen decreases in the Atlantic Flyway Mid-winter Waterfowl Survey. From 2001 to 2011, American black duck numbers decreased 27 percent and northern pintail decreased about 75 percent (USFWS 2011). Numerous species of shorebirds, including black-bellied plover, semipalmated plover, greater yellowlegs, semipalmated sandpiper, dunlin, and short- and long-billed dowitchers utilize Refuge impoundments. While systematic data is lacking for most of these areas, anecdotal information suggests some of these areas receive high wildlife usage. During 2013, the northernmost American black duck brood reported on refuge lands was observed in the Stouts Creek impoundments, which contained lush growth of wigeongrass.

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APPENDIX A: PLAN DEVELOPMENT TEAM

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Bill Haglan, Biologist, and Michael Spratt Planner Gap Solutions, Inc., were contracted to write this plan. Paul M. Castelli, Wildlife Biologist, E.B. Forsythe National Wildlife Refuge, served as editor and a contributing author.

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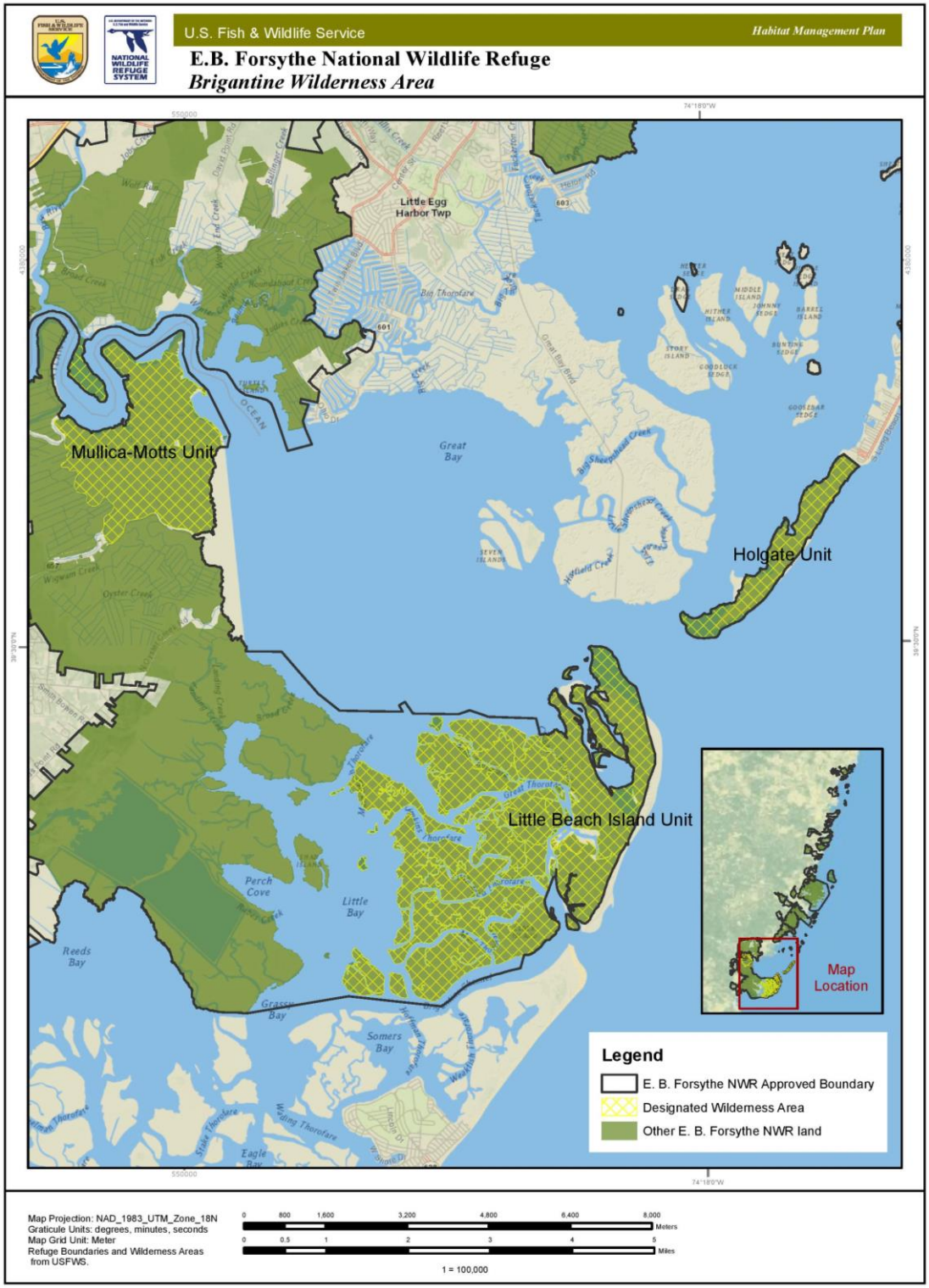
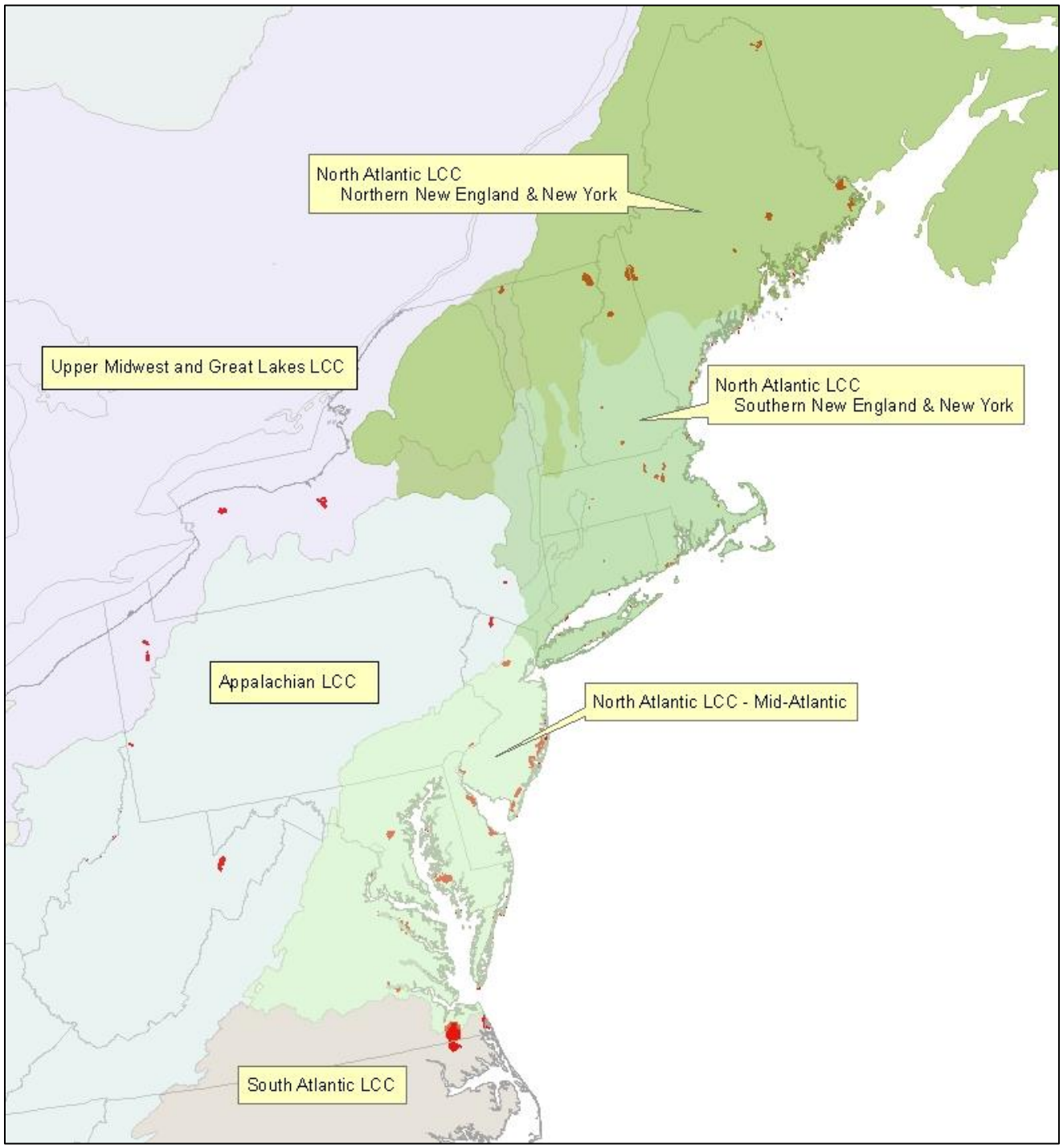
APPENDIX B: MAPS

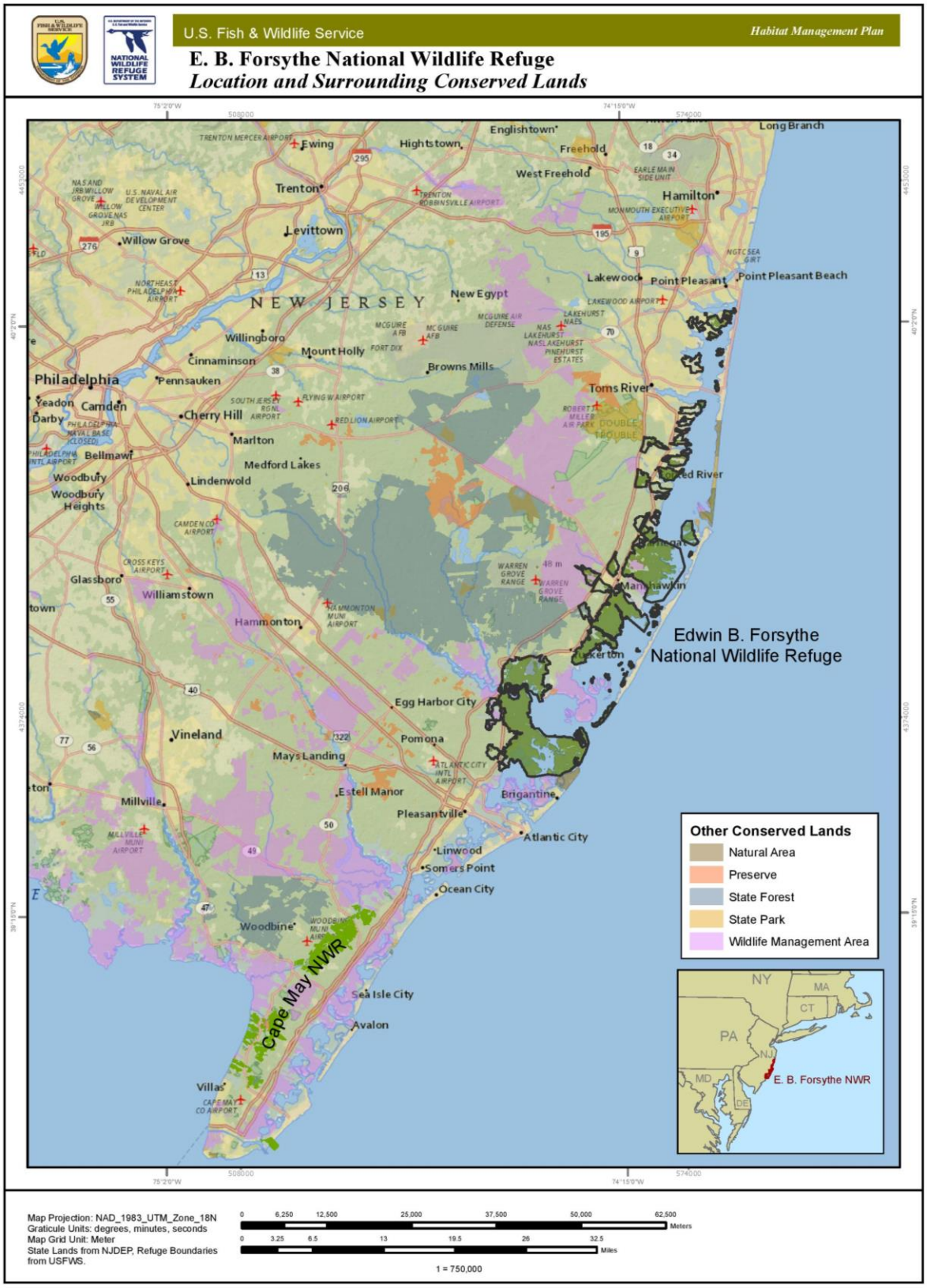
Map 1. E. B. Forsythe National Wildlife Refuge, Brigantine Wilderness Area



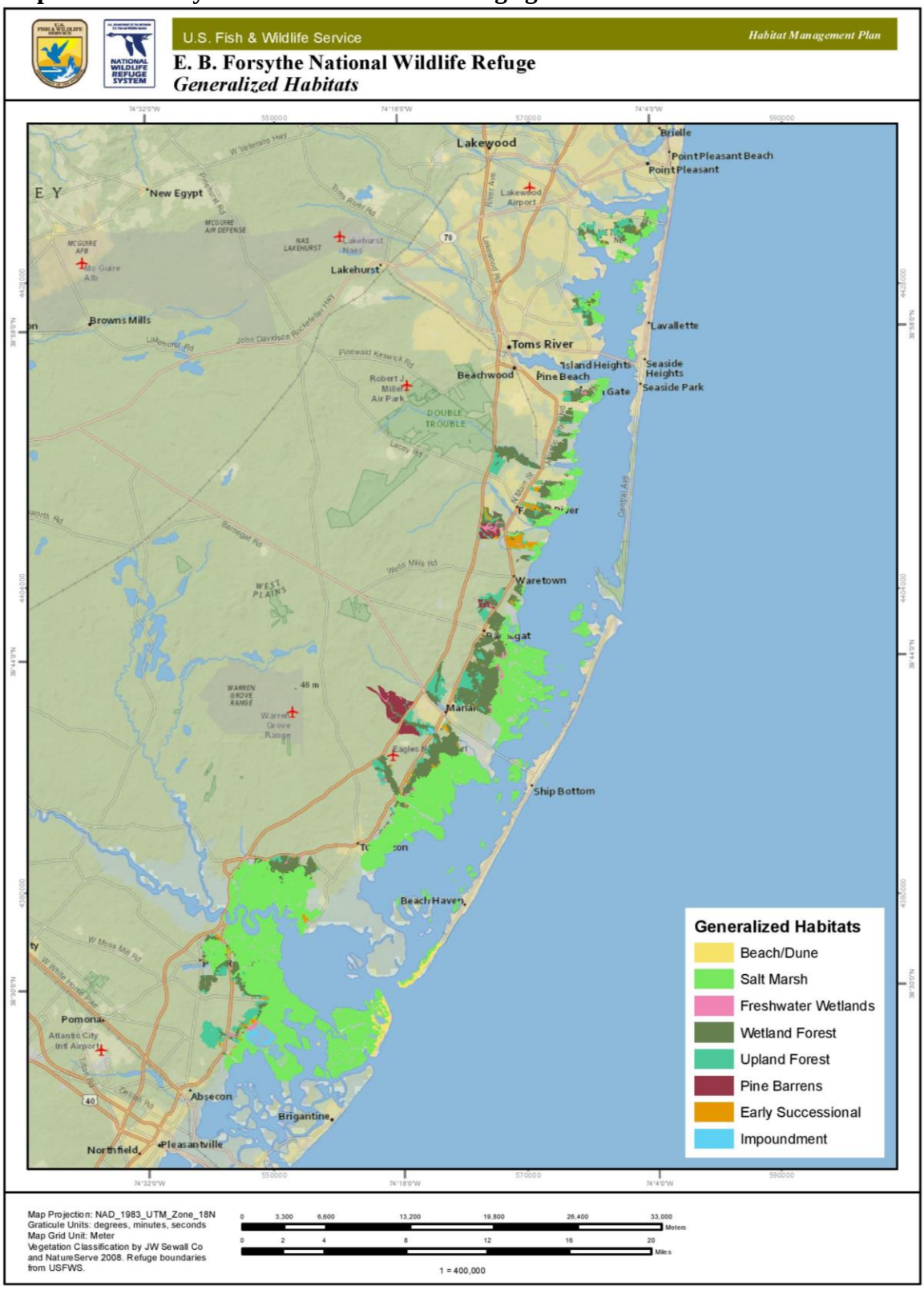
Map 2. Landscape Conservation Cooperatives and Region 5 Refuges
(North Atlantic LCC subregions in shades of green, refuges in red.)



