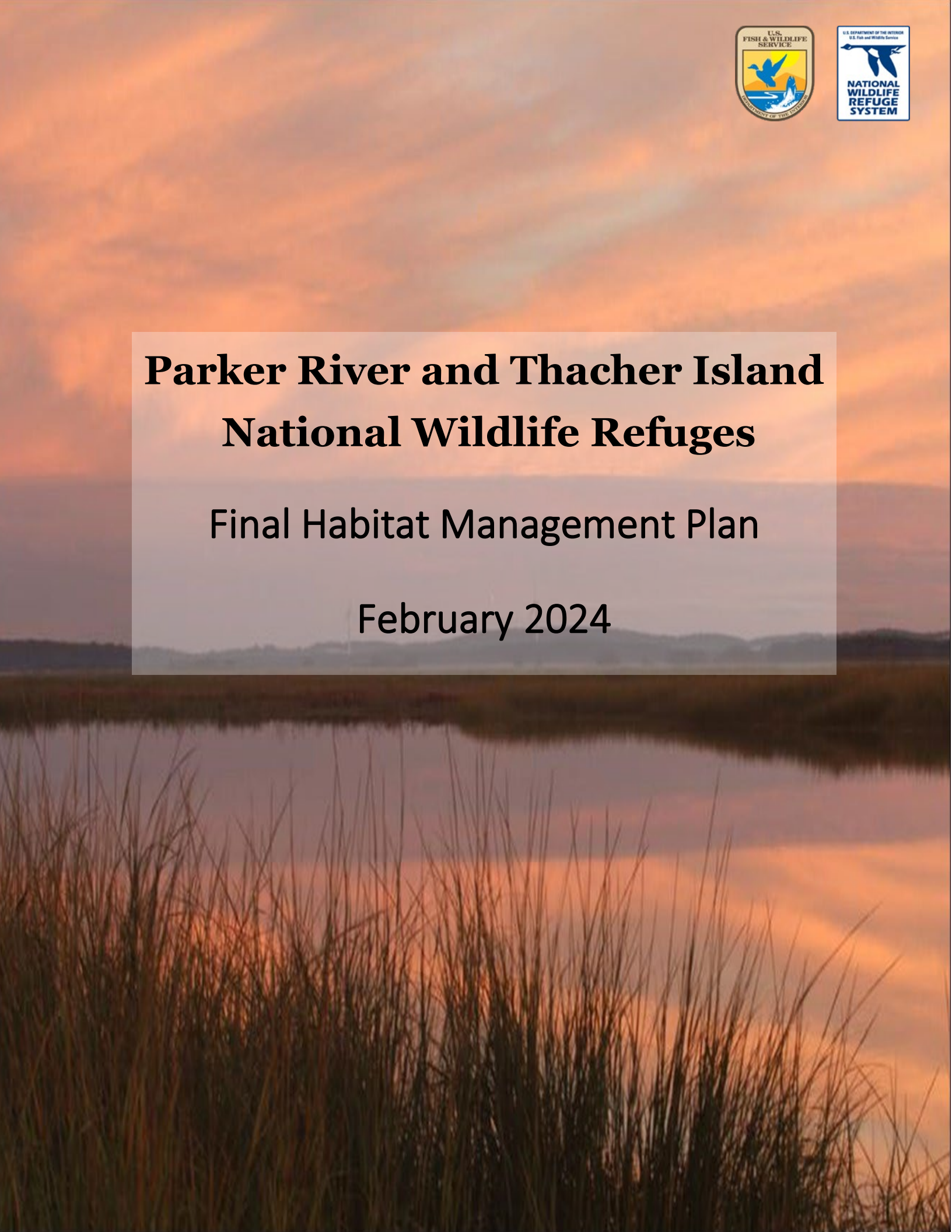

Parker River and Thacher Island National Wildlife Refuges

Final Habitat Management Plan

February 2024

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations.

Parker River and Thacher Island National Wildlife Refuges
Habitat Management Plan

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LAND ACKNOWLEDGEMENTS

Parker River and Thacher Island National Wildlife Refuges are located on **N'dakinna,** which is the traditional ancestral homeland of the Abenaki, Pennacook, and Wabanki Peoples, past and present. We acknowledge and honor with gratitude the land and waterways and the **alnobak** (people) who have stewarded these lands throughout the generations. This plan seeks to steward these lands for the enduring benefits of nature and future generations, welcoming indigenous ecological knowledge to meet that goal.

ACCESSIBILITY

We have made this document accessible to all individuals. Some of the information displayed is complex due to the nature of biological systems, and thus may not always be fully accessible to all readers. If you need assistance reading or understanding any of the figures, tables, or maps, please contact the Parker River National Wildlife Refuge at parkerriver@fws.gov.

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Chapter 1. INTRODUCTION

SCOPE AND RATIONALE

This Habitat Management Plan (HMP) provides a long-term vision and specific guidance on managing priority species, habitats, and ecosystems at Parker River and Thacher Island National Wildlife Refuges (NWRs). This is accomplished by determining the refuges' priorities, setting goals and objectives for sustaining habitats and natural processes, and determining appropriate management strategies needed to achieve the refuges' desired conditions. The contributions of these refuges to ecosystem and landscape scale wildlife and biodiversity conservation are incorporated into this HMP.

This HMP adheres to the *Habitat Management Plan (HMP) policy* (620 FW 1) for the National Wildlife Refuge System (NWRS, System), which states that all refuge habitats shall be managed in accordance with approved Comprehensive Conservation Plans (CCPs) and HMPs that, when implemented, will help achieve refuge purposes, fulfill the System mission, and meet other mandates (USFWS 2002). This policy requires that an HMP and, where appropriate, a Habitat Work Plan (HWP) be developed for each refuge in the System. An HMP is a step-down management plan of the refuge CCP, and the HWP is a plan that steps down the HMP on an annual or biannual basis.

An Environmental Assessment (EA) that evaluates the potential environmental effects associated with implementing this HMP (the proposed action) is included as Appendix A. The EA complies with the National Environmental Policy Act of 1969 (NEPA; Public Law 91-190, 42 U.S.C. 4321 *et seq*.) in accordance with Council on Environmental Quality regulations (40 Code of Federal Regulations [CFR] 1500–1508) and U.S. Department of the Interior regulations and policies (Secretarial Order 3355; 43 CFR 46; 516 Departmental Manual 8; 550 FW 3).

The staff at Parker River NWR also administer Wapack NWR, Great Bay NWR, and the Karner Blue Easement in Concord, all of which are in New Hampshire. The New Hampshire refuges are not included in this HMP.

LEGAL MANDATES

Statutory Authority

National Wildlife Refuges are managed under the guidance of several statutory and acquisition authorities which may be specific to the refuge. In addition, habitat management on refuges is guided by federal policies, legal mandates, and regulations, as well as resource plans and conservation initiatives. The National Wildlife Refuge System Improvement Act of 1997 and the Biological Integrity, Diversity, and Environmental Health Policy are two of the most important mandates (Table 1-1).

Table 1-1 Statutory authority for refuge habitat management.

Statutory Authority	Description/Components
*National Wildlife Refuge System Improvement Act of 1997 (*PL 105-57*)*	The most important legislative mandate for refuges is the National Wildlife Refuge System Administration Act of 1966, as amended by the NWRS Improvement Act of 1997. The Improvement Act provides direction for how national wildlife refuges should be managed and used. (National Wildlife Refuge System Improvement Act of 1997, PL 105-57)
*Biological Integrity, Diversity, and Environmental Health Policy (*BIDEH*) (601 FW 3)*	A requirement that the Secretary of the Interior maintains the biological integrity, diversity, and environmental health of the Refuge System. (USFWS 2002b)

Enabling Legislation and Refuge Purposes

The enabling legislation is the legal authority by which the refuge was initially established and how lands were acquired. Each refuge has specific purposes derived from the legal documents establishing, authorizing, or expanding the refuge. Refuge policy (601 FW 1, and 601 FW Exhibit 1) describes the process for determining a refuge's purpose(s) (Table 1-2) (USFWS 2006).