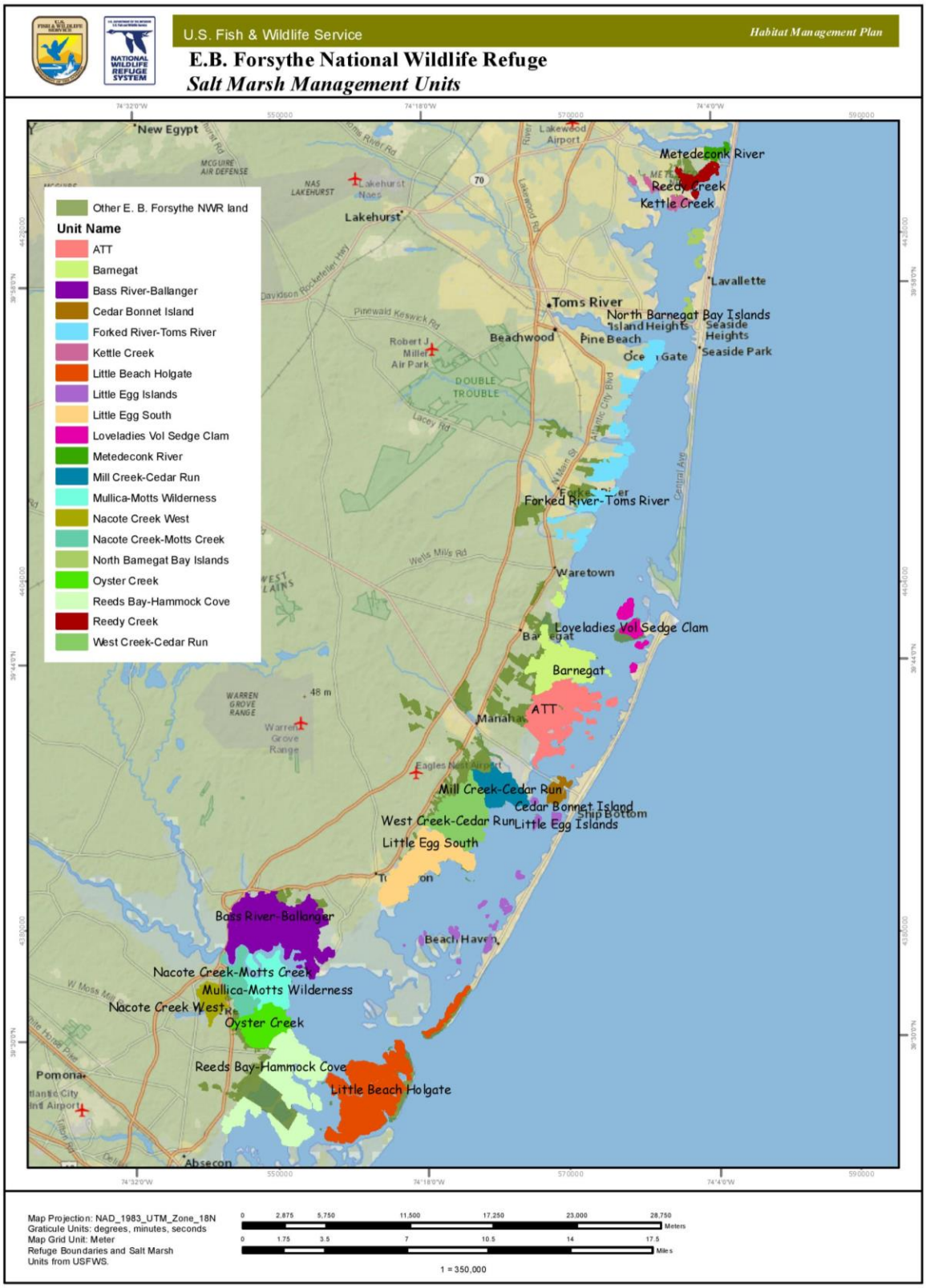
Map 3. E. B. Forsythe National Wildlife Refuge location and surrounding conserved lands.



Map 4. E. B. Forsythe National Wildlife Refuge generalized habitats.



Map 5. E. B. Forsythe National Wildlife Refuge Salt marsh Management Units.



APPENDIX C: POTENTIAL REFUGE RESOURCES OF CONCERN

Potential Refuge Resources of Concern for Edwin B. Forsythe NWR							
Species	**Seasons on Refuge[1]**	**Global Rank[2]**	**Federal T&E[3]**	**New Jersey Rank[4]**	**BCR 30[5]**	**Partners in Flight 44[6]**	**North Atlantic LCC Representative Species**
WATERBIRDS							
American Bittern (*Botaurus lentiginosus*)	Y	G4		E		ll	
Black-crowned Night-heron (*Nycticorax nyticorax*)	Y	G5		T			
Black Skimmer (*Rynchops niger*)	M B	G5		E			
Black Rail (*Laterallus jamaicensis*)	M B			T			
Black Tern (*Chlidonias niger*)	S M	G5					
Bonapart's Gull (*Chroicocephalus philadelphia*)	Y	G5		S			
Bridled Tern (*Sterna anaethetus*)	M						
Caspian Tern (*Hydroprogne caspia*)	S M	G5		SC			
Cattle Egret (*Bubulcus ibis*)	S M B	G5		T			
Clapper Rail (*Rallus longirostris*)	Y	G5			H	lb	B
Common Tern (*Sterna hirundo*)	M	G5		SC	M		B
Double-crested Cormorant (*Phalacrocorax auritus*)	Y	G5		S			
Forster's Tern (*Sterna forsteri*)	S M B	G5		S	H		
Glossy Ibis (*Plegadis falcinellus*)	Y	G5		SC	H		
Great Black-backed Gull (*Larus marinus*)	Y	G5		S			
Great Blue Heron (*Ardea Herodias*)	Y	G5		SC			
Great Cormorant (*Phalacrocorax carbo*)	W M	G5					
Great Egret (*Ardea alba*)	Y	G5		S			
Green Heron (*Butorides virescens*)	S M B	G5		S			
Gull-billed Tern (*Sterna nilotica*)	M	G5		SC			
Herring Gull (*Larus argentatus*)	Y	G5		S			
Horned Grebe (*Podilymbus auritus*)	M	G5		S	H		
King Rail (*Rallus elegans*)	S M B	G4G5				lb	B NB
Laughing Gull (*Leucophaeus atricilla*)	Y	G5		S			
Least Bittern (*Ixobrychus exilis*)	M	G5		SC		ll	B
Least Tern (*Sternula antillarum*)	M	G4		E	H	ll	B
Lesser Black-backed Gull (*Larus fuscus*)	W M	G5		S			
Little Blue Heron (*Egretta caerulea*)	Y	G5		SC			
Pied-billed Grebe (*Podilymbus podiceps*)	Y	G5		E			

PipingPlover (Charadrius melodus))	M	G3	T	E	HH	1a	B
Red Knot (*Calidris canutus*)	M	G5		T	HH		B
Red-throated Loon (*Gavia stellata*)	W M	G5		S	HH		
Ring-billed Gull (*Larus delawarensis*)	Y	G5		S			
Royal Tern (*Sterna maxima*)	M	G5		S			
Snowy Egret (*Egretta thula*)	Y	G5		SC			
Sora (*Porzana carolina*)	S M B	G5					
Tricolored Heron (*Egretta tricolor*)	S M B	G5		SC	M		
Virginia Rail (*Rallus limicola*)	Y	G5					
Yellow-crowned Night-heron (*Nyctanassa violacea)*	S M B	G5		T	M		

WATERFOWL							
American Black Duck (*Anas rubripes*)	Y	G5			HH	lb	B NB
American Wigeon (*Anas americana*)	W M	G5			M		
Black Scoter (*Melanitta nigra*)	W M	G5			H		NB
Blue-winged Teal (*Anas discors*)	Y	G5					
Brant (*Branta bernicla*)	M	G5			HH		
Bufflehead (*Bucephala albeola*)	W M	G5			H		NB
Canada Goose (*Branta canadensis*)	W M	G5			HH		
Canvasback (*Aythya valisineria*)	W M	G5			H		NB
Common Eider (*Somateria mollissima*)	M						
Common Goldeneye (*Bucephala clangula*)	W M	G5			M		
Common Merganser (*Mergus merganser*)	W M	G5					NB
Gadwall (*Anas strepera*)	Y	G5			M		
Greater Scaup (*Aythya marila*)	W M	G5			H		
Green-winged Teal (*Anas crecca*)	Y	G5			M		
Harlequin Duck (*Histrionicus histrioncus*)	M						
Hooded Merganser (*Lophodytes cucullatus*)	W M	G5			M		
Lesser Scaup (*Aythya affinis*)	W M	G5			H		
Long-tailed Duck (*Clangula hyemalis*)	W M	G5			H		
Mallard (*Anas platyrhynchos*)	Y	G5			H		
Northern Pintail (*Anas acuta*)	Y	G5			M		NB
Northern Shoveler (*Anas clypeata*)	W M	G5					
Red-breasted Merganser (*Mergus serrator*)	W M	G5			M		
Redhead (*Aythya americana*)	W M	G5					
Ring-necked Duck (*Aythya collaris*)	W M	G5					NB
Ross's Goose (*Chen rossii*)	W M	G5					
Ruddy Duck (*Oxyura jamaicensis*)	Y	G5			M		
Surf Scoter (*Melanitta perspicillata*)	W M	G5			H		
Tundra Swan (*Cygnus columbianus*)	W M	G5			H		
White-winged Scoter (*Melanitta fusca*)	W M	G5			H		NB
Wood Duck (*Aix sponsa*)	Y	G5			M		B

SHOREBIRDS							
American Golden-Plover (*Pluvialis dominica*)	M			X			
Amercian Oystercatcher (*Haemaptopus palliatus*)	M	G5		SC	HH	lb	
American Woodcock (*Scolopax minor*)	Y	G5			HH		
Baird's Sandpiper (*Calidris bairdii*)	M	G5		S			
Black-bellied Plover (*Pluvialis squatarola*)	M	G5		S	H		
Buff-breasted Sandpiper (*Tryngites subruficollis*)	M	G4		S			
Dunlin (*Calidris alpine*)	W M	G5		S	H		
Greater Yellowlegs (*Tringa melanoleuca*)	Y	G5		S	H		
Killdeer (*Charadrius vociferous*)	Y	G5		S	M		
Least Sandpiper (*Calidris minutilla*)	M W	G5		S	M		
Lesser Yellowlegs (*Tringa flavipes*)	Y	G5		S	M		
Long-billed Dowitcher (*Limnodromus scolopaceus*)	M W	G5		S			
Hudsonian Godwit (*Limosa hemastica*)	M			SC			
Marbled Godwit (*Limosa fedoa*)	M			S			
Pectoral Sandpiper (*Calidris melanotos*)	M W	G5		S			
Pipling Plover (*Charadrius melodus*)	M B		T	E			
Purple Sandpiper (*Calidris maritima*)	M W	G5		S	H		
Red Knot (*Calidris canutus*)	M W	G5		T	HH		B
Ruddy Turnstone (*Arenaria interpres*)	M W	G5		S	HH		
Sanderling (*Calidris alba*)	M W	G5		SC	HH		B
Semipalmated Plover (*Charadrius semipalmatus*)	SM	G5		S	M		
Semipalmated Sandpiper (*Calidris pusilla*)	M W	G5		SC	H		
Short-billed Dowitcher (*Limnodromus griseus*)	M W	G5		S	H		
Solitary Sandpiper (*Tringa solitaria*)	M W	G5		S	H		
Spotted Sandpiper (*Actitis macularius*)	SM B	G5		SC	M		
Stilt Sandpiper (*Calidris himantopus*)	M W	G5		S			
Upland Sandpiper (*Bartramia longicauda*)	SM B	G5		E	M	lb	
Western Sandpiper (*Calidris mauri*)	M W	G5		S	M		
Whimbrel (*Numenius phaeopus*)	MW	G5		SC	HH		
White-rumped Sandpiper (*Calidris fuscicollis*)	S M	G5		S	H		
Willet (*Tringa semipalmata*)	S M	G5		S	H		B
Wilson's Phalarope (*Phalaropus tricolor*)	M W	G5		S	H		
Wilson's Snipe (*Gallinago delicate*)	M W			S			

LANDBIRDS							
Acadian Flycatcher (*Empidonax virescens*)	S M B	G5		S		lb	
American Kestrel (*Falco sparverius*)	Y	G5		T		ll	
Bald Eagle (*Haliaeetus leucocephalus*)	Y	G5		E			
Baltimore Oriole (*Icterus galbula*)	Y	G5		S	H		
Barred Owl (*Strix varia*)	Y	G5		T			

Bay-breasted Warbler (*Dendroica castanea*)	M			S	H		
Black-and-white Warbler (*Mniotilta varia*)	S M B	G5			H		B
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	S M B	G5		S			
Black-throated Blue Warbler (*Dendroica caerulescens*)	M	G5		SC			
Black-throated Green Warbler (*Dendroica virens*)	M	G5		SC			
Blackburnian Warbler (*Dendroica fusca*)	M	G5		SC	M		
Blue-headed Vireo (*Vireo solitaries*)	M	G5		SC	M		
Blue-winged Warbler (*Vermivora pinus*)	S M B	G5		S	HH	lb	
Bobolink (*Dolichonyx oryzivorus*)	S M B	G5		T			
Broad-winged Hawk (*Buteo platypterus*)	S M B	G5		SC	H		
Brown Thrasher (*Toxostoma rufum*)	Y	G5		SC	H	ll	B
Canada Warbler (*Wilsonia canadensis*)	M	G5		SC			
Carolina Chickadee (*Poecile carolinensis*)	Y			S		ll	
Cerulean Warbler (*Dendroica cerulean*)	M	G5		SC		lb	
Chimney Swift (*Chaetura pelagica*)	S M B	G5		S	H	ll	
Chuck-wills Widow *Caprimulgus carolinensis*)	S M B	G5		S			
Cliff Swallow (*Petrochelidon pyrrhonota*)	M	G5		SC			
Coastal Plain Swamp Sparrow (*Melospiza nigrescens*)	S M B	G5			M		
Common Barn Owl (*Tyto alba*)	Y	G5		SC			
Common Nighthawk (*Chordeiles minor*)	Sp S F	G5		SC			B
Cooper's Hawk (*Accipiter cooperii*)	Y			SC			
Dickcissel (*Spiza americana*)	Y	G5		S			
Eastern Kingbird (*Tyrannus tyrannus*)	S M B	G5		S	H		
Eastern Meadowlark (*Sturnella magna*)	Y	G5		SC			B NB
Eastern Screech-owl (*Megascops asio*)	Y	G5		S			
Eastern Towhee (*Pipilo erythrophthalmus*)	Y	G5		S	H	ll	B
Eastern Whip-poor-will (*Caprimulgus vociferus*)	S M B	G5		SC	H		NB
Eastern Wood-pewee (*Contopus virens*)	S M B	G5		S		lb	B
Field Sparrow (*Spizella pusilla*)	Y	G5		S	H	ll	
Golden-winged Warbler (*Vermivora chrysoptera*)	M	G5		E	M		
Grasshopper Sparrow (*Ammodramus savannarum*)	Y	G5		T	M	ll	B
Gray Catbird (*Dumetella carolinensis*)	Y	G5		S	M	ll	
Gray-cheeked Thrush (*Catharus minimus*)	M	G5		SC			
Great-crested Flycatcher (*Myiarchus crinitus*)	S M B	G5		S	H		
Hooded Warbler (*Wilsonia citrine*)	S M B	G5		SC			
Horned Lark (*Eremophila alpestris*)	Y	G5		T			
Indigo Bunting (*Passerina cyanea*)	S M B	G5		S			
Kentucky Warbler (*Oporornis fromosus*)	S M B	G5		SC	H	lb	B
Least Flycatcher (*Empidonax minimus*)	M	G5		SC			
Loggerhead Shrike (*Lanius ludovicianus*)	W M	G5		E			
Long-eared Owl (*Asio otus*)	W M	G5		T			
Louisiana Waterthrush (*Seiurus motacilla*)	S M B	G5		S	H	lb	B

Marsh Wren (*Cistothorus palustris*)	Y	G5		S	H		B
Northern Bobwhite (*Colinus virginianus*)	Y				H	ll	
Northern Flicker (*Colaptes auratus*)	Y	G5		S	H		
Northern Goshawk (*Accipiter gentilis*)	W M	G5		E			
Northern Harrier (*Circus cyaneus*)	Y	G5		E			
Northern Parula (*Parula americana*)	M	G5		SC			
Olive-sided Flycatcher (*Contopus cooperi*)	M			S			
Osprey (*Pandion haliaetus*)	Y	G5		T			
Ovenbird (*Seiurus aurocapilla*)	M B	G5		S			B
Peregrine Falcon (*Falco peregrinus*)	Y	G5		E			
Pine Warbler (*Dendroica pinus*)	Y	G5		S			2B
Prairie Warbler (*Dendroica discolor*)	S M B	G5		S	HH	lb	B
Prothonotary Warbler (*Protonotaria citrea*)	S M B	G5		S	H	lb	B
Purple Finch (*Carpodacus purpureus*)	W M	G5		S			
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	W M	G5		T	M	ll	
Red-shouldered Hawk (*Buteo lineatus*)	Y	G5		E			B
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	M	G5		S			
Ruffed Grouse (Bonasa umbellus)	Y						
Rusty Blackbird (*Euphagus carolinus*)	W M			S	H		
Saltmarsh Sparrow (*Ammodramus caudacutus*)	Y	G5		SC	HH		B
Savannah Sparrow (*Passerculus sandwichensis*)	Y	G5		T			
Scarlet Tanager (*Piranga olivacea*)	SM B	G5		S	H	ll	
Seaside Sparrow (*Ammodramus maritimus*)	Y	G5		S	M	lb	
Sedge Wren (*Cistothorus platensis*)	Y	G5		E	M	lb	
Sharp-shinned Hawk (*Accipiter striatus*)	W M	G5		SC			
Short-eared Owl (*Asis flammeus*)	Y	G5		E	M		
Summer Tanager (*Piranga rubra*)	S M B			S			
Swainson's hawk (*Buteo swainsoni*)	M			S			
Veery (*Catharus fuscescens*)	M	G5		SC			
Vesper Sparrow (*Pooecetes gramineus*)	WM	G5		E			
Willow Flycatcher (*Empidonax traillii*)	S M B			S			
Winter Wren (*Troglodytes troglodytes*)	WM	G5		SC			
Wood Thrush (*Hylocichla mustelina*)	S M B	G5		SC	HH	lb	B
Worm-eating Warbler (*Helmitheros vermivorum*)	M	G5		SC		lb	B
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	W M	G5		S			
Yellow-billed Cuckoo (*Coccyzus americanus*)	S M B	G5		S			
Yellow-breasted Chat (*Icteria virens*)	Y	G5		SC		ll	
Yellow-throated Vireo (*Vireo flavifrons*)	M			S			

MAMMALS (excluding marine mammals)							
Eastern red bat (*Lasiurus borealis*)		G5		U			B
Eastern small-footed myotis (*Myotis eibii*)		G3		U			
Hoary bat (*Lasiurus cinereus*)		G5		U			

Little brown Bat (*Myotis lucifugus*)	Y			U			
Marsh rice rat *(Oryzomys palustris)*		G5		U			
River Otter (*Lontra canadensis*)		G5					
Silver-haired bat (*Lasionycteris noctivagans*)		G5		U			
Southern bog lemming (*Synaptomys cooperi)*		G5		U			

AMPHIBIANS							
Eastern Mud Salamander (*Pseudotriton montanus*)	Y	G5		T			
Fowler's Toad (*Anaxyrus woodhousii fowleri*)	Y	G5		C			
Marbled Salamander	Y	G5		C			B
Pine Barrens Treefrog (*Hyla andersonii*)	Y	G4		T			
Southern Gray Treefrog *(Hyla chrysoscelis)*	Y	G5		E			
Wood Frog (*Lithobates sylvatica*)	Y	G5					B

REPTILES							
Coastal Plains Milk Snake (*Lampropeltis temporalis*)	Y	GCN		S			
Eastern Box Turtle (*Terrapene carolina*)	Y	GCN		SC			
Eastern Kingsnake (*Lampropeltisg getula*)	Y	G5		SC			
Eastern Painted Turtle (*Pseudemys picta*)	Y	G5		S			X
Northern Diamondback Terrapin (*Malaclemys terrapin*)	Y	G4		S			B NB
Northern Pine Snake (*Pituophis melanoleucus*)	Y	G4		T			X
Spotted Turtle (*Clemmys insculpta*)	Y	G4		SC			

FISH							
Alewife (*Alosa pseudoharengus*)	Y	G5					X
American Brook Lamprey (*Lampetra appendix*)	Y	G4		X			
American Eel (*Anguilla rostrata*)	Y	G4					
American Shad (*Alosa sapidissima*)	S M	G5					X
Atlantic Croaker (*Micropogonias undulatus*)	Y	G5					
Atlantic Menhaden (*Brevoortia tyrannus*)	Y	G5					
Atlantic Sturgeon (*Acipenser oxyrhynchus*)	Y	G3		X			
Banded sunfish (*Enneacabthus chatedon*)	Y			SC			
Bay Anchovy (*Anchoa mitchilli*)	Y	G5					
Black-banded Sunfish (*Enneacabthus obesus*)							
Blueback Herring (*Alosa aestivalis*)	Y	G5					
Bluefish (*Pomatomus saltatrix*)	S M	G5					
Hickory Shad (*Alosa mediocris*)	S M	G5		SC			
Ironcolor Shiner (*Notropis chalybaeus*)	Y	G4		SC			

Margined Madtom (*Hyoentelium nigricans*)	Y			SC			
Rainbow Smelt (*Osmerus mordax*)	Y	G5		SC			X
Shield Darter (*Peca peltana*)	Y			SC			
Shortnose Sturgeon (*Acipenser brevirostrum*)	Y	G3	E	E			X
Spot (*Leiostomus xanthurus*)	Y	G5					
Striped Bass (*Morone saxatilis*)	Y	G5					
Summer Flounder (*Paralichthys dentatus*)	S M	GNR					
Weakfish (*Cynoscion regalis*)	S M B	GNR					
Winter Flounder (*Pleuronectes americanus*)	Y	G5					

MOLLUSKS							
Creeper (*Strophitus undulatus*)	Y	G5		SC			
Eastern Lampmussel (*Lampsilis radiate*)	Y	G5		T			
Tidewater Mucket (*Leptodea ochracea*)	Y	G3G4		T			
Triangle Floater (*Alasmidonta undulata*)	Y	G4		T			
Yellow Lampmussel (*Lampsilis cariosa*)	Y	G3G4		T			

INVERTEBRATES							
Terrestrial							
Bronze Copper	Y	G5		E			
Maritime Sunflower Borer (*Papaipema maritime*)	Y	G3		SC			
Frosted Elfin (*Callophrys irus*)	Y	G3		T			
Hessel's Hairstreak (*Callophyrs hesseli*)	Y	G3G4					
Monarch Butterfly (*Danaus plexippus*)	Y	G4					
Aquatic							
Blue Crab (*Callinectes sapidus*)	Y	G5					
Horseshoe Crab (*Limulus polyphemus*)	M B						B

PLANTS							
Coast Flat Sedge (*Cyperus polystachyos var. texensis)*	Y	G5					
Floating Marsh-Pennywort (*Hydrocotyle ranunculoides*)	Y	G5					
New England Bulrush (*Schoenoplectus novaeangliae*)	Y	G5					
Seabeach Amaranth (*Amaranthus pumilus*)	Y		T	E			
Sensitive Joint-vetch (*Aeschynomene virginica*)	Y	G2					
Swamp Pink (*Helonias bullata*)	Y	G3	T	E			

Potential Seasons on Refuge:[1]

W=Winter
S=Summer
M=Migration
Y=Year-round
B=Breeds or formerly did breed in Salem County

Global Ranking[2]

G1: Critically imperiled globally because of extreme rarity (five or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2: Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3: Either very rare and local throughout its range or found locally (even abundantly at some of the locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences in the range of 21-100.

G4: Apparently secure globally; although it may be quite rare in parts of its range, especially at the periphery.

G5: Demonstrably secure globally; although it may be quite rare in parts of its range, especially at the periphery

Federal Endangered Species List[3]

E=Endangered
T=Threatened

BCR30[5] **New England/Mid Atlantic Coast Bird Conservation Region Implementation Plan**

HH=Highest Priority
H=High Priority
M=Moderate Priority

PIF Area 44[6]**=Brian D. Watts. 1999. Partners in Flight Bird Conservation Plan for the Mid- Atlantic Coastal Plain** (Physiographic Area 44), Version 1.0.

IA=High Continental Priority and High Regional Responsibility
IB=High Continental Priority and Low Regional Responsibility
IIA=High Regional Priority and High Regional Concern
IIB= High Regional Priority and High Regional Responsibility
IIC= High Regional Priority and High Regional Threats

New Jersey State Rank[4]

E=Endangered

T=Threatened

SC=Special Concern

S=Secure-stable
SC=Conservation Concern
X=Priority Nongame Species that are not State listed as endangered, threatened, or conservation concern
U=Undetermined-unknown

North Atlantic LCC Representative Species

B= Breeding
NB=Non-breeding
X= other

APPENDIX D

POTENTIAL HABITAT MANAGEMENT STRATEGIES

This section identifies potential management tools or strategies that are available to land managers to achieve desired habitat objectives. These strategies were identified through successful refuge application, literature review and in consultation with other refuges and land managers**.** The information in the habitat management plans for Montezuma and Parker River National Wildlife Refuges was a major source for development of this section. Whenever possible, the prevailing management philosophy is to maintain natural habitat succession and processes. Habitats are not static. Natural disturbances, such as hurricanes, storm surges, wind throw, herbivory, beaver activity, disease and insect outbreaks, and fire are natural phenomena that often counter-balance succession. Managers can use these natural processes to maintain desired habitat type. It is important to monitor these habitats though, to ensure that the hands-off approach results in high value habitats for wildlife. Should intervention in the form of habitat manipulation become necessary, the potential actions listed below serve as a "toolbox" for managers.

Invasive Species Management

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

1. Prevent invasion of potential invaders.
2. Eradicate new and/or small infestations.
3. Control and/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, the refuge manager must understand the biology of the species to be controlled. A number of resources are available on the internet to assist with invasive species management. The following is a partial list of helpful websites:

- USDA Invasives Species Toolkit: http://www.invasivespeciesinfo.gov/toolkit/preventionbmp.shtml
- BLM Equipment Inspection and Cleaning Manual: http://www.usbr.gov/mussels/prevention/docs/EquipmentInspectionandCleaningManual2010.pdf
- Hazard Analysis of Critical Control Point Planning (HACCP) Manual: http://training.fws.gov/CSP/Resources/pdf/HACCP%20Manual.pdf
- National Invasive Species Information Center: http://invasivespeciesinfo.gov/index.shtml

- National Biological Information Infrastructure Invasive Species Information Node: http://invasivespecies.nbii.gov/
- The Global Invasive Species Initiative: http://tncweeds.ucdavis.edu/control.html
- USGS Invasive Species Program: http://biology.usgs.gov/invasive/
- Invasive Plant Atlas of New England (IPANE):http://nbii-nin.ciesin.columbia.edu/ipane/
- Weeds Gone Wild: http://www.nps.gov/plants/alien/index.htm
- Aquatic Invasive Species: http://www.midatlanticpanel.org/resources/links.htm

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

Work with Partners
Working with partners is the most effective way to manage invasive species on a refuge. Control efforts on the refuge will have little long-term impact if the surrounding lands and waters are infested with invasives. The New Jersey Invasive Species Strike Team (NJISST) has formed to reduce the spread and impact of invasive species through coordinated prevention, detection, and control measures. Refuge staff should continue to work with NJISST to stay informed regarding invasive species issues surrounding the Refuge.