Both Parker River and Thacher Island NWRs are administered by one refuge management team, based at refuge headquarters in Newburyport, Massachusetts.

Table 1-2 Summary of the establishment legislation for Parker River and Thacher Island National Wildlife Refuges.

National Wildlife Refuge	Date	Enabling Legislation, Encumbrances, Considerations	Purpose
Parker River NWR	1941	Migratory Bird Conservation Act (16 U.S.C. § 715d)	For use as an inviolate sanctuary, or for any other management purpose, for migratory birds.
Parker River NWR	1948	Proclamation 2817 (60 Stat. 238)	Closed 1,753 acres of tidal waters surrounding the refuge to pursuing, hunting, taking, capture, or killing of migratory birds, or attempting to take, capture, or kill migratory birds.
Parker River NWR	1962	Refuge Recreation Act (16 U.S.C. § 460k-460k-4)	For the: 1) incidental fish and wildlife oriented recreational development; 2) protection of natural resources; and 3) conservation of federal endangered or threatened species.

Thacher Island NWR	1972	An Act Authorizing the Transfer of Certain Real Property for Wildlife, or other purposes (16 U.S.C. § 667b)	For… particular value in carrying out the National Migratory Bird Management Program.
Parker River NWR	1974	Proposed: Wilderness Act of 1964 (16 U.S.C. 1131-1136, 78 Stat. 890)	Proposed Wilderness Area (3,110 acres) - These lands are managed in the same manner as designated wilderness, so that, if they become wilderness, their wilderness character is preserved.

Photo 1-1 Shorebirds flying above the surf.

REFUGE PLANS

These refuge-specific plans inform and guide management on the refuge. All refuge plans tier from the CCP.

Master Plan for Parker River National Wildlife Refuge (*1986*)

In 1980, a 9-step comprehensive planning process and extensive public involvement effort to document long-range management and development goals for Parker River was initiated. The planning process was accomplished through the cooperation of a Fish and Wildlife Service team of refuge planners, wildlife managers, landscape architects, biologists, resource specialists, computer mapping specialists, and cartographers. The resulting technical report describes management measures necessary to retain the natural, wildlife, and human values associated with the refuge.

Habitat Management Plan (*2007*)

In 2007, an HMP was developed for Parker River and Thacher Island NWRs (USFWS 2007). The 2007 HMP prioritized resources, including species and habitats, and served as a guide for management priorities and actions. Management goals, objectives, and strategies were developed for each habitat type in this earlier management plan (Taylor & Paveglio 2017; Adamcik et al. 2004; Powell & Casey 2019). The 2023 HMP will supersede the 2007 HMP.

Inventory and Monitoring Plan (*2021*)

The Parker River, Great Bay, and Thacher Island National Wildlife Refuges Inventory and Monitoring Plan (IMP) describes specific surveys and programs to monitor population trends, frequencies, and abundance for our highest priorities: barrier beaches and salt marshes (Pau 2021b). The IMP was used to help determine which surveys are needed to help inform management actions. Surveys selected are closely tied to priority habitats and species, and habitat objectives. The IMP was developed in collaboration with the Service's Inventory and Monitoring Program, and in accordance with Service Manual 701 FW 2 (USFWS 2013).

Fire Management Plan (*2005*)

A Fire Management Plan (FMP) was completed in 2005 for Parker River NWR as mandated by Service policy, which prescribed control of all wildfire events. However, the 2005 FMP did not address prescribed fire strategies. This HMP and EA incorporate prescribed fire as a management tool for achieving certain management objectives. Parker River NWR has not had an active prescribed fire program in over two decades. A map-based spatial Fire Management Plan will be completed within two years of finalizing the HMP, and a more detailed Prescribed Fire Plan will be completed as necessary following current agency policy and National Wildfire Coordinating Group guidelines as found in *NWCG Standards for Prescribed Fire Planning and Implementation*.

Habitat Work Plan

Each NWR prepares a Habitat Work Plan (HWP) that includes a review of the habitat management activities from the previous year, an evaluation of monitoring programs, and specific recommendations for habitat and wildlife management strategies and prescriptions for the coming year. It is a tool to implement and fulfill goals and objectives established in this Habitat Management Plan. The work plan incorporates adaptive management practices by evaluating the success or outcomes of specific management strategies and prescriptions that were implemented. While work is planned annually, due to staff capacity and the multiple-year nature of most biological programs, the habitat work plan is published bi-annually.

Regional and National Plans

Regional and national conservation plans issued by partner agencies and organizations also inform habitat management on refuges, especially the selection of priority species and habitats. Conservation concerns documented by these groups alert refuge staff about current and potential future threats and influence management priorities via the process of selecting Priority Resources of Concern (Chapter 3). The following list of plans and initiatives were used in the selection process:

- Federal Threatened and Endangered Species (USFWS 2022b)
- Massachusetts List of Threatened and Endangered Species (MassWildlife 2022a)
- Massachusetts State Wildlife Action Plan (MassWildlife 2022b)
- USFWS Priority At-Risk Species, Northeast Region (USFWS 2021a)
- North Atlantic Landscape Conservation Cooperative Representative Species (USFWS 2014)
- North Atlantic Landscape Conservation Cooperative Rare Plants
- The State of the Birds 2016 Report (NABCI 2016)
- New England/Mid-Atlantic Coast Bird Conservation Region (BCR 30) Implementation Plan (Steinkamp 2008)

- USFWS Birds of Conservation Concern (USFWS 2021b)
- Marine Bird Species Priority List (AMBCC 2014)
- North American Waterfowl Management Plan (NAWMP 2012, 2018)
- Endangered and Threatened Marine Species under NMFS Jurisdiction (Whale Sense 2022)
- Marine Mammals Protection Act Species List (NOAA 2022b)
- Species of Greatest Conservation Need (USGS 2022)

RESEARCH AND MONITORING

Refuge staff are engaged in several research and monitoring projects designed to inform habitat management and decision making. These shift over time to address changing priorities and emerging scientific uncertainties. The highest priority projects are outlined in the refuges' 2021 *Inventory and Monitoring Plan*. The following section summarizes major inventory and monitoring efforts and ongoing research projects.

Wildlife Population Monitoring

Refuge staff have conducted extensive wildlife population surveys over the decades including weekly bird use of impoundments, breeding bird surveys, wintering eagle surveys, deer surveys, predator surveys, frog call surveys, bird banding during breeding season, migratory shorebird, marsh, and wading bird surveys in impoundments and throughout Refuge, duck banding. For many of these populations, analysis of existing data demonstrates that populations are not declining, and we have established good baseline data. Because of the migratory nature of many species, trends at any one location are not as meaningful for conservation. Instead, most population level monitoring is being coordinated on a State or regional level. The Refuge continues to contribute to these State or regional level surveys, including tern, whip-poor-will, breeding piping plover, and sparrow surveys. The multiple years of Refuge survey data will provide good baseline to compare trends to for any species arising to conservation concern.

Impoundment Studies

Originally constructed for breeding waterfowl, impoundment management shifted to benefiting migratory shorebirds and waterfowl in the 1990s after recognizing that most breeding occurred in Canada and mid-west US. In 2000-2001 and 2005-2007, Parker River Refuge participated in a regional study to better understand how to manage water levels to optimize use for shorebirds and waterfowl. The study document response of benthic invertebrates, vegetation communities, shorebird and waterfowl use, and available foraging habitat at each impoundment using Spring and Fall drawdown schemes. As part of this study, bird abundance and phenology were tied to prescribed water levels based on bathymetry. Recommendations from this study are still being used to manage Bill Forward and Stage Island; however, water level prescription need to be adjusted due to changes in bathymetry and unpredictable tides.