Incorporate Invasive Species Prevention in All Facilities and Construction Projects
Minimize ground disturbance and restore disturbed areas. Require mulch, sand, gravel, dirt, and other construction materials to be certified as free of noxious weed seeds. Avoid stockpiles of weed-infested materials. To prevent the spread of invasives along transportation corridors, maintain invasive species-free zones along trails, around parking lots and boat launches, and at other related facilities. Inspect these areas often and control new infestations immediately. Minimize the number and size of roads on the Refuge. Remove all mud, dirt, and plant parts from all equipment between projects or when equipment is moved from one location to another.

Incorporate Invasive Species Prevention in Impoundment Design and Management
Minimize infrastructure development in managed wetland units to reduce unnecessary dikes, waterways, and access roads. These often are sources of infestation and pathways of spread. Plant a native cool season grass mix that will establish quickly to stabilize banks and dikes and to prevent the establishment of invasive species. Consider adding annual ryegrass (*Lolium perenne*) so bare soil is not exposed to erosion or to invasive plant seeds and rhizomes. This non-native plant will establish quickly and then drop out of the mix after one or two years. Time flooding and drawdowns to minimize the germination and spread of invasive plant seeds and encourage the growth of native species. Flooding can also be used to stunt the growth of some invasive species as described below under Water Level Management.

Early Detection and Rapid Response
Where prevention is not possible, early detection and rapid response is the next best strategy. Success will depend, in part, on participation by all refuge staff, contractors, volunteers, and visitors in efforts to report and respond to invasions. The refuge manager must have access to up-to-date reliable scientific and management information on species that are likely to invade. The NJISST is an excellent source for such information. For some species, an active monitoring protocol may be established to facilitate early detection. For example, artificial substrates may be suspended in water bodies and checked regularly for the early detection of zebra mussels on the Refuge. When small infestations are spotted, they should be eradicated as soon as possible. The site must then be monitored for several years to ensure the control was effective.

Prioritizing Invasive Species Control Efforts
The first step in prioritizing invasive species control efforts is to determine the abundance and distribution of invasive species on the Refuge or management unit. However, control efforts should not be delayed to collect statistically rigorous survey data. Baseline data regarding the location of many invasives on the Refuge already may be available via observations of staff, volunteers, contractors, and refuge visitors. These observations should be documented and mapped. If a more formalized mapping procedure is desired the North American Weed Management Association (http://www.nawma.org) has information on mapping procedures. There are a number of ranking tools to assist land managers with the daunting task of prioritizing their invasive plant control efforts. The *Fulfilling the Promise* National Invasive Species Management Strategy Team recommends using the following order of priority to determine appropriate actions:

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

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

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

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

- Morse, L.E., J.M. Randall, N. Benton, R. Hiebert, and S. Lu. 2004. An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impact on Biodiversity. Version 1. NatureServe, Arlington, Virginia. *Website:* http://www.natureserve.org/getData/plantData.jsp

- R. D. Hiebert and J. Stubbendieck. 1993. *Handbook for Ranking Exotic Plants for Management and Control* (Natural Resources Report NPS/NRMWRO/NRR-93/08), U.S. National Park Service, Midwest Regional Office, Omaha, NE.

- APRS Implementation Team. 2000. Alien plants ranking system version 5.1. Jamestown, ND: Northern Prairie Wildlife Research Center Online. (Version 30SEP2002). *Website*: http://www.npwrc.usgs.gov/resource/literatr/aprs

Restore Altered Habitats and Reintroduce Native Plants

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

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

Biological Control

Biological control is the use of animals or disease organisms that feed upon or parasitize the invasive species target. Usually, the control agent is imported from the invasive species' home range, and artificially high numbers of the control agent are fostered and maintained. There are also "conservation" or "augmentation" biological control methods where populations of biological agents already in the environment (usually native) are maintained or enhanced to target an invasive species. The advantages of this biological control are that it avoids the use of chemicals and can provide relatively inexpensive and permanent control over large areas. Appropriate control agents do not exist for all invasive species. Petitions must be submitted to, and approved by, the USDA Technical Advisory Group on weed biological control before any proposed biological control agent can be released in the United States.

Manual and Mechanical Control

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

in place), girdling (removing cambium layer), mulching, tilling, smothering (black plastic or other material), 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 high costs for labor and difficulty in controlling large areas of infestation. For many invasive species, mechanical treatments alone are not effective, especially for mature plants or well-established plants. For some invasive plants, mechanical treatments alone exacerbate the problem by causing vigorous suckering. Mechanical treatments are most effective when combined with herbicide treatments (e.g. girdle and herbicide treatment).

Water Level Management in Impoundments

Water level management is also used to control invasives and promote desirable plants. Robust plants such as *Phragmites* require air pockets to survive. Flooding an impoundment through all or part of a growing season, particularly after mowing or chemical application, stymies growth of robust vegetation. Drawdown following flooding will allow for germination of moist-soil plants preferred by waterfowl. Timing and speed of drawdown affects species diversity, density, and seed production. Slow drawdown (4-8 weeks) early in the season creates greater species diversity, while fast drawdown (< 2 weeks) results in lush, extensive stands of less diverse vegetation. Late in the season, however, slow drawdown promotes greater vegetation diversity and density, whereas fast drawdown promotes undesirable plant composition (Lane and Jensen 1999). Flooding also promotes robust perennial control by muskrats.

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

Prescribed Fire

Fire can either suppress or encourage any given plant species, so great care must be taken to understand the ecosystem and the life histories of the native and invasive plants before use. This tool is most successful when it is used to mimic natural fire regimes. Proper timing of prescribed burns is essential for controlling target invasive species. The most effective fires for invasive plant control occur just prior to flower or seed set, or at the young sapling/seedling stage. Invasive plants are well adapted to disturbance, often surviving fire and rapidly spreading through a disturbed landscape. Studies in northeastern successional habitats have generally shown that fire alone will not remove invasive shrubs. Additional herbicide and/or cutting treatments are necessary (Richburg and Patterson 2003).

This tool requires a good deal of pre-planning (including permitting) and requires a trained crew available on short notice during the burn window. Spot burning using a torch can be a good method to control small infestations of invasive plants. It can be advantageous where it is too wet or where there is too little fuel to carry a prescribed fire.

There are several principles that should be considered when employing prescribed fire to control woody plants:

1. Plant mortality is strongly tied to death of "growth points" (i.e. meristems/buds), which are more sensitive to heat damage when actively growing, and when tissue moisture is high (Miller 2000). Therefore, applying fire during spring, when target plants are mobilizing water/nutrients and breaking dormancy of leaf/flower buds, or during fall cold-acclimation periods, is more likely to kill growth points than prescribed fire during dormant periods.
2. Concentrations of metabolic compounds (i.e.. sugars, salts, lignins) vary seasonally, and have been shown to relate to seasonal effects on shrubs. Consequently, timing of treatments may be more important than the type (cutting versus burning) in controlling invasive plants. To maximally reduce biomass, fires should be applied during periods of low below-ground carbohydrate storage (i.e., immediately after spring flushing and growth) and should be followed with a second growing season treatment (such as mowing, herbicide, or more prescribed fire) before total non-structural carbohydrate (TNC) levels are replenished. Repeated burning (several consecutive years) during the low point of a plant's TNC cycle can amplify the negative effects of the treatment (Richburg and Patterson 2003, Richburg et al. 2004).

Deer Control

Invasive plant problems often are exacerbated by white-tailed deer over-browsing native species. Public hunting should be used to reduce the deer population wherever necessary and logistically feasible. Deer control must be conducted in combination with other invasive plant control measures as deer control alone will not be effective if invasive plants are already established. Deer exclosures should be considered only in small highly sensitive areas (e.g., where invasive plants are out-competing rare plants and the rare plants will be extirpated without intervention). This method is labor intensive and costly to employ and should only be used on a very limited basis until the native community is firmly established and the invasive species are controlled.

Herbicides

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

The right chemicals, applied correctly, can produce desired results over a large area for a reasonable cost. However, chemicals may affect non-target species at the site (including the applicator) and/or contaminate surface or groundwater. Proper planning includes using the most

target-specific, least hazardous (to humans and the environment), and most effective chemical for the job. Additionally, the minimum effective dosage should be applied.
Herbicides often are most effective when used in combination with mechanical methods described above.

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

Beaver Control
Because beavers are part of the natural landscape, and can be beneficial in creating wetland habitats, harvest of nuisance beavers will only be conducted when negative impacts are determined to be excessive. Beavers can interfere with impoundment management by damaging or clogging water control structures and altering water levels on surrounding lands so impoundments either cannot be filled or cannot be drained. Whenever possible, water control structures and drainage pipes should be fitted with guards to prevent beavers from clogging the pipes or damaging the structures. Trapping is the most effective method of removing problem beavers and may be conducted either during fur season or by contract at other times of the year.

Control of Over-abundant or Non-native Waterfowl Populations
Controlling invasive or over-abundant waterfowl, such as mute swans, snow geese, and resident population Canada geese, is a strategy used to protect native water birds and fisheries, and prevent the destruction of wetland habitats on refuges. Control methods include harvest, harassment, egg addling, sterilization, and removal.

The Atlantic Flyway Council's (2003) "*Atlantic Flyway Mute Swan Management Plan 2003-2013* outlines the coordination of state (lead) and federal wildlife agencies "to reduce mute swan populations in the Atlantic Flyway to levels that will minimize negative ecological impacts to wetland habitats and native migratory waterfowl and to prevent further range expansion into unoccupied areas." Target populations of mute swans vary by state and range from 0 to 500 free-flying birds.

In fall 2006, the U. S. Fish and Wildlife Service completed an Environmental Impact Statement that included a multi-faceted approach for managing resident Canada geese (http://migratorybirds.fws.gov/issues/cangeese/deis.html). At the recommendation of the Atlantic Flyway Council, the Service approved the use of special regulations beginning in 2007 to help curb the population growth of these geese in the eastern U.S. Included in this approach was the expansion of hunting methods during September seasons.

In 2009, the U. S. Fish and Wildlife Service, Canadian Wildlife Service and Atlantic Flyway Council developed a Management Plan for Greater Snow Geese in the Atlantic Flyway. This plan seeks to sustain the greater snow goose populations at a level that maximizes a balance between benefits to society and habitat integrity (Atlantic Flyway Council 2009). It sets a population objective for greater snow geese of 500,000 to 750,000 to optimize the balance between a healthy population that can easily recover from catastrophic events and one that does

not negatively impact its natural habitats and associated biodiversity. The population is considered overabundant and is causing habitat and crop damage on staging and wintering areas.

Expanded hunting opportunities are encouraged for all species of over-abundant or non-native waterfowl where possible, including opening areas used by these species that are normally closed to hunting. Hunting in sanctuaries that serve as roosts often has a synergistic effect. Besides birds that are harvested directly, some are driven to new areas where they might not otherwise have been harvested and the surviving flocks often abandon the disturbed roost site. In extreme situations, direct culling is an option, especially for waterfowl that undergo a molt on site.

Beach/Dune Management

To date, natural processes, such as salt spray, storms, wind and tide, have maintained Refuge barrier islands in a natural state. The closures of nesting and foraging areas at Little Beach Island and Holgate Beach have been deemed necessary to protect sensitive nesting bird species and habitats. Posting "no disturbance" or "area closed" signs near bird nesting areas, nesting islands, or individual nest locations, is conducted to help prevent disturbance caused by pedestrians and boaters. Signs are placed in appropriate areas in the spring and are maintained throughout the nesting season. If disturbance is noted by refuge staff, additional areas are posted, and Law Enforcement patrols are conducted.

While Refuge sites are critically important for beach-nesting birds, the sites have a history of not meeting Recovery Plan goals for piping plovers. Over the next few years, Refuge staff plan to focus on determining the causes of low productivity. To start, we have applied for a grant that will, in part, determine the optimal habitat attributes for nesting and brood rearing and whether these habitats are limiting the population at Forsythe.

There are no plans for future habitat modification projects on the Refuge. If research determines that representative species would benefit from specific manipulations, potential management projects on Holgate Beach or Little Beach Island would be considered. However, due to the wilderness status of these sites, any habitat manipulation would need to be assessed through the lens of the Wilderness Act.

Upland, Wetland, and Pine Barrens Forest Management-Silvicultural Prescriptions

Active management generally is not necessary to maintain Refuge forest communities. However, if a forested tract is degraded and not meeting habitat objectives, then a silvicultural prescription (forest management plan) may be needed. A silvicultural prescription is a detailed set of written instructions for the treatment of a forested property and should be developed prior to the treatment of forested tracts other than invasive species treatments http://www.sref.info/courses/mtf2/mtf2-2-1.pdf. A forester should be consulted to develop a prescription based on the site conditions and habitat objectives identified in the Habitat Management Plan.

Shrubland Management

Nearly all upland shrublands need to be periodically disturbed to maintain their shrubland character. Shrublands left undisturbed will eventually succeed to young forests and will no longer provide habitat for shrubland dependent wildlife. The number of years between

disturbances depends on how quickly a particular shrubland matures and also at what stage the shrubland is being managed. As an example, a very young shrubland that is dominated by herbaceous vegetation with only a few scattered shrubs may provide excellent habitat for singing woodcock and nesting field sparrows, but poor habitat for golden-winged and chestnut-sided warblers. If your goal is to manage for singing woodcock, then you would likely disturb the area more regularly than if you were managing for golden-winged warblers. Managing several different shrubland units will allow a refuge to disturb a few units every year or every few years and still provide all shrubland stages from very young to very mature.
The seasonal timing of disturbance can alter the vegetative character of the shrubland. Resprouting of both trees and shrubs will be greater if cut after the growing season (Sepik et al. 1981). Cutting encroaching trees during the growing season will often result in better control of trees the following year whereas cutting during the dormant season will often stimulate more robust tree resprouting the following year. If managing during the growing season, care should be taken to time the disturbance after most bird species have fledged. Listed below are several techniques available for the management of shrubland vegetation.

Mechanized Equipment
Several pieces of equipment are available for use in cutting shrubs and small trees (see bullets below). All of these tools can be used with varying degrees of effectiveness, depending on what is being cut. Special consideration needs to be given to ground disturbance when using heavy equipment. Soils may be compacted and rutted which could cause a change in the vegetation component of the area. Disturbed soils are also more likely to promote germination of invasive species, an undesirable outcome of any shrubland management program.