Salt Marsh

Refuge staff have been involved in several long-term salt marsh habitat studies. From 2001 to 2010, the Open Marsh Water Management (OMWM) study investigated the response of this commonly used mosquito control technique on hydrology, vegetation, mosquito breeding, fish, and bird use (James-Pirri et al. 2012; James-Pirri et al. 2008). The OMWM study generated questions that led to the Salt Marsh Integrity (SMI) study (2008 to 2016), which attempted to identify indicators of salt marsh integrity that are effective across large geographic regions, responsive to a wide range of threats, useful from a management perspective, and feasible to implement within funding and staffing constraints of the NWRS (Neckles et al. 2013). The SMI study identified diversity across the refuge marsh and rapid changes that led to additional investigations.

In 2014, refuge staff collaborated with partners within the Great Marsh and larger northeast region to better understand rapid changes in the salt marsh ecosystem. Several innovative restoration techniques (runnel, ditch remediation, ditch plug removal, OMWM plug modification, microtopography, alternative *Phragmites* control) were piloted at Parker River NWR (Burdick et al. 2020; Pau 2021b). These studies culminated in a suite of restoration techniques to restore marsh hydrology and improve habitat for Saltmarsh Sparrow; the techniques are being implemented by multiple organizations in the Great Marsh. Refuge staff are collaborating with partners to investigate other innovative marsh restoration techniques, such as thick layer deposition, mud engines (where sediment is placed in intertidal zones to be deposited on marsh surface with flooding tides), and methods that will promote marsh accretion.

Natural salt marsh adaptation monitoring

We are also documenting and monitoring several natural salt marsh adaptation strategies. These include natural breaching of pools, which is used to inform runnel creation, and natural sediment deposition and sediment flux. In 2019, a winter Nor'easter deposited significant sediment on top of salt marshes from Boston, MA to Portland, ME (Fitzgerald et al. 2020). The largest deposit that occurred at the refuge included a 40-acre marsh area just west of the North Pool impoundment. The event deposited 15-years' worth of sediment in one week, and the entire marsh area revegetated within three months (Moore et al. 2019; Moore et al. 2021). Refuge staff collaborate with The Plum Island Estuary Long Term Ecological Research station (PIE LTER), the University of New Hampshire, Boston University, and U.S. Geological Survey (USGS) scientists to monitor and understand these marsh processes that are evolving with a changing climate. Understanding these changing processes ensures that management intervention complements natural resilience and helps to inform future innovative and nature-based restoration techniques.

Impoundment decommissioning/salt marsh restoration study

From 1999 to 2004, the refuge collaborated with Massachusetts Division of Ecological Restoration to investigate the feasibility of restoring the North Pool impoundment (Konisky 2004; Louis Berger Group 2004) to tidal flow. The study determined that restoration of the impoundment to tidal estuary is feasible and should move forward. Restoration was deferred, however, due to opposition from the Massachusetts Division of Fisheries and Wildlife (MassWildlife) and local bird watchers. From 2015 to 2019, the refuge contracted for more detailed field data and hydrodynamic modeling for all three impoundments (Woods Hole Group 2019b). Follow-up conversations with MassWildlife used a structured decision-making framework to identify agency values and decision points. At the conclusion of these meetings, MassWildlife withdrew their objections to impoundment decommissioning. The objectives for impoundments and salt marshes were developed based on these studies and discussions.

Photo 1-2 View of North Pool Impoundment from the Hellcat dike. Open water was created when marsh peat was excavated to create the berm. USFWS photo.

Geomorphological Studies

In response to increased beach erosion and storm activity, Parker River NWR participated in two geomorphological studies of the beach and dunes from 2011 to 2021. The surveys were designed to monitor changes in beach profile and mean high water line through time, providing a baseline of the beach and dunes. At Parker River, the refuge has not found evidence of dune rollover and westward erosion; however, increased flux in beach and dune dynamics has been recorded (Psuty et al. 2017). With no directional retreat, we have decided to pause this monitoring protocol. Future surveys can be re-initiated if erosion concerns arise.

Saltmarsh Sparrow Study

From 2006 to 2012, the refuge conducted a long-term monitoring and research of Saltmarsh Sparrows, and the role mercury may play in their life cycle and reproduction. We monitored productivity, food chain pathways, and environmental sources of mercury. Results of this study are summarized in (Pau et al. 2021; Lane et al. 2020; Lane et al. 2011).

From 2011 to 2014, a collaboration of academic researchers from Maine to Delaware formed the Saltmarsh Habitat & Avian Research Program (SHARP) to study the demographics and conservation needs of tidal marsh nesting birds (SHARP 2023). Parker River contributed to this regional study by hosting a demographic research site and contributing additional point count and demographic data.

As the refuge and partners focus marsh restoration to benefit Saltmarsh Sparrows, we are using historical survey data and existing protocols to detect local population trends and monitor restoration success for this species. We are using SHARP rapid demo protocol to evaluate whether we can detect changes in productivity from long term marsh changes and from restoration efforts.

Photo 1-3 Saltmarsh Sparrow. Credit: Brian Harris/USFWS.

Shrub Restoration

Maritime shrublands support many berry-producing native shrubs that provide important food sources for migrating songbirds in the fall. Unfortunately, invasive, non-native shrubs are highly competitive in these habitats, creating a need to better understand the effectiveness of our restoration practices. Parker River NWR collaborated with other New England refuges to test methods which will improve shrub habitat for birds (Koch et al. 2008). The goal is to create very dense shrubs that provide cover and high-quality berries to fuel the birds during migration. More details can be found in the draft Shrub Adaptative Management Project (Pau et al. 2012).

Migratory Movement Study Using Nanotags

Parker River NWR was an early adopter of the Motus Wildlife Tracking Network (Taylor et al. 2017). This coordinated array of automated radiotelemetry towers allows detection of any tagged individual bird migrating from Canada to South America. Six nanotag receiver stations were installed at Parker River and Great Bay NWRs starting in 2013 for various research projects; two of these are still operational as of 2023. Staff collaborated with other researchers to study shorebird migration, Saltmarsh Sparrow spring and fall migration, and movement of Red and Northern Long-eared Bats during fall migration. The towers currently operating on the refuge support partner research projects and provide valuable information on species migrating or stopping over at the refuges.

Chapter 2. LOCATION, LANDSCAPE & CLIMATE

LOCATION

Parker River and Thacher Island NWRs are located along the coast of northeast Massachusetts, approximately 30 miles apart. Both refuges are approximately 40 miles north of Boston, MA, which has a metro area population of 694,000 people (2020 U.S. Census). Refuge headquarters and the visitor center are located on the mainland, in Newburyport, a city with a population of approximately 18,300 people (2020 U.S. Census). The 4,727-acre Parker River NWR is located within the towns of Newbury, Newburyport, Rowley, and Ipswich in Essex County. It occupies the southern three-fourths of Plum Island, a 9-mile-long barrier island, and hosts salt marshes, maritime dunes, maritime shrubland and forest, interdunal swales, sandplain grasslands, pitch pine woodlands, freshwater and brackish marshes, tidal estuary, beaches, rocky shores, and mudflats (Figure 2-1).

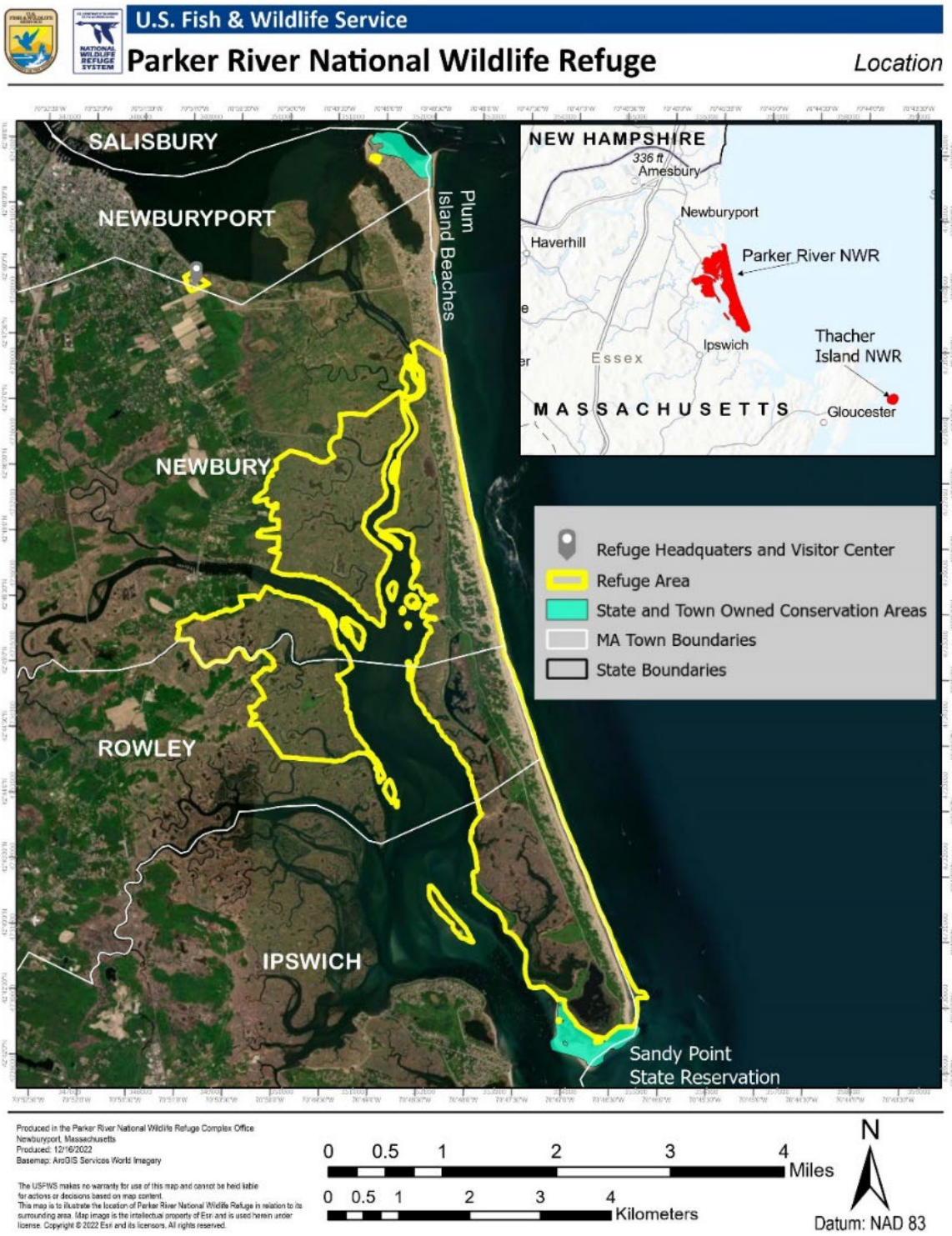

Figure 2-1 Map of Parker River NWR showing refuge boundary.

Thacher Island NWR is located at the northern end of Thacher Island, a 50-acre island one mile off the coast of the mainland portion of Rockport, Massachusetts. The refuge encompasses 22 acres of rocky intertidal shore and maritime shrubland ecosystems (Figure 2-2). The town of Rockport owns the remaining 28 acres of the island, which is managed by the Thacher Island Town Committee and the Thacher Island Association as a historic site and tourist destination; they provide transportation to the island for the public.

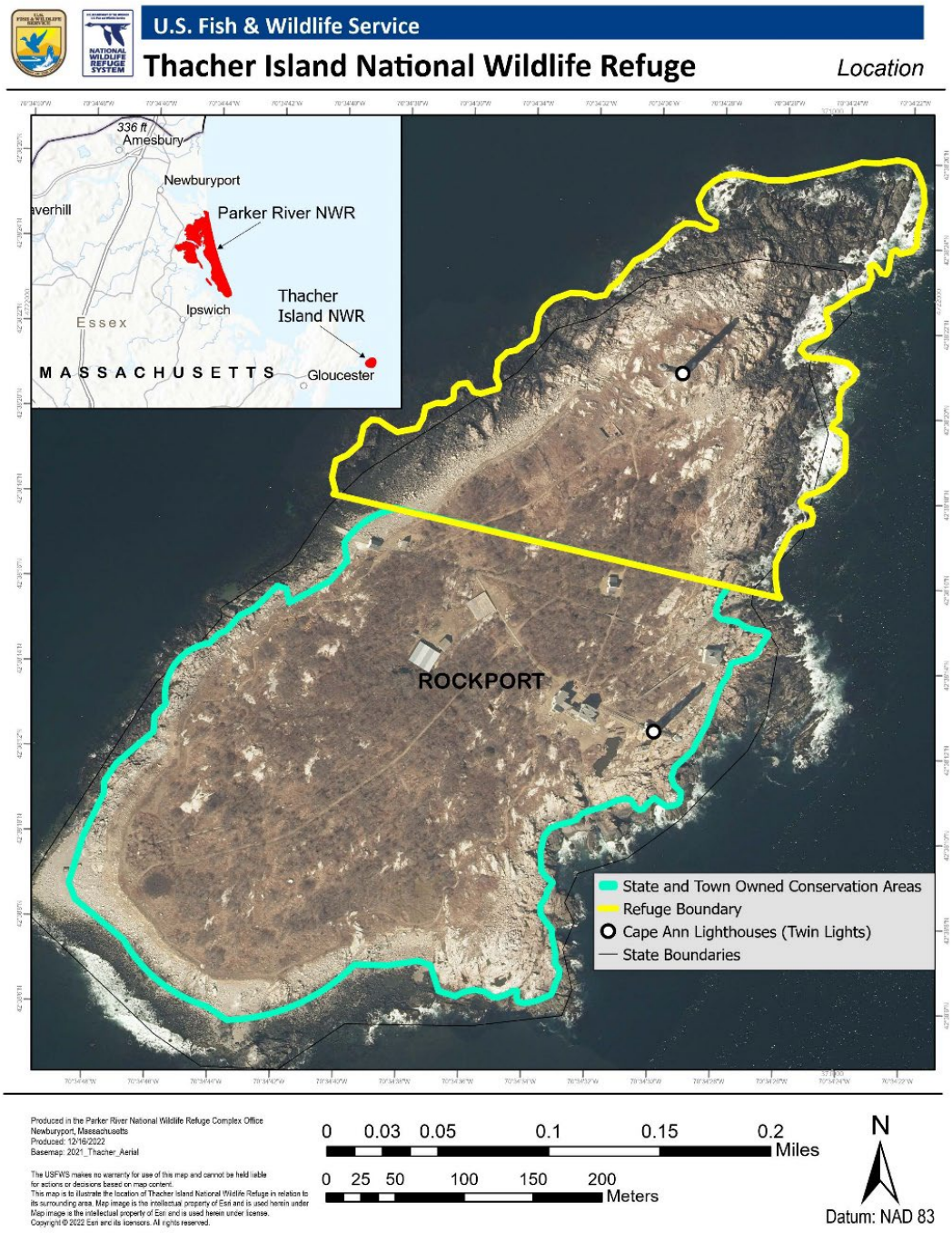

Figure 2-2 Map of Thacher Island NWR showing refuge boundary.