Examples of shrub and tree cutting equipment:

- Drum mowers – for removal of small trees.
- Hydro-Axe – this piece of equipment consists of an articulated tractor with a mower mounted on the front. It is generally able to cut trees up to approximately 6-8" dbh. Woody material is reduced to fine chips, often finer than those resulting from a roller mower.
- Roller Chopper Mower – used to knock down and chop up shrubs and trees. This technique causes significant disturbance to the soil and should probably be reserved for situations where the area is going to be seeded after treatment.
- Mowing and brush hogging – mowing is an appropriate treatment for grass, forbs and small shrubs and saplings. Vegetation > 4 inches often needs a higher powered machine.
- Girdling – Girdling can be appropriate to kill single trees to create snags and open up the canopy. It can also cause stump sprouting.
- Chainsaw – Saw work can be appropriate to remove single trees or groups of trees to open up the canopy. Stump sprouting may occur.

Chemical Treatment
Chemical treatment in shrublands usually involves the selective spraying of individual or small groups of trees or undesirable shrubs (e.g., invasive species or post mature plants) to maintain the

shrub component of the vegetation and prevent trees from shading out the shrubs. This technique can be very labor intensive over a large area if there is a significant tree component to the shrubland. If trees are sprayed on a regular basis (e.g., every few years) then it can be a relatively easy process, assuming the shrubland acreage is small. Over time, shrub density is likely to increase which in turn decreases encroachment of trees. In the best of situations, this scenario will result in a climax shrub community (Niering and Goodwin 1974). This technique could be very useful when managing for mature shrublands, such as providing foraging areas for migrating and wintering songbirds.

Prescribed Fire

Prescribed fire can be difficult to use effectively as a shrubland maintenance tool in itself. Shrublands can be too moist and the shrubs too sparse to produce a good burn. However, prescribed fire can be used in conjunction with another management technique, such as after mowing, to help return nutrients to the soil and stimulate regrowth of treated shrubs.

Invasive Species Control

Any disturbance to a shrubland has the potential to stimulate the germination or continued growth of invasive species. Care should be taken to reduce this potential by disturbing the soil as little as possible. Any equipment used on the site should be free of invasive plant parts and seeds. Additionally, within one or two years after disturbing a shrubland the area should be surveyed for the presence of invasive species and where possible these plants should be treated with one or more of the strategies described in the invasive species control section earlier in this document.

Shrubland Establishment

Patch size and distribution on the landscape are important considerations in planning and managing habitats. Small patches of habitat (<25 acres) or habitat patches with a lot of edge may be suitable for shrubland establishment as shrubland-dependent species tend to be less area-sensitive than grassland and forest species.

Shrublands may be established by allowing the area to succeed naturally, by seeding herbaceous and shrub species, by planting shrub seedlings or saplings, or by a combination of these methods. The plants in the surrounding landscape should be surveyed to determine the seed stock. If desirable shrubs are in the surrounding landscape, the invasive species load is low, and there is not an immediate need for shrubland habitat, then natural succession should be allowed to proceed. Invasive or other undesirable species can be selected out with herbicides. It may be desirable to plant only those species that are not already present in the surrounding landscape.

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

they become well-established. The invasives in the surrounding landscape also should be controlled as resources permit.

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

Grassland Management

Historically, most of the Northeast was forested, except for a period following European settlement when much of the region was cleared for agriculture and subsequently grasslands and open fields became abundant. Currently, Forsythe Refuge contains a limited amount of grasslands. Grasslands are presumed to have been a relatively small component of the pre-European habitat found in this area; however fires, both natural and those set by Native Americans, were frequent in this area. Grasslands provide breeding habitat for representative species, such as the northern bobwhite, as well as migration and wintering habitat for migratory birds.

Refuge grasslands consist of both cool- and warm-season grasses. Cool season grasses start growing in spring as soon as the snow melts and the days start to warm up. They grow best in spring and fall and tend to stop growing during the hot dry days of summer. They are usually relatively short and do not grow as dense as many warm-season grasses. Conversely, warm-season grasses do not start growing until late spring and grow best during the hot dry summer months. They generally grow taller and denser than cool-season grasses.

Currently, most cool-season grasses on the refuge are exotic species from. Most warm-season grasses are native to U.S. prairies and some varieties are native to the Northeast as well. Some seed companies are beginning to propagate native cool season grasses making them more available for planting, but still at a relatively high price.

Without periodic treatment most refuge grasslands quickly revert to brush and forests. While most early successional habitats on the Refuge will be managed as shrubland or reverting forest, it is desirable to maintain some patches of grassland to provide a natural array of habitats and provide for grassland-dependent species. Several management techniques designed to maintain grasslands on the Refuge are explained below.

Mowing/Haying

Mowing and haying (collectively, cutting) are very effective at controlling broad leaf forbs and woody species, provided it occurs during the growing season of these plants. Cutting should be delayed until after the nesting season of most grassland birds (usually mid-July) but should be done as soon as possible after this date to allow for maximum stress on invading forbs and shrubs. Depending on the amount of forb and shrub invasion, some grassland fields may require repeated cutting during any one season. Cutting should be done often enough to keep the grassland in the intended state. This may require annual haying to provide habitat for species that prefer short sparse grasslands such as grasshopper sparrow, or mowing every third year (or

more) for species that prefer tall rank grasslands such as Henslow's sparrow. Mowing tends to accumulate thatch whereas haying removes this thatch and keeps the grassland in a more open condition. Occasionally it is possible to selectively mow small sections of forb and tree encroachment within larger grassland fields, thus saving the refuge resources and reducing disturbance to the grassland as a whole.

Prescribed Fire

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

Most prescribed fires will result in only a top-killing of woody plants. Therefore, resprouting is likely to occur later in the season. This top-killing is usually sufficient to maintain the woody species as only a small portion of the vegetative community provided fire is applied on a regular schedule (e.g., once every four years). Broad leaf forbs are often less susceptible to damage from fire and may not be controlled at all. It may be necessary to use other management techniques (mowing, herbicide) to effectively control broad leaf forbs within a grassland unit.

Fire removes thatch from a grassland unit. This result is often desirable, but can also be detrimental to species that perfer a thatch component for nesting (e.g., Henslow's sparrow) (Zimmerman 1988). The conversion of thatch into nutrients by fire results in an immediate return of nutrients to the soil, stimulating the growth of new plants during the growing season immediately following the fire.

Herbicides

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

Disking

Fall and winter disking can be used to decrease warm season grass cover and increase forb cover in established warm season grasslands (Gruchy and Harper 2006). Forbs are an important component of bobwhite brood habitat. This technique should not be used if there are invasive plants in or surrounding the grassland as the soil disturbance likely will provide ideal conditions for invasives.

Grassland Establishment

As stated above, patch size and distribution on the landscape are important considerations in planning and managing habitats. Grasslands should not be established in fields that are 25 acres or less as most grassland-dependent species are area sensitive. Field shape also is important; edge should be minimized so round or square fields are preferable to linear fields. Seeding and planting desirable plants can be used to enhance existing grasslands, in restoration of degraded grasslands, or in conversion of croplands. Selection of species and ecotypes is a critical step in seeding and restoration. While many species are commercially available for grassland restoration, few are native to the Northeast. Using local seed and plant materials is important in restoration as plants have wide genetic diversity across geographic space.

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

To establish warm season grasses, weeds are usually controlled by clipping with a sicklebar mower set at a height where only the leaf tips of the warm season grass seedlings are cut, and the growing point is not damaged. This will reduce the shading competition but not hurt the emerging seedlings. Mowing weeds before flowering will prevent seed production. Mowing 2-3 times may be necessary during the establishment year; however, if clipped too frequently, weeds may "stool out" (grow out instead of up) (NRCS-USDA 2006).

Impoundment Management

Water Level Manipulation

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

several weeks) drawdowns will provide a greater diversity of moist-soil plants than faster (over a few days) drawdowns (Frederickson and Taylor 1982).

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

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

Vegetation Management

Plants that occur in an impoundment can be either desirable or undesirable based on their value to wildlife. Generally, plants that provide cover, energy, or nutritional value for objective wildlife are desirable. Plants that quickly develop monocultures and impede foraging by wildlife are undesirable, even if they are native. Whether a plant is desirable or not also depends on why the impoundment is being managed. For example, cattail (Typha sp.) is undesirable to shorebirds and waterfowl because it forms dense monotypic stands and reduces foraging habitat (mudflats and moist-soil vegetation) of shorebirds and waterfowl. In contrast, it provides cover and breeding habitat for marsh birds, and therefore is desirable if managing for those species. The challenge of impoundment management is balancing the needs of various wildlife guilds. In addition to the water level manipulation techniques listed in the previous paragraphs, below are available strategies for promoting desirable vegetation and controlling undesirable or invasive plants.

Herbicide

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

Prescribed Burning

Prescribed burning in impoundments has been used to control undesirable vegetation and may promote growth of desirable plants (Baldassarre and Bolen 1994). Burning can kill perennial plants and reduce excessive litter accumulation, allowing moist soil vegetation to germinate. However, successful control of species such as cattail requires root burns, which rarely occur since rhizomes are usually covered by a layer of soil, mud and/or water. Prescribed fire will often remove accumulated leaf litter and dead standing material, giving seeds of other species an

opportunity to germinate. Removing litter may also increase shoot germination of undesirable plants by increasing light availability to the ground.

Seeding/Planting

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

APPENDIX E: PLANT LISTS FOR E. B. FORSYTHE NWR PROPERTIES

Accepted Symbol	Scientific Name	Common Name	Family	Native
ABTH	Abutilon theophrasti	Velvetleaf	Malvaceae	I
ACNE2	Acer negundo	boxelder	Aceraceae	N
ACPL	Acer platanoides	Norway maple	Aceraceae	I
ACRU	Acer rubrum	red maple	Aceraceae	N
ACSA2	Acer saccharinum	silver maple	Aceraceae	N
ACMI2	Achillea millefolium	common yarrow	Asteraceae	N
AGMA3	Agalinis maritima	saltmarsh false foxglove	Scrophulariaceae	N
AGPU5	Agalinis purpurea	purple false foxglove	Scrophulariaceae	N
AGAL5	Ageratina altissima	white snakeroot	Asteraceae	N
AGCA5	Agrostis capillaris	colonial bentgrass	Poaceae	I
AGPE	Agrostis perennans	upland bentgrass	Poaceae	N
AGST2	Agrostis stolonifera	creeping bentgrass	Poaceae	I
AIAL	Ailanthus altissima	tree of heaven	Simaroubaceae	I
AJRE	Ajuga reptans	common bugle	Lamiaceae	I
ALFA2	Aletris farinosa	white colicroot	Liliaceae	N
ALPE4	Alliaria petiolata	Garlic mustard	Brassicaceae	I
ALCA3	Allium canadense	meadow garlic	Liliaceae	N
ALVI	Allium vineale	wild garlic	Liliaceae	I
ALIN2	Alnus incana	gray alder	Betulaceae	N
ALSE2	Alnus serrulata	hazel alder	Betulaceae	N
ALAE	Alopecurus aequalis	shortawn foxtail	Poaceae	N
ALOF2	Althaea officinalis	common marshmallow	Malvaceae	I
AMAR2	Ambrosia artemisiifolia	annual ragweed	Asteraceae	N
AMAR3	Amelanchier arborea	common serviceberry	Rosaceae	N
AMCA4	Amelanchier canadensis	Canadian serviceberry	Rosaceae	N
AMOB2	Amelanchier obovalis	coastal serviceberry	Rosaceae	N
AMBR	Ammophila breviligulata	American beachgrass	Poaceae	N
AMBR7	Ampelopsis brevipedunculata	Amur peppervine	Vitaceae	I
ANGE	Andropogon gerardii	big bluestem	Poaceae	N
ANGL2	Andropogon glomeratus	bushy bluestem	Poaceae	N
ANGY2	Andropogon gyrans	Elliott's bluestem	Poaceae	N
ANVI2	Andropogon virginicus	broomsedge bluestem	Poaceae	N
ANVE	Angelica venenosa	hairy angelica	Apiaceae	N
ANNE	Antennaria neglecta	field pussytoes	Asteraceae	N
ANPL	Antennaria plantaginifolia	woman's tobacco	Asteraceae	N
ANAR6	Anthemis arvensis	corn chamomile	Asteraceae	I
ANCO2	Anthemis cotula	stinking chamomile	Asteraceae	I

ANAR7	Anthoxanthum aristatum	annual vernalgrass	Poaceae	I
ANOD	Anthoxanthum odoratum	sweet vernalgrass	Poaceae	I
APAM	Apios americana	groundnut	Fabaceae	N
APAN2	Apocynum androsaemifolium	spreading dogbane	Apocynaceae	N
APCA	Apocynum cannabinum	Indianhemp	Apocynaceae	N
AQCA	Aquilegia canadensis	red columbine	Ranunculaceae	N
ARTH	Arabidopsis thaliana	mouseear cress	Brassicaceae	I
ARUV	Arctostaphylos uva-ursi	kinnikinnick	Ericaceae	N
ARSE2	Arenaria serpyllifolia	thymeleaf sandwort	Caryophyllaceae	I
ARTR	Arisaema triphyllum	Jack in the pulpit	Araceae	N
ARLO16	Aristida longespica	slimspike threeawn	Poaceae	N
ARAB3	Artemisia absinthium	absinthium	Asteraceae	I
ARLU	Artemisia ludoviciana	white sagebrush	Asteraceae	N
ARST6	Artemisia stelleriana	oldwoman	Asteraceae	I
ASAM	Asclepias amplexicaulis	clasping milkweed	Asclepiadaceae	N
ASIN	Asclepias incarnata	swamp milkweed	Asclepiadaceae	N
ASLA2	Asclepias lanceolata	fewflower milkweed	Asclepiadaceae	N
ASPU2	Asclepias purpurascens	purple milkweed	Asclepiadaceae	N
ASRU	Asclepias rubra	red milkweed	Asclepiadaceae	N
ASSY	Asclepias syriaca	common milkweed	Asclepiadaceae	N
ASTU	Asclepias tuberosa	butterfly milkweed	Asclepiadaceae	N
ASVA	Asclepias variegata	redring milkweed	Asclepiadaceae	N
ASOF	Asparagus officinalis	garden asparagus	Liliaceae	I
ASGL4	Astragalus glycyphyllos	licorice milkvetch	Fabaceae	N
ATFI	Athyrium filix-femina	common ladyfern	Dryopteridaceae	N
ATCR2	Atriplex cristata	crested saltbush	Chenopodiaceae	N
ATPA4	Atriplex patula	spear saltbush	Chenopodiaceae	I
BAHA	Baccharis halimifolia	eastern baccharis	Asteraceae	N
BAVE	Barbarea verna	early yellowrocket	Brassicaceae	I
BETH	Berberis thunbergii	Japanese barberry	Berberidaceae	I
BELE	Betula lenta	sweet birch	Betulaceae	N
BEPO	Betula populifolia	gray birch	Betulaceae	N
BIBI7	Bidens bipinnata	Spanish needles	Asteraceae	N
BICO	Bidens coronata	crowned beggarticks	Asteraceae	N
BIFR	Bidens frondosa	devil's beggartick	Asteraceae	N
BOCY	Boehmeria cylindrica	smallspike false nettle	Urticaceae	N
BOVI	Botrychium virginianum	rattlesnake fern	Ophioglossaceae	N
BRSC	Brasenia schreberi	watershield	Cabombaceae	N
BRIN2	Bromus inermis	smooth brome	Poaceae	N
BRSE	Bromus secalinus	rye brome	Poaceae	I
BRTE	Bromus tectorum	cheatgrass	Poaceae	I
BUCA2	Bulbostylis capillaris	densetuft hairsedge	Cyperaceae	N

CAED	Cakile edentula	American searocket	Brassicaceae	N
CACA4	Calamagrostis canadensis	bluejoint	Poaceae	N
CACO71	Calamagrostis coarctata	arctic reedgrass	Poaceae	N
CAST36	Calamagrostis stricta	slimstem reedgrass	Poaceae	N
CABR2	Calamovilfa brevipilis	pine barren sandreed	Poaceae	N
CAHE3	Callitriche heterophylla	twoheaded water-starwort	Callitrichaceae	N
CATE19	Callitriche terrestris	terrestrial water-starwort	Callitrichaceae	N
CASE13	Calystegia sepium	hedge false bindweed	Convolvulaceae	N
CARA2	Campsis radicans	trumpet creeper	Bignoniaceae	N
CABU2	Capsella bursa-pastoris	shepherd's purse	Brassicaceae	I
CABU3	Cardamine bulbosa	bulbous bittercress	Brassicaceae	N
CAFL14	Cardamine flexuosa	woodland bittercress	Brassicaceae	I
CAPE3	Cardamine pensylvanica .	Pennsylvania bittercress	Brassicaceae	N
CAAT4	Carex atlantica	prickly bog sedge	Cyperaceae	N
CAHY4	Carex hystericina	bottlebrush sedge	Cyperaceae	N
CAKO2	Carex kobomugi	Japanese sedge	Cyperaceae	I
CALU5	Carex lurida	shallow sedge	Cyperaceae	N
CAPA17	Carex pallescens	pale sedge	Cyperaceae	N
CAPE6	Carex pensylvanica	Pennsylvania sedge	Cyperaceae	N
CASE6	Carex seorsa	weak stellate sedge	Cyperaceae	N
CAST6	Carex straminea	eastern straw sedge	Cyperaceae	N
CAST41	Carex striata	Walter's sedge	Cyperaceae	N
CAST8	Carex stricta	upright sedge	Cyperaceae	N
CAAL27	Carya alba	mockernut hickory	Juglandaceae	N
CABI8	Catalpa bignonioides	southern catalpa	Bignoniaceae	N
CEAM	Ceanothus americanus	New Jersey tea	Rhamnaceae	N
CEOR7	Celastrus orbiculatus	Oriental bittersweet	Celastraceae	I
CEOC	Celtis occidentalis	common hackberry	Ulmaceae	N
CETE	Celtis tenuifolia	dwarf hackberry	Ulmaceae	N
CETR	Cenchrus tribuloides	sanddune sandbur	Poaceae	N
CEST8	Centaurea stoebe	spotted knapweed	Asteraceae	I
CEFO2	Cerastium fontanum	common mouse-ear chickweed	Caryophyllaceae	I
CECA4	Cercis canadensis	eastern redbud	Fabaceae	
CHFA2	Chamaecrista fasciculata	partridge pea	Fabaceae	N
CHTH2	Chamaecyparis thyoides	Atlantic white cedar	Cupressaceae	N
CHCA2	Chamaedaphne calyculata	leatherleaf	Ericaceae	N
CHMA15	Chamaesyce maculata	spotted sandmat	Euphorbiaceae	N
CHNU9	Chamaesyce nutans	eyebane	Euphorbiaceae	N
CHPO6	Chamaesyce	seaside sandmat	Euphorbiaceae	N

	polygonifolia			
CHAN9	Chamerion angustifolium	fireweed	Onagraceae	N
CHLA6	Chasmanthium laxum	slender woodoats	Poaceae	N
CHAL7	Chenopodium album	lambsquarters	Chenopodiaceae	N
CHAM	Chenopodium ambrosioides	Mexican tea	Chenopodiaceae	I
CHMA3	Chimaphila maculata	striped prince's pine	Pyrolaceae	N
CHUM	Chimaphila umbellata	pipsissewa	Pyrolaceae	N
CHVE2	Chloris verticillata	tumble windmill grass	Poaceae	N
CHJU	Chondrilla juncea	rush skeletonweed	Asteraceae	I
CHMA14	Chrysopsis mariana	Maryland goldenaster	Asteraceae	N
CIIN	Cichorium intybus	Chickory	Asteraceae	I
CIMA2	Cicuta maculata	spotted water hemlock	Apiaceae	N
CIAR4	Cirsium arvense	Canada thistle	Asteraceae	I
CLTE4	Clematis terniflora	sweet autumn virginsbower	Ranunculaceae	N
CLVI5	Clematis virginiana	devil's darning needles	Ranunculaceae	N
CLAL3	Clethra alnifolia	coastal sweetpepperbush	Clethraceae	N
COCO3	Commelina communis	Asiatic dayflower	Commelinaceae	I
COPE80	Comptonia peregrina	sweet fern	Myricaceae	N
COCO13	Conoclinium coelestinum	blue mistflower	Asteraceae	N
COMA7	Convallaria majalis	European lily of the valley	Liliaceae	I
COCA5	Conyza canadensis	Canadian horseweed	Asteraceae	N
COCO9	Corema conradii	broom crowberry	Empetraceae	N
COLA5	Coreopsis lanceolata	lanceleaf tickseed	Asteraceae	N
COVE5	Coreopsis verticillata	whorled tickseed	Asteraceae	N
COFL2	Cornus florida	flowering dogwood	Cornaceae	N
CRCA3	Crepis capillaris	smooth hawksbeard	Asteraceae	I
CUGR	Cuscuta gronovii	scaldweed	Cuscutaceae	N
CYDE2	Cyperus dentatus	toothed flatsedge	Cyperaceae	N
CYER2	Cyperus erythrorhizos	redroot flatsedge	Cyperaceae	N
CYES	Cyperus esculentus	yellow nutsedge	Cyperaceae	N
CYFL	Cyperus flavescens	yellow flatsedge	Cyperaceae	N
CYGR2	Cyperus grayi	Gray's flatsedge	Cyperaceae	N
CYOD	Cyperus odoratus	fragrant flatsedge	Cyperaceae	N
CYSC3	Cyperus schweinitzii	Schweinitz's flatsedge	Cyperaceae	N
CYST	Cyperus strigosus	strawcolored flatsedge	Cyperaceae	N
CYAC3	Cypripedium acaule	moccasin flower	Orchidaceae	N
DAGL	Dactylis glomerata	orchardgrass	Poaceae	I
DAST	Datura stramonium	jimsonweed	Solanaceae	I
DACA6	Daucus carota	Queen Anne's lace	Apiaceae	I

DEVE	Decodon verticillatus	swamp loosestrife	Lythraceae	N
DEPU2	Dennstaedtia punctilobula	eastern hayscented fern	Dennstaedtiaceae	N
DIAR	Dianthus armeria	Deptford pink	Caryophyllaceae	I
DICL	Dichanthelium clandestinum	deertongue	Poaceae	N
DICI	Digitaria ciliaris	southern crabgrass	Poaceae	N
DISA	Digitaria sanguinalis	hairy crabgrass	Poaceae	I
DITE2	Diodia teres	poorjoe	Rubiaceae	N
DIVI4	Dioscorea villosa	wild yam	Dioscoreaceae	N
DIVI5	Diospyros virginiana	common persimmon	Ebenaceae	N
DRVE2	Draba verna L.	spring draba	Brassicaceae	I
DRFI	Drosera filiformis	threadleaf sundew	Droseraceae	N
DRIN3	Drosera intermedia	spoonleaf sundew	Droseraceae	N
DRRO	Drosera rotundifolia	roundleaf sundew	Droseraceae	N
DUIN	Duchesnea indica	Indian strawberry	Rosaceae	I
DUAR3	Dulichium arundinaceum	threeway sedge	Cyperaceae	N
ECCR	Echinochloa crus-galli	barnyardgrass	Poaceae	I
ECMU2	Echinochloa muricata	rough barnyardgrass	Poaceae	N
ELUM	Elaeagnus umbellata	autumn olive	Elaeagnaceae	I
ELAC	Eleocharis acicularis	needle spikerush	Cyperaceae	N
ELFA	Eleocharis fallax	creeping spikerush	Cyperaceae	N
ELHA2	Eleocharis halophila	saltmarsh spikerush	Cyperaceae	N
ELMI2	Eleocharis microcarpa	smallfruit spikerush	Cyperaceae	N
ELOV	Eleocharis ovata	ovate spikerush	Cyperaceae	N
ELPA3	Eleocharis palustris	common spikerush	Cyperaceae	N
ELPA5	Eleocharis parvula	dwarf spikerush	Cyperaceae	N
ELRO	Eleocharis robbinsii	Robbins' spikerush	Cyperaceae	N
ELRO2	Eleocharis rostellata	beaked spikerush	Cyperaceae	N
ELTE	Eleocharis tenuis	slender spikerush	Cyperaceae	N
ELTR5	Eleocharis tricostata	three-angle spikerush	Cyperaceae	N
ELTU	Eleocharis tuberculosa	cone-cup spikerush	Cyperaceae	N
EPRE2	Epigaea repens	trailing arbutus	Ericaceae	N
EPCO	Epilobium coloratum	purpleleaf willowherb	Onagraceae	N
EQAR	Equisetum arvense	field horsetail	Equisetaceae	N
EQHY	Equisetum hyemale	scouringrush horsetail	Equisetaceae	N
ERPH	Erigeron philadelphicus	Philadelphia fleabane	Asteraceae	N
ERST3	Erigeron strigosus	prairie fleabane	Asteraceae	N
ERCO7	Eriocaulon compressum	flattened pipewort	Eriocaulaceae	N
ERDE5	Eriocaulon decangulare	tenangle pipewort	Eriocaulaceae	N
ERTE12	Eriophorum tenellum	fewnerved cottongrass	Cyperaceae	N
ERVI8	Eriophorum virginicum	tawny cottongrass	Cyperaceae	N
ERCI6	Erodium cicutarium	redstem stork's bill	Geraniaceae	I

EURA5	Eubotrys racemosa	swamp doghobble	Ericaceae	N
EUAL2	Eupatorium album	white thoroughwort	Asteraceae	N
EUHY	Eupatorium hyssopifolium	hyssopleaf thoroughwort	Asteraceae	N
EULE	Eupatorium leucolepis	justiceweed	Asteraceae	N
EUPE3	Eupatorium perfoliatum	common boneset	Asteraceae	N
EUPU10	Eupatorium purpureum	sweetscented joe pye weed	Asteraceae	N
EURE8	Eupatorium resinosum	pine barren thoroughwort	Asteraceae	N
EURO4	Eupatorium rotundifolium	roundleaf thoroughwort	Asteraceae	N
EUSE2	Eupatorium serotinum	lateflowering thoroughwort	Asteraceae	N
EUCY2	Euphorbia cyparissias	cypress spurge	Euphorbiaceae	I
EUES	Euphorbia esula	leafy spurge	Euphorbiaceae	I
EUCA26	Euthamia caroliniana	slender goldentop	Asteraceae	N
EUGR5	Euthamia graminifolia	flat-top goldentop	Asteraceae	N
EUDU6	Eutrochium dubium	coastal plain joe pye weed	Asteraceae	N
FAGR	Fagus grandifolia	American beech	Fagaceae	N
FICA3	Fimbristylis caroliniana	Carolina fimbry	Cyperaceae	N
FICA4	Fimbristylis castanea	marsh fimbry	Cyperaceae	N
FRVE	Fragaria vesca	woodland strawberry	Rosaceae	N
FRVI	Fragaria virginiana	Virginia strawberry	Rosaceae	N
FRGR3	Froelichia gracilis	slender snakecotton	Amaranthaceae	N
FUPU	Fuirena pumila	dwarf umbrella-sedge	Cyperaceae	N
FUSQ	Fuirena squarrosa	hairy umbrella-sedge	Cyperaceae	N
GAAP2	Galium aparine	stickywilly	Rubiaceae	N
GACI2	Galium circaezans	licorice bedstraw	Rubiaceae	N
GAOB	Galium obtusum	bluntleaf bedstraw	Rubiaceae	N
GAPA3	Galium palustre	common marsh bedstraw	Rubiaceae	N
GAPI2	Galium pilosum	hairy bedstraw	Rubiaceae	N
GAPU3	Gamochaeta purpurea	spoonleaf purple everlasting	Asteraceae	N
GAPR2	Gaultheria procumbens	eastern teaberry	Ericaceae	N
GABA	Gaylussacia baccata	black huckleberry	Ericaceae	N
GADU	Gaylussacia dumosa	dwarf huckleberry	Ericaceae	N
GAFR2	Gaylussacia frondosa	blue huckleberry	Ericaceae	N
GECA5	Geranium carolinianum	Carolina geranium	Geraniaceae	N
GEMO	Geranium molle	dovefoot geranium	Geraniaceae	I
GEAL3	Geum aleppicum	yellow avens	Rosaceae	N