LANDSCAPE

The Parker River and Thacher Island 2007 HMP (USFWS 2007) provides a comprehensive description of the landscape and geographic setting of the two refuges. We provide a short summary here.

Ecological Region

Ecological regions (or ecoregions) are broad landscape classifications with distinct ecology, geography, and climate that help focus efforts to preserve the ecological integrity of these large landscapes. The Nature Conservancy (TNC) classified Massachusetts into three ecoregions. Parker River and Thacher Island are in the North Atlantic Coast TNC Ecoregion (Figure 2-3). It has a straight-line distance of 475 miles but encompasses almost 5,000 miles of irregular shoreline habitat.

Anderson and Ferree (2010) suggested that within a given climatic region (e.g., Northeastern North America), geologic diversity, latitude, and elevation range, rather than climate, explain species diversity patterns. Thus, in the face of climate change, conserving geophysical settings rather than predicted distributions of species based on climatic conditions, may be more effective in conserving biodiversity over long time scales. Conserving functioning ecosystems in specific geophysical settings, in addition to near term strategies for conserving rare species, places more emphasis on allowing dynamic processes, maintaining ecological function, and building adaptive capacity. Using these concepts, TNC developed a *resilient lands mapping tool* to assist land managers in assessing resiliency at their site.

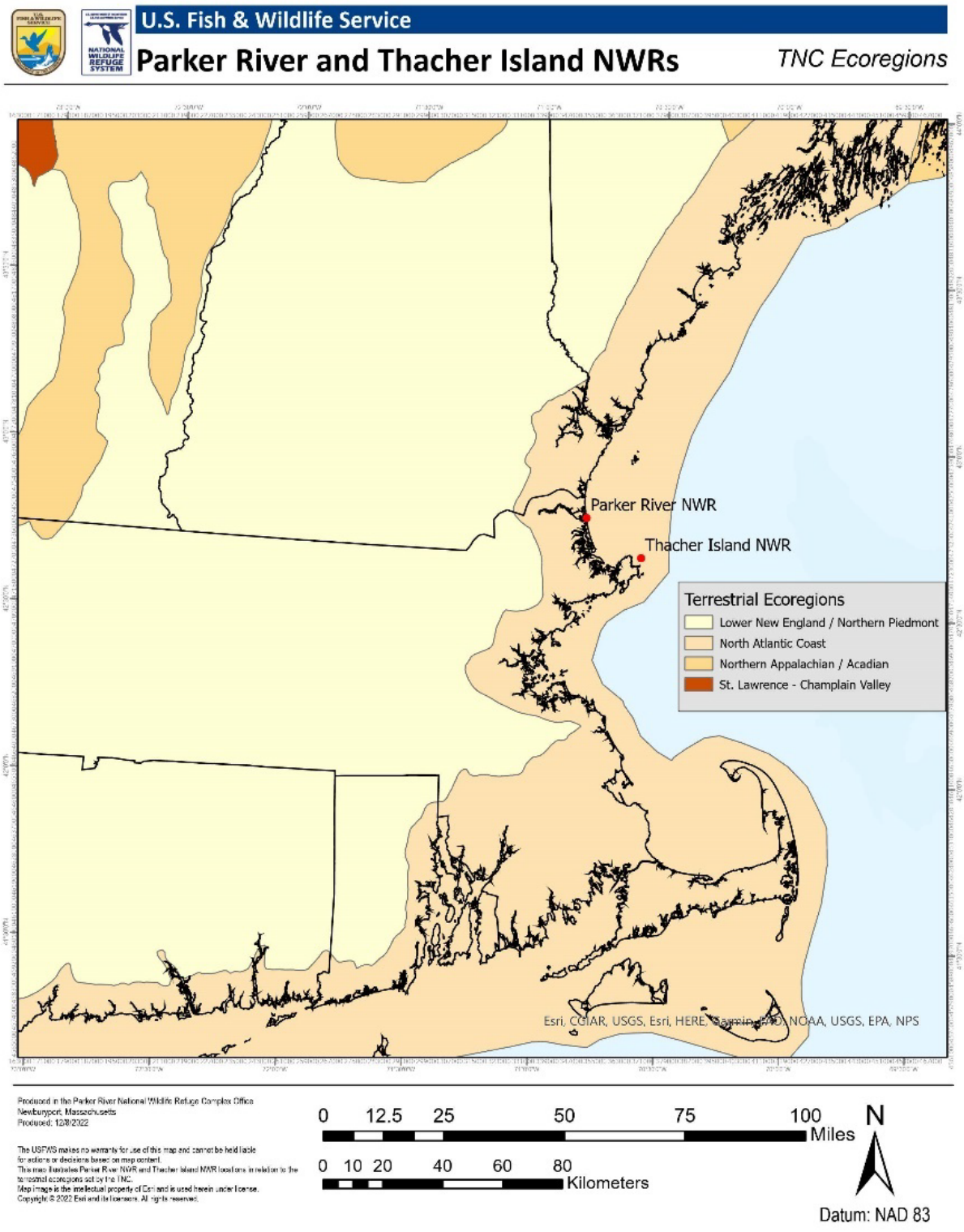

Figure 2-3 Map showing Parker River and Thacher Island NWRs within The Nature Conservancy's North Atlantic Coast Ecoregion.

Gulf of Maine Watershed

Both Parker River and Thacher Island NWRs lie within the Gulf of Maine watershed, which extends from Nova Scotia and New Brunswick, Canada to Cape Cod, Massachusetts (Figure 2-4). One of the world's most productive environments, the Gulf of Maine's marine waters and shoreline habitats host some 2,000 species of plants and animals. Ocean currents control temperatures and bring nutrients and food to the plants and animals that occupy the rich undersea terrain.