GEVI4	Geum virginianum	cream avens	Rosaceae	N
GLHE2	Glechoma hederacea	ground ivy	Lamiaceae	I
GOPU	Goodyera pubescens	downy rattlesnake plantain	Orchidaceae	N
GRAU	Gratiola aurea	golden hedgehyssop	Scrophulariaceae	N
HAVI4	Hamamelis virginiana	American witchhazel	Hamamelidaceae	N
HEHE	Hedera helix	English ivy	Araliaceae	I
HECA3	Helianthemum canadense	longbranch frostweed	Cistaceae	N
HEGI	Helianthus giganteus	giant sunflower	Asteraceae	N
HEBU	Helonias bullata	swamppink	Liliaceae	N
HEFU	Hemerocallis fulva	orange daylily	Liliaceae	I
HESU3	Heterotheca subaxillaris	camphorweed	Asteraceae	N
HIMO	Hibiscus moscheutos	crimsoneyed rosemallow	Malvaceae	N
HIGR3	Hieracium gronovii	queendevil	Asteraceae	N
HIKA2	Hieracium kalmii	Kalm's hawkweed	Asteraceae	N
HOCA4	Houstonia caerulea	azure bluet	Rubiaceae	N
HUER	Hudsonia ericoides	pine barren goldenheather	Cistaceae	N
HUTO	Hudsonia tomentosa	woolly beachheather	Cistaceae	N
HULU	Humulus lupulus	common hop	Cannabaceae	N
HULU2	Huperzia lucidula	shining clubmoss	Lycopodiaceae	N
HYUM	Hydrocotyle umbellata	manyflower marshpennywort	Apiaceae	N
HYBO2	Hypericum boreale	northern St. Johnswort	Clusiaceae	N
HYCA7	Hypericum canadense	lesser Canadian St. Johnswort	Clusiaceae	N
HYDE	Hypericum densiflorum	bushy St. Johnswort	Clusiaceae	N
HYGE	Hypericum gentianoides	orangegrass	Clusiaceae	N
HYHY	Hypericum hypericoides	St. Andrew's cross	Clusiaceae	N
HYMU	Hypericum mutilum	dwarf St. Johnswort	Clusiaceae	N
HYPE	Hypericum perforatum	common St. Johnswort	Clusiaceae	I
HYRA3	Hypochaeris radicata	hairy cat's ear	Asteraceae	I
ILGL	Ilex glabra	inkberry	Aquifoliaceae	N
ILLA	Ilex laevigata	smooth winterberry	Aquifoliaceae	N
ILOP	Ilex opaca	American holly	Aquifoliaceae	N
ILVE	Ilex verticillata	common winterberry	Aquifoliaceae	N
Euthamia	Impatiens capensis	jewelweed	Balsaminaceae	N
IPPA	Ipomoea pandurata	wild potato vine	Convolvulaceae	N
IPPU2	Ipomoea purpurea	tall morning-glory	Convolvulaceae	I
IRVE2	Iris versicolor	harlequin blueflag	Iridaceae	N
ISRI	Isoetes riparia	shore quillwort	Isoetaceae	N
ITVI	Itea virginica	Virginia sweetspire	Grossulariaceae	N

IVFR	Iva frutescens	bigleaf marsh-elder	Asteraceae	N
JUNI	Juglans nigra	black walnut	Juglandaceae	N
JUAC	Juncus acuminatus	tapertip rush	Juncaceae	N
JUBI	Juncus biflorus	bog rush	Juncaceae	N
JUBU	Juncus bufonius	toad rush	Juncaceae	N
JUCA2	Juncus caesariensis	New Jersey rush	Juncaceae	N
JUCA3	Juncus canadensis	Canadian rush	Juncaceae	N
JUDE	Juncus debilis	weak rush	Juncaceae	N
JUDI	Juncus dichotomus	forked rush	Juncaceae	N
JUEF	Juncus effusus	common rush	Juncaceae	N
JUGE	Juncus gerardii	saltmeadow rush	Juncaceae	N
JUGR	Juncus greenei	Greene's rush	Juncaceae	N
JUMA4	Juncus marginatus	grassleaf rush	Juncaceae	N
JUPE	Juncus pelocarpus	brownfruit rush	Juncaceae	N
JUSC	Juncus scirpoides	needlepod rush	Juncaceae	N
JUSU	Juncus subcaudatus	woodland rush	Juncaceae	N
JUTE	Juncus tenuis	poverty rush	Juncaceae	N
JUTO	Juncus torreyi	Torrey's rush	Juncaceae	N
JUVI	Juniperus virginiana	eastern redcedar	Cupressaceae	N
KAAN	Kalmia angustifolia	sheep laurel	Ericaceae	N
KALA	Kalmia latifolia	mountain laurel	Ericaceae	N
KOVI	Kosteletzkya virginica	Virginia saltmarsh mallow	Malvaceae	N
KRBI	Krigia biflora	twoflower dwarfdandelion	Asteraceae	N
KRVI	Krigia virginica	Virginia dwarfdandelion	Asteraceae	N
LACA5	Lachnanthes caroliana	Carolina redroot	Haemodoraceae	N
LACA	Lactuca canadensis	Canada lettuce	Asteraceae	N
LASA	Lactuca saligna	willowleaf lettuce	Asteraceae	I
LASE	Lactuca serriola	prickly lettuce	Asteraceae	I
LAAM	Lamium amplexicaule	henbit deadnettle	Lamiaceae	I
LEIN	Lechea intermedia	largepod pinweed	Cistaceae	N
LEMA	Lechea maritima	beach pinweed	Cistaceae	N
LEOR	Leersia oryzoides	rice cutgrass	Poaceae	N
LEVI2	Leersia virginica	whitegrass	Poaceae	N
LEBU	Leiophyllum buxifolium	sandmyrtle	Ericaceae	N
LEMI3	Lemna minor	common duckweed	Lemnaceae	N
LECA5	Lepidium campestre	Field pepperweed	Brassicaceae	I
LEVI3	Lepidium virginicum	Virginia pepperweed	Brassicaceae	N
LECA8	Lespedeza capitata	roundhead lespedeza	Fabaceae	N
LECU	Lespedeza cuneata	sericea lespedeza	Fabaceae	I
LEFR5	Lespedeza frutescens	shrubby lespedeza	Fabaceae	N
LEVU	Leucanthemum vulgare	oxeye daisy	Asteraceae	I

LIVU	Ligustrum vulgare	European privet	Oleaceae	I
LICA17	Limonium carolinianum	lavender thrift	Plumbaginaceae	N
LIVU2	Linaria vulgaris	butter and eggs	Scrophulariaceae	I
LIBE3	Lindera benzoin	northern spicebush	Lauraceae	N
LIST2	Liquidambar styraciflua	sweetgum	Hamamelidaceae	N
LITU	Liriodendron tulipifera	tuliptree	Magnoliaceae	N
LOCA2	Lobelia cardinalis	cardinalflower	Campanulaceae	N
LONU	Lobelia nuttallii	Nuttall's lobelia	Campanulaceae	N
LOJA	Lonicera japonica	Japanese honeysuckle	Caprifoliaceae	I
LOCO6	Lotus corniculatus	bird's-foot trefoil	Fabaceae	I
LUPA	Ludwigia palustris	marsh seedbox	Onagraceae	N
LUAC	Luzula acuminata	hairy woodrush	Juncaceae	N
LYAL5	Lycopodiella alopecuroides	foxtail clubmoss	Lycopodiaceae	N
LYCA5	Lycopodiella caroliniana	slender clubmoss	Lycopodiaceae	N
LYIN2	Lycopodiella inundata	inundated clubmoss	Lycopodiaceae	N
LYDI3	Lycopodium digitatum	fan clubmoss	Lycopodiaceae	N
LYOB	Lycopodium obscurum	rare clubmoss	Lycopodiaceae	N
LYTR	Lycopodium tristachyum	deeproot clubmoss	Lycopodiaceae	N
LYAM2	Lycopus amplectens	clasping water horehound	Lamiaceae	N
LYLI	Lyonia ligustrina	maleberry	Ericaceae	N
LYMA2	Lyonia mariana	piedmont staggerbush	Ericaceae	N
LYHY	Lysimachia hybrida	lowland yellow loosestrife	Primulaceae	N
LYTE2	Lysimachia terrestris	earth loosestrife	Primulaceae	N
LYLI2	Lythrum lineare	wand lythrum	Lythraceae	N
LYSA2	Lythrum salicaria	purple loosestrife	Lythraceae	I
MAVI2	Magnolia virginiana	sweetbay	Magnoliaceae	N
MAST4	Maianthemum stellatum	starry false lily of the valley	Liliaceae	N
MAAN3	Malus angustifolia	southern crab apple	Rosaceae	N
MACO5	Malus coronaria	sweet crab apple	Rosaceae	N
MELI2	Melampyrum lineare	narrowleaf cowwheat	Scrophulariaceae	N
MEOF	Melilotus officinalis	sweetclover	Fabaceae	I
MISC	Mikania scandens	climbing hempvine	Asteraceae	N
MICA8	Minuartia caroliniana	pine barren stitchwort	Caryophyllaceae	N
MIRE	Mitchella repens	partridgeberry	Rubiaceae	N
MOVE	Mollugo verticillata	green carpetweed	Molluginaceae	N
MODI	Monarda didyma	scarlet beebalm	Lamiaceae	N
MOFI	Monarda fistulosa	wild bergamot	Lamiaceae	N
MOHY3	Monotropa hypopithys	pinesap	Monotropaceae	N
MOUN3	Monotropa uniflora	Indianpipe	Monotropaceae	N

MOCA7	Morella caroliniensis	southern bayberry	Myricaceae	N
MOCE2	Morella cerifera	wax myrtle	Myricaceae	N
MOPE6	Morella pensylvanica	northern bayberry	Myricaceae	N
MOAL	Morus alba	white mulberry	Moraceae	I
MORU2	Morus rubra	red mulberry	Moraceae	N
MUSY	Muhlenbergia sylvatica	woodland muhly	Poaceae	N
MYAR	Myosotis arvensis	field forget-me-not	Boraginaceae	I
MYST2	Myosotis stricta	strict forget-me-not	Boraginaceae	I
NAFL	Najas flexilis	nodding waternymph	Najadaceae	N
NAAM	Narthecium americanum	yellow asphodel	Liliaceae	N
NULU	Nuphar lutea	yellow pond-lily	Nymphaeaceae	N
NUCA	Nuttallanthus canadensis	Canada toadflax	Scrophulariaceae	N
NYOD	Nymphaea odorata	American white waterlily	Nymphaeaceae	N
NYSY	Nyssa sylvatica	blackgum	Cornaceae	N
OEBI	Oenothera biennis	common evening primrose	Onagraceae	N
OEHU	Oenothera humifusa	seabeach evening primrose	Onagraceae	N
OELA	Oenothera laciniata	cutleaf evening primrose	Onagraceae	N
OEPA5	Oenothera parviflora	northern evening primrose	Onagraceae	N
ONSE	Onoclea sensibilis	sensitive fern	Dryopteridaceae	N
OPHU	Opuntia humifusa	devil's-tongue	Cactaceae	N
ORAQ	Orontium aquaticum	goldenclub	Araceae	N
OSCI	Osmunda cinnamomea	cinnamon fern	Osmundaceae	N
OSCL2	Osmunda claytoniana	interrupted fern	Osmundaceae	N
OSRE	Osmunda regalis	royal fern	Osmundaceae	N
OXDI2	Oxalis dillenii	slender yellow woodsorrel	Oxalidaceae	N
OXRI	Oxypolis rigidior	stiff cowbane	Apiaceae	N
PAAM2	Panicum amarum	bitter panicgrass	Poaceae	N
PACA6	Panicum capillare	witchgrass	Poaceae	N
PADI	Panicum dichotomiflorum	fall panicgrass	Poaceae	N
PAPH	Panicum philadelphicum	Philadelphia panicgrass	Poaceae	N
PARI4	Panicum rigidulum	redtop panicgrass	Poaceae	N
PAVI2	Panicum virgatum	switchgrass	Poaceae	N
PAQU2	Parthenocissus quinquefolia	Virginia creeper	Vitaceae	N
PAVI5	Parthenocissus vitacea	woodbine	Vitaceae	N
PEVI	Peltandra virginica	green arrow arum	Araceae	N

PEGL2	Pennisetum glaucum	pearl millet	Poaceae	I
PELA8	Penstemon laevigatus	eastern smooth beardtongue	Scrophulariaceae	N
PEPR4	Petrorhagia prolifera	childing pink		
PHAR3	Phalaris arundinacea	reed canarygrass	Poaceae	N
PHHE11	Phegopteris hexagonoptera	broad beechfern	Thelypteridaceae	N
PHLE14	Phoradendron leucarpum	oak mistletoe	Viscaceae	N
PHAU7	Phragmites australis	common reed	Poaceae	N
PHAM4	Phytolacca americana	American pokeweed	Phytolaccaceae	N
PIRU	Picea rubens	red spruce	Pinaceae	N
PIEC2	Pinus echinata	shortleaf pine	Pinaceae	N
PIRI	Pinus rigida	pitch pine	Pinaceae	N
PIST	Pinus strobus	eastern white pine	Pinaceae	N
PIFA	Pityopsis falcata	sickleleaf silkgrass	Asteraceae	N
PLAR3	Plantago aristata	largebracted plantain	Plantaginaceae	N
PLLA	Plantago lanceolata	narrowleaf plantain	Plantaginaceae	I
PLMA2	Plantago major	common plantain	Plantaginaceae	I
PLMA3	Plantago maritima	goose tongue	Plantaginaceae	N
PLBL	Platanthera blephariglottis	white fringed orchid	Orchidaceae	N
PLCA7	Pluchea camphorata	camphor pluchea	Asteraceae	N
PLOD	Pluchea odorata	sweetscent	Asteraceae	N
POAN	Poa annua	annual bluegrass	Poaceae	I
POCO	Poa compressa	Canada bluegrass	Poaceae	I
POCU4	Poa cuspidata	early bluegrass	Poaceae	N
PONE	Poa nemoralis	wood bluegrass	Poaceae	N
POPA2	Poa palustris	fowl bluegrass	Poaceae	N
POPR	Poa pratensis	Kentucky bluegrass	Poaceae	N
POOP	Pogonia ophioglossoides	snakemouth orchid	Orchidaceae	N
POBR2	Polygala brevifolia	littleleaf milkwort	Polygalaceae	N
POCR	Polygala cruciata	drumheads	Polygalaceae	N
POLU	Polygala lutea	orange milkwort	Polygalaceae	N
POAR4	Polygonella articulata	coastal jointweed	Polygonaceae	N
POAR6	Polygonum arifolium	halberdleaf tearthumb	Polygonaceae	N
POCO10	Polygonum convolvulus	black bindweed	Polygonaceae	I
POCU6	Polygonum cuspidatum	Japanese knotweed	Polygonaceae	I
POHY2	Polygonum hydropiperoides	swamp smartweed	Polygonaceae	N
POPE2	Polygonum pensylvanicum	Pennsylvania smartweed	Polygonaceae	N
POPE10	Polygonum perfoliatum	Asiatic tearthumb	Polygonaceae	I
POSA5	Polygonum sagittatum	arrowleaf tearthumb	Polygonaceae	N