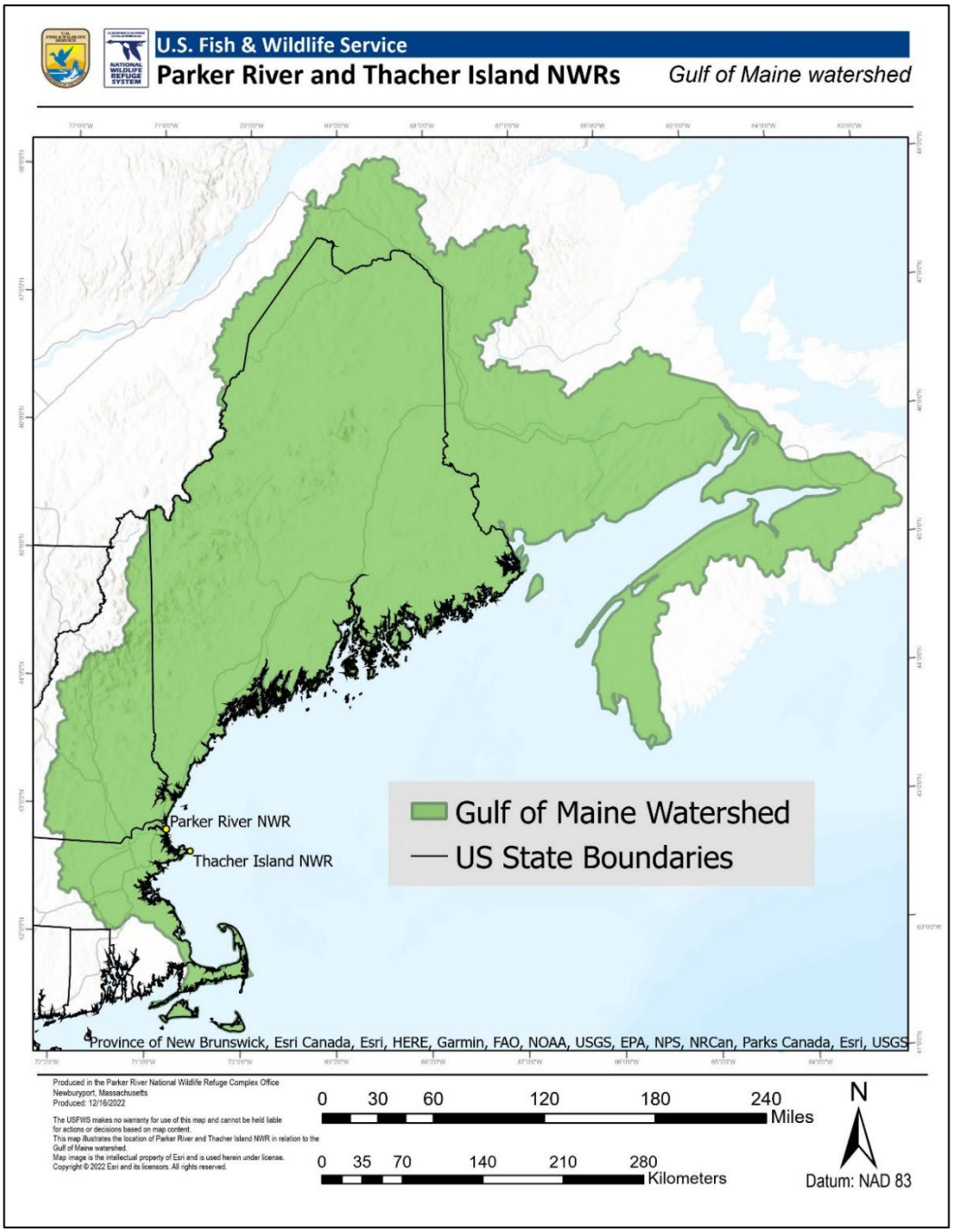

Figure 2-4 Map showing the location of Parker River and Thacher Island refuges within the Gulf of Maine Watershed.

Great Marsh

Parker River NWR is also situated within the 25,500-acre Great Marsh, a state-designated Area of Critical Environmental Concern (ACEC) (CZM 2000). The Great Marsh is the largest contiguous salt marsh in New England, extending from Gloucester, Massachusetts to the New Hampshire border (Figure 2-5). Ecosystems within the Great Marsh include the barrier beach, dune, salt marsh, tidal river, and other water bodies. In recognition of its important wildlife value, a large portion of the area was designated by the State of Massachusetts as the Parker River/Essex Bay Area of Critical Environmental Concern in 1979. An ACEC receives special consideration and protection by the State. The Great Marsh was also designated a Western Hemisphere Shorebird Reserve Network Regional site in 2004 for its importance as a migration stopover for shorebirds.

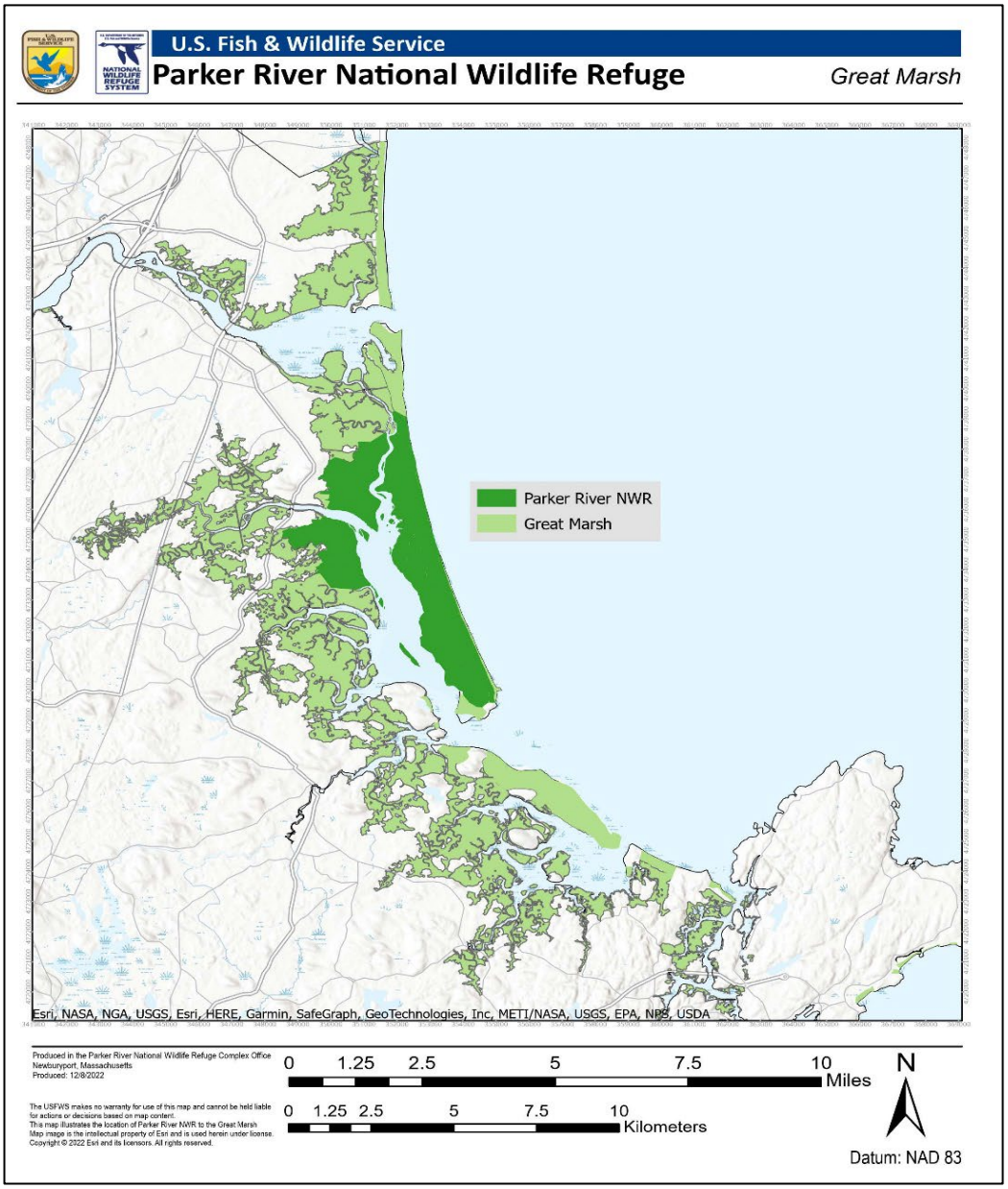

Figure 2-5 Map showing the extent of Great Marsh.

Parker River Watershed

The Parker River watershed is in the northeast corner of Massachusetts, between the Merrimack River watershed to the north and the Ipswich River watershed to the south (Figure 2-6). It drains an area of 82 square miles, meandering 21 miles from its headwaters through a rolling landscape before emptying into Plum Island Sound at Parker River NWR (Figure 2-8). Of the estimated 52,000 acres in the Parker River watershed, approximately 15,000 acres, or 29% of the watershed, are in some form of permanent protection either through public ownership or with conservation easements or agriculture preservation restrictions (Tomczyk 2002).

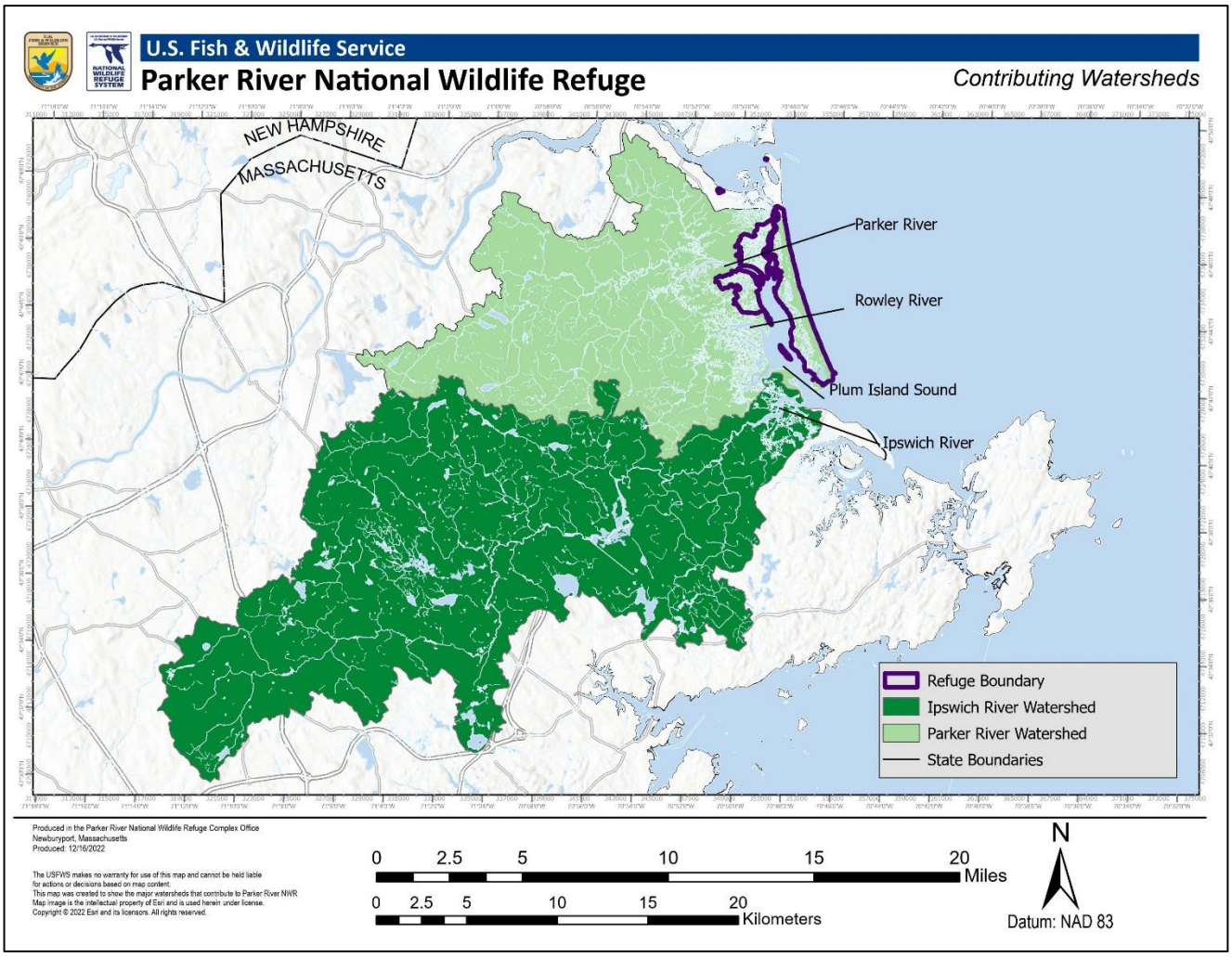

Figure 2-6 Map showing the Parker River and Ipswich Watersheds.

SITE CAPABILITIES

Topography

Elevations in the Parker River watershed range from 300 ft in the western headwaters to sea level at the river's mouth where it enters Plum Island Sound. The eastern portion of the watershed is composed of extensive salt marshes interlaced with tidal creeks and streams. Topography on the refuge ranges from 0 to 64 feet above sea level (Wurster & Hunt 2015).

Geology and Soils

The geology of the Parker River watershed has been shaped by past glaciations. The present-day barrier island overlies tills of Wisconsin and Illinois glaciations as well as late Pleistocene glaciomarine clay deposited during the post-glacial sea-level high stand approximately 17,000 years ago. The present-day barrier island and its tidal marshes are believed to have originated approximately 6,000 years ago from reworking of nearshore sediment and glacial-fluvial deposits from the Merrimack River (Hein et al. 2012). These same currents dominate present-day sediment supply to some portions of Plum Island (Hein et al. 2019). More recent (Holocene-age) sediment began to accumulate around 7,000 to 8,000 years ago from erosion of the Parker River channel. Plum Island stabilized in its modern position about 3,500-4,000 years ago and has undergone relative stability in the last 3,000 years, with relative low rates of sea level rise (Hein et al. 2012).

Soil types in the lower section of Parker River include Ipswich and Westbrook mucky peats (poorly drained, inundated daily), Agawam fine sandy loam (well drained, moderate to rapid permeability), Maybid silt loam (deep, poorly drained, and slow permeability) and Canton extremely fine silty loam (moderately rapid permeability) (USDA NRCS). The peaty salt marsh and glacial till soils that make up most of the refuge boundary (44%) are characterized by slow infiltration and high runoff potential. Soils with the highest capacity for infiltration occur in the beaches and dunes of Plum Island. For more information on geology and soils, see Wurster and Hunt (2015).

The soil horizon layer on Nelson Island, Stage Island and Cross Farm have been altered due to a long history of farming prior to refuge establishment and extensive grassland management after refuge establishment (Weare 1996). The large dike separating North Pool and Bill Forward pool from the adjacent salt marsh consists of Udorthents soils. This soil is common in areas where sediment has been artificially deposited; they range from sand and gravel to fine sandy loam.

Thacher Island consists of exposed granite rock, covered in places by a thin layer of Rock Outcrop-Hollis Complex soil (USDA NRCS 2022).

Current Hydrology

Over 75% of Parker River NWR is considered estuarine marsh and saline habitat, while 5% is classified as freshwater marsh (mostly human-made). There are four major rivers (Merrimack, Parker, Rowley, and Ipswich) that influence the hydrology and ecosystem function within the refuge. With Parker River's location on the ocean, the refuge's habitats are also heavily influenced by tidal forces.

Hurricanes and Nor'easter storms can abruptly alter refuge habitats and physical features. Nor'easters generally occur during the fall, winter, and spring, and are characterized as slow moving, low-pressure systems that move up the Atlantic coast, generating strong northeast winds that cause flooding and erosion. Seasonal extreme high tides affect the refuge periodically.

The salt marshes and tidal flats of Plum Island Sound are the most extensive wetland types within the refuge. These habitats are currently experiencing increased inundation associated with sea level rise, storm-driven tides, and legacy alterations (see Historic Influences). From 2009 to 2019, refuge staff and partners observed unprecedented acceleration of marsh conversion and marsh loss. Therefore, we have been investigating several innovative restoration techniques to help counteract these threats, including the use of runnels and ditch remediation (Burdick et al. 2020; Pau et al. 2022). Success from these pilot projects has led to planning large-scale hydrological restoration throughout the Great Marsh. The refuge implemented the 100-acre marsh project in 2021 and 2022, using all the piloted restoration techniques to restore flood/ebb hydrology to the entire project area (Pau 2021a).

Photo 2-1 Coastal salt marsh at Parker River National Wildlife Refuge in Massachusetts. Credit: Matt Poole/USFWS.

Refuge impoundments and the numerous small freshwater wetlands in Plum Island's dunes make up a much smaller portion of the wetlands in the refuge's boundary. The natural freshwater habitats are interdunal swales, which are low, shallow depressions that form between sand dunes as part of the barrier beach ecosystem. Most of these swales are cranberry bogs, and a small number act as vernal pools, providing important amphibian breeding habitat and a source of freshwater for other wildlife within the otherwise very dry dune system.