POAC4	Polystichum acrostichoides	Christmas fern	Dryopteridaceae	N
POCO14	Pontederia cordata	pickerelweed	Pontederiaceae	N
POGR4	Populus grandidentata	bigtooth aspen	Salicaceae	N
POTR5	Populus tremuloides	quaking aspen	Salicaceae	N
POOR2	Portulaca oleracea	little hogweed	Poaceae	I
POCO12	Potamogeton confervoides	Tuckerman's pondweed	Potamogetonaceae	N
PODI	Potamogeton diversifolius	waterthread pondweed	Potamogetonaceae	N
PORE5	Potentilla recta	sulphur cinquefoil	Rosaceae	I
POSI2	Potentilla simplex	common cinquefoil	Rosaceae	N
PRVU	Prunella vulgaris	common selfheal	Lamiaceae	N
PRMA2	Prunus maritima	beach plum	Rosaceae	N
PRSE2	Prunus serotina	black cherry	Rosaceae	N
PRVI	Prunus virginiana	chokecherry	Rosaceae	N
PSHE4	Pseudognaphalium helleri	Heller's cudweed	Asteraceae	N
PSOB3	Pseudognaphalium obtusifolium	rabbit-tobacco	Asteraceae	N
PTAQ	Pteridium aquilinum	western brackenfern	Dennstaedtiaceae	N
PYAM	Pyrola americana	American wintergreen	Pyrolaceae	N
PYBA	Pyxidanthera barbulata	flowering pixiemoss	Diapensiaceae	N
QUAL	Quercus alba	white oak	Fagaceae	N
QUCO2	Quercus coccinea	scarlet oak	Fagaceae	N
QUFA	Quercus falcata	southern red oak	Fagaceae	N
QUIL	Quercus ilicifolia	bear oak	Fagaceae	N
QUMA3	Quercus marilandica	blackjack oak	Fagaceae	N
QUMI	Quercus michauxii	swamp chestnut oak	Fagaceae	N
QUPA2	Quercus palustris	pin oak	Fagaceae	N
QUPH	Quercus phellos	willow oak	Fagaceae	N
QUPR2	Quercus prinus	chestnut oak	Fagaceae	N
QURU	Quercus rubra	northern red oak	Fagaceae	N
QUST	Quercus stellata	post oak	Fagaceae	N
QUVE	Quercus velutina	black oak	Fagaceae	N
RACO3	Ratibida columnifera	upright prairie coneflower	Asteraceae	N
RHAR	Rhexia aristosa	awnpetal meadowbeauty	Melastomataceae	N
RHMA	Rhexia mariana	Maryland meadowbeauty	Melastomataceae	N
RHVI	Rhexia virginica	handsome Harry	Melastomataceae	N
RHAT	Rhododendron	dwarf azalea	Ericaceae	N

	atlanticum			
RHPE4	Rhododendron periclymenoides	pink azalea	Ericaceae	N
RHVI2	Rhododendron viscosum	swamp azalea	Ericaceae	N
RHCO	Rhus copallinum	winged sumac	Anacardiaceae	N
RHGL	Rhus glabra	smooth sumac	Anacardiaceae	N
RHAL3	Rhynchospora alba	white beaksedge	Cyperaceae	N
RHCH2	Rhynchospora chalarocephala	loosehead beaksedge	Cyperaceae	N
RHGR	Rhynchospora gracilenta	slender beaksedge	Cyperaceae	N
RHPA	Rhynchospora pallida	pale beaksedge	Cyperaceae	N
RHTO4	Rhynchospora torreyana	Torrey's beaksedge	Cyperaceae	N
ROPS	Robinia pseudoacacia	black locust	Fabaceae	N
ROMU	Rosa multiflora	multiflora rose	Rosaceae	I
RORA	Rotala ramosior	lowland rotala	Lythraceae	N
RUAR2	Rubus argutus	sawtooth blackberry	Rosaceae	N
RUCU	Rubus cuneifolius	sand blackberry	Rosaceae	N
RUFL	Rubus flagellaris	northern dewberry	Rosaceae	N
RUHI	Rubus hispidus	bristly dewberry	Rosaceae	N
RUPE3	Rubus pensilvanicus	Pennsylvania blackberry	Rosaceae	N
RURE2	Rubus recurvicaulis	arching dewberry	Rosaceae	N
RUHI2	Rudbeckia hirta	blackeyed Susan	Asteraceae	N
RULA3	Rudbeckia laciniata	cutleaf coneflower	Asteraceae	N
RUAC3	Rumex acetosella	common sheep sorrel	Polygonaceae	I
RUCR	Rumex crispus	curly dock	Polygonaceae	I
RUHA2	Rumex hastatulus	heartwing sorrel	Polygonaceae	N
SAAN	Sabatia angularis	rosepink	Gentianaceae	N
SAST5	Sabatia stellaris	rose of Plymouth	Gentianaceae	N
SAEN	Sagittaria engelmanniana	Engelmann's arrowhead	Alismataceae	N
SALA2	Sagittaria latifolia	broadleaf arrowhead	Alismataceae	N
SAMO	Sagittaria montevidensis	giant arrowhead	Alismataceae	I
SABI	Salicornia bigelovii	dwarf saltwort	Chenopodiaceae	N
SADE10	Salicornia depressa	Virginia glasswort	Chenopodiaceae	N
SAAL2	Salix alba	white willow	Salicaceae	I
SANI	Salix nigra	black willow	Salicaceae	N
SASE10	Salix x sepulcralis	weeping willow	Salicaceae	I
SAKA	Salsola kali	Russian thistle	Chenopodiaceae	I
SALY2	Salvia lyrata	lyreleaf sage	Lamiaceae	N
SANI4	Sambucus nigra	black elderberry	Caprifoliaceae	N
SAOF4	Saponaria officinalis	bouncingbet	Caryophyllaceae	I
SAAL5	Sassafras albidum	sassafras	Lauraceae	N
SCSC	Schizachyrium scoparium	little bluestem	Poaceae	N

SCAM6	Schoenoplectus americanus	chairmaker's bulrush	Cyperaceae	N
SCMA8	Schoenoplectus maritimus	cosmopolitan bulrush	Cyperaceae	N
SCCY	Scirpus cyperinus	woolgrass	Cyperaceae	N
SCLO	Scirpus longii	Long's bulrush	Cyperaceae	N
SCPE4	Scirpus pendulus	rufous bulrush	Cyperaceae	N
SCAN2	Scleranthus annuus	German knotgrass	Caryophyllaceae	I
SCMI4	Scleria minor	slender nutrush	Cyperaceae	N
SCRE	Scleria reticularis	netted nutrush	Cyperaceae	N
SCTR	Scleria triglomerata	whip nutrush	Cyperaceae	N
SCVE2	Scleria verticillata	low nutrush	Cyperaceae	N
SECE	Secale cereale	cereal rye	Poaceae	I
SEVA4	Securigera varia	crownvetch	Fabaceae	I
SEAP	Selaginella apoda	meadow spikemoss	Selaginellaceae	N
SEMA3	Sesuvium maritimum	slender seapurslane	Aizoaceae	N
SEFA	Setaria faberi	Japanese bristlegrass	Poaceae	I
SEIT	Setaria italica	foxtail millet	Poaceae	I
SEPA10	Setaria parviflora	marsh bristlegrass	Poaceae	N
SEVI4	Setaria viridis	green bristlegrass	Poaceae	I
SIAN2	Silene antirrhina	sleepy silene	Caryophyllaceae	N
SILA21	Silene latifolia	bladder campion	Caryophyllaceae	I
SIVU	Silene vulgaris	maidenstears	Caryophyllaceae	I
SIAN3	Sisyrinchium angustifolium	narrowleaf blue-eyed grass	Iridaceae	N
SIAT	Sisyrinchium atlanticum	eastern blue-eyed grass	Iridaceae	N
SMGL	Smilax glauca	cat greenbrier	Smilacaceae	N
SMLA	Smilax laurifolia	laurel greenbrier	Smilacaceae	N
SMRO	Smilax rotundifolia	roundleaf greenbrier	Smilacaceae	N
SMTA2	Smilax tamnoides	bristly greenbrier	Smilacaceae	N
SMWA	Smilax walteri	coral greenbrier	Smilacaceae	N
SODU	Solanum dulcamara	climbing nightshade	Solanaceae	I
SOPT7	Solanum ptycanthum	West Indian nightshade	Solanaceae	N
SOAR	Solidago arguta	Atlantic goldenrod	Asteraceae	N
SOCA6	Solidago canadensis	Canada goldenrod	Asteraceae	N
SOER	Solidago erecta	showy goldenrod	Asteraceae	N
SOFI	Solidago fistulosa	pine barren goldenrod	Asteraceae	N
SOGI	Solidago gigantea	giant goldenrod	Asteraceae	N
SOSE	Solidago sempervirens	seaside goldenrod	Asteraceae	N
SOAS	Sonchus asper	spiny sowthistle	Asteraceae	I
SONU2	Sorghastrum nutans	Indiangrass	Poaceae	N
SOHA	Sorghum halepense	Johnsongrass	Poaceae	I
SPAL	Spartina alterniflora	smooth cordgrass	Poaceae	N

SPCY	Spartina cynosuroides	big cordgrass	Poaceae	N
SPPA	Spartina patens	saltmeadow cordgrass	Poaceae	N
SPPE	Spartina pectinata	prairie cordgrass	Poaceae	N
SPLA4	Spiranthes lacera	northern slender lady's tresses	Orchidaceae	N
SPCL	Sporobolus clandestinus	rough dropseed	Poaceae	N
SPVA	Sporobolus vaginiflorus	poverty dropseed	Poaceae	N
SULI	Suaeda linearis	annual seepweed	Chenopodiaceae	N
SUMA	Suaeda maritima	herbaceous seepweed	Chenopodiaceae	N
SYDU2	Symphyotrichum dumosum	rice button aster	Asteraceae	N
SYNO3	Symphyotrichum novi-belgii	New York aster	Asteraceae	N
SYSU5	Symphyotrichum subulatum	eastern annual saltmarsh aster	Asteraceae	N
SYTE6	Symphyotrichum tenuifolium	perennial saltmarsh aster	Asteraceae	N
SYFO	Symplocarpus foetidus	skunk cabbage	Araceae	N
TAOF	Taraxacum officinale	common dandelion	Asteraceae	N
THTH2	Thalictrum thalictroides	rue anemone	Ranunculaceae	N
THNO	Thelypteris noveboracensis	New York fern	Thelypteridaceae	N
THPA	Thelypteris palustris	eastern marsh fern	Thelypteridaceae	N
THSI2	Thelypteris simulata	bog fern	Thelypteridaceae	N
TIDI	Tipularia discolor	crippled cranefly	Orchidaceae	N
TOPA6	Torreyochloa pallida	pale false mannagrass	Poaceae	N
TORA2	Toxicodendron radicans	eastern poison ivy	Anacardiaceae	N
TRVI	Tradescantia virginiana	Virginia spiderwort	Commelinaceae	N
TRLA30	Tragopogon lamottei	Yellow goat's beard	Asteraceae	I
TRVI2	Triadenum virginicum	Virginia marsh St. Johnswort	Clusiaceae	N
TRBO2	Trientalis borealis	starflower	Primulaceae	N
TRAR4	Trifolium arvense	rabbitfoot clover	Fabaceae	I
TRCA5	Trifolium campestre	field clover	Fabaceae	I
TRPR2	Trifolium pratense	red clover	Fabaceae	I
TRRE3	Trifolium repens	white clover	Fabaceae	I
TRMA20	Triglochin maritima	seaside arrowgrass	Juncaginaceae	N
TRPE4	Triodanis perfoliata	clasping Venus' looking-glass	Campanulaceae	N
TYAN	Typha angustifolia	narrowleaf cattail	Typhaceae	N
TYLA	Typha latifolia	broadleaf cattail	Typhaceae	N
UTCO	Utricularia cornuta	horned bladderwort	Lentibulariaceae	N
UTGE	Utricularia geminiscapa	hiddenfruit bladderwort	Lentibulariaceae	N

UTGI	Utricularia gibba	humped bladderwort	Lentibulariaceae	N
UTIN2	Utricularia inflata	swollen bladderwort	Lentibulariaceae	N
VAHI2	Vaccaria hispanica	cow soapwort	Caryophyllaceae	I
VAAN	Vaccinium angustifolium	lowbush blueberry	Ericaceae	N
VACO	Vaccinium corymbosum	highbush blueberry	Ericaceae	N
VAMA	Vaccinium macrocarpon	cranberry	Ericaceae	N
VAOX	Vaccinium oxycoccos	small cranberry	Ericaceae	N
VAPA4	Vaccinium pallidum	Blue Ridge blueberry	Ericaceae	N
VAST	Vaccinium stamineum	deerberry	Ericaceae	N
VALO	Valerianella locusta	Lewiston cornsalad	Valerianaceae	I
VAAM3	Vallisneria americana	American eelgrass	Hydrocharitaceae	N
VEBL	Verbascum blattaria	moth mullein	Scrophulariaceae	I
VETH	Verbascum thapsus	common mullein	Scrophulariaceae	I
VEHA2	Verbena hastata	swamp verbena	Verbenaceae	N
VESI	Verbena simplex	narrowleaf vervain	Verbenaceae	N
VEUR	Verbena urticifolia	white vervain	Verbenaceae	N
VENO	Vernonia noveboracensis	New York ironweed	Asteraceae	N
VEAM2	Veronica americana	American speedwell	Scrophulariaceae	N
VIDE	Viburnum dentatum	southern arrowwood	Caprifoliaceae	N
VIAM	Vicia americana	American vetch	Fabaceae	N
VISA	Vicia sativa	garden vetch	Fabaceae	I
VIVI	Vicia villosa	winter vetch	Fabaceae	I
VIMI2	Vinca minor	common periwinkle	Apocynaceae	I
VIBR	Viola brittoniana	northern coastal violet	Violaceae	N
VILA4	Viola lanceolata	bog white violet	Violaceae	N
VISO	Viola sororia	common blue violet	Violaceae	N
VIAE	Vitis aestivalis	summer grape	Vitaceae	N
VILA8	Vitis labrusca	fox grape	Vitaceae	N
VIVU	Vitis vulpina	frost grape	Vitaceae	N
VUMY	Vulpia myuros	annual fescue	Poaceae	I
VUOC	Vulpia octoflora	sixweeks fescue	Poaceae	N
WIFL	Wisteria floribunda	Japanese wisteria	Fabaceae	I
WOAR	Woodwardia areolata	netted chainfern	Blechnaceae	N
WOVI	Woodwardia virginica	Virginia chainfern	Blechnaceae	N
XAST	Xanthium strumarium	rough cocklebur	Asteraceae	N
XYCA	Xyris caroliniana	Carolina yelloweyed grass	Xyridaceae	N
XYTO	Xyris torta	slender yelloweyed grass	Xyridaceae	N
YUFI	Yucca filamentosa	Adam's needle	Agavaceae	N
ZILE	Zigadenus leimanthoides	pine barren deathcamas	Liliaceae	N
ZIAQ	Zizania aquatica	annual wildrice	Poaceae	N
ZOMA	Zostera marina	seawrack	Zosteraceae	N

Edwin B. Forsythe Staff, October 3, 2012