The three impoundments on the refuge receive their water source from precipitation and tidal water from the Sound. The salinity of the water in the impoundments varies during the year depending on the relative contribution of rainwater (freshwater) and tidal water during drawdowns and reflooding (creating brackish conditions). Since the 1970s, the refuge has been addressing various issues related to impoundment management, including the lack of a fresh water source, invasive plants, anaerobic conditions, threats from sea-level rise, poor water quality, silting of channels and ditches, and increasing maintenance cost. These issues are detailed in the *2007 HMP* and in the North Pool Restoration Feasibility Study report {Louis Berger Group, 2004 #38534} . A detailed field survey and hydrodynamic modeling study was conducted from 2015-2020 to better understand the vulnerability of these impoundments to climate impacts and feasibility of restoring tidal flooding to these systems (Fitzgerald et al. 2017; Woods Hole Group 2018, 2019a).

For a more thorough assessment of hydrology and hydrological issues on the refuge, refer to the 2015 Water Resources Inventory and Assessment of Parker River NWR (Wurster & Hunt 2015).

Historic Influences

From the 1600s to the 1800s, salt hay farmers systematically installed berms (embankments) and water control structures (boots) that worked in conjunction with the ditches to divide salt marshes into individual haying units, controlling hydrology to increase yield (Photo 2-2) (Adamowicz et al. 2020).

Photo 2-2 Painting (1985) by Azor Vienneau “Repairing a dyke", depicting life in Belle Isle, Nova Scotia circa 1720s; Nova Scotia Museum. Access number 87.120.2.

In the 1930s, the Works Progress Administration further altered the salt marsh by adding additional ditches to help drain the marsh platform--with the objective to reduce mosquito breeding habitat.

In 1948, after the refuge was established, refuge staff created two impoundments (North and Bill Forward Pools) by building a 1.5-mile dike in the salt marsh. A second shorter dike was built perpendicular to the first, splitting the area into two pools. Several years later, a third impoundment (Stage Island Pool) was created at the southern end of the refuge by similarly damming the salt marsh. In the 1990s, water control structures were built from the impoundments to the Sound to improve management capacities and water quality.

From 1984 to 2009, the refuge partnered with the Mosquito Control District to implement open marsh water management (OMWM), a tool widely used to biologically control mosquito larvae and reduce pesticide use. OMWM involved installing plugs in ditches, creating additional pools as fish habitat, and constructing shallow access channels to connect the pools. The objective of OMWM is to keep water from ebbing from the marsh so that fish have access to all potential mosquito breeding areas during the entire tidal cycle. Following a regional study (James-Pirri et al. 2012; Rochlin et al. 2012), concerns were raised regarding the effects of impounding water on the marsh and the impact to marsh peat, particularly with sea-level rise (SLR) concerns. These discussions prompted the refuge in 2012 to discontinue further OMWM restoration.

Photo 2-3 Side by side comparison of a site impacted by ditch plugs installed as part of OMWM before (2015) and after (2020) runnels (a baby creek) were installed. USFWS photo.

These layers of human alternations resulted in a heavily impacted salt marsh system. In a salt marsh system, a few centimeters of elevation difference separate mudflats from vegetated marsh. These past alterations generally prevented the monthly tides that flood the marsh from draining back to the creeks on an ebbing tide, leading to marsh die-back and a shift in vegetation. The impacts are compounded by increased flooding from sea level rise and storm surge, resulting in widespread and rapid loss of high marsh habitat in recent years.

Photo 2-4 Aerial images showing remnants of previous human practices. Credit: Geoff Wilson.

Note: Photo on left shows a marsh area with open water and wet areas, converting S. patens to S. alterniflora and open water. In photo on right, the same image but with overlay of old ditches (white) and hay farming berms (orange) that caused the ponding and inundation of the marsh platform.

Contaminants

There are four areas of potential concern regarding environmental contaminants on the refuge; these are described in the 2007 HMP (USFWS 2007). Additionally, recent studies have shown that Saltmarsh Sparrows at Parker River NWR have significantly higher levels of methyl mercury than sparrows in other New England marshes, with marsh processes (anaerobic conditions, high organic content) methylating historical mercury input. Research by refuge staff and partners from 2004 to 2016 demonstrated that mercury levels in sparrows and their invertebrate prey were higher in sites that were less frequently flooded, with dilution as a major mitigation for methyl mercury concentration (Pau et al. 2021). Marsh sites that supported Saltmarsh Sparrows had the highest concentration of methyl mercury. Saltmarsh Sparrows typically nest in high elevation areas that are the least frequently flooded, and thus, where the methyl mercury is less diluted. Also, the areas preferred by nesting sparrows—near pools and salt pannes — methylate mercury at a higher rate.

ANIMAL COMMUNITIES

Birds

Parker River NWR is noted as one of the best bird watching spots in the country with over 350 species recorded. Raptors migrate through in April and May, with high single-day counts of several hundred. Waves of migrating songbirds, especially warblers, vireos, thrushes, and flycatchers pass through in May and June and again in September and October. Up to hundreds of thousands of shorebirds migrate through the refuge from July to October.

Songbirds

The refuge provides quality stopover habitat for fall migrating songbirds due to its density of berry-producing shrubs and trees that provide a carbohydrate-packed food source. More than 150 species of songbirds use the shrub and forested habitats on the refuge. These include BCR 30 high priority birds such as Brown Thrasher, Eastern Towhee, and Baltimore Oriole (Steinkamp 2008). More than 200,000 Tree Swallows stage at Parker River during fall migration. The Whip-poor-will, a species of high concern in BCR 30 and the State of Massachusetts, nests in refuge forests. Willow Flycatcher and Eastern Kingbird, two other species of high priority, use the refuge's shrublands for nesting and the salt marsh and other open areas for feeding.

Several salt marsh-obligate songbirds use the refuge, including Saltmarsh Sparrow (Massachusetts species of concern), Nelson's Sparrow, and Seaside Sparrow. Other songbird species that nest regularly in the marsh include Red-winged Blackbird, Bobolink, and Marsh Wren. Winter brings a different suite of songbirds to the refuge, including the Ipswich Savannah Sparrow, Horned Lark, and Snow Bunting, attracted to the open dunes and grassland habitats.

The refuge provides artificial nesting gourds for purple martins at two locations, which are managed by volunteers and the Friends of Parker River NWR.

Saltmarsh Sparrow

The Saltmarsh Sparrow is unique among passerines in being an obligate tidal-marsh specialist. The Seaside Sparrow is also a tidal marsh obligate but is uncommon on the refuge. Flooding, particularly during new and full moon tides, is the primary cause of nest failure for the Saltmarsh Sparrow, which is synchronized to nest immediately after a flooding tide (Greenlaw et al. 2020). Females wedge or suspend a nest in medium-high salt marsh grass just above the substrate or water.

Parker River NWR has a large area of potential nesting sites and a relatively large population of Saltmarsh Sparrows; it provides essential habitat for a species that has declined more than 80% over 15 years, down to less than 30,000 individuals (Hartley & Weldon 2020). Trend analysis of the refuge population does not show the population decline seen throughout the rest of the range (Hartley & Weldon 2020; Walker & Pau 2021). The Atlantic Coast Joint Venture has worked with partners to set a population goal of 25,000 individuals, which would stabilize the population (Figure 2-7).

As noted under the "Contaminants" section, Saltmarsh Sparrows on the refuge have extremely elevated levels of blood mercury (Lane et al. 2011; Lane et al. 2020). There is no known strategy for mitigating mercury that is already deposited in an estuarine system. As sea level rises, we anticipate a loss of nesting habitat for this species throughout its range, making this species highly vulnerable to extinction. Due to these concerns, the USFWS has developed several *regional goals and strategies* for this species (Figure 2-7).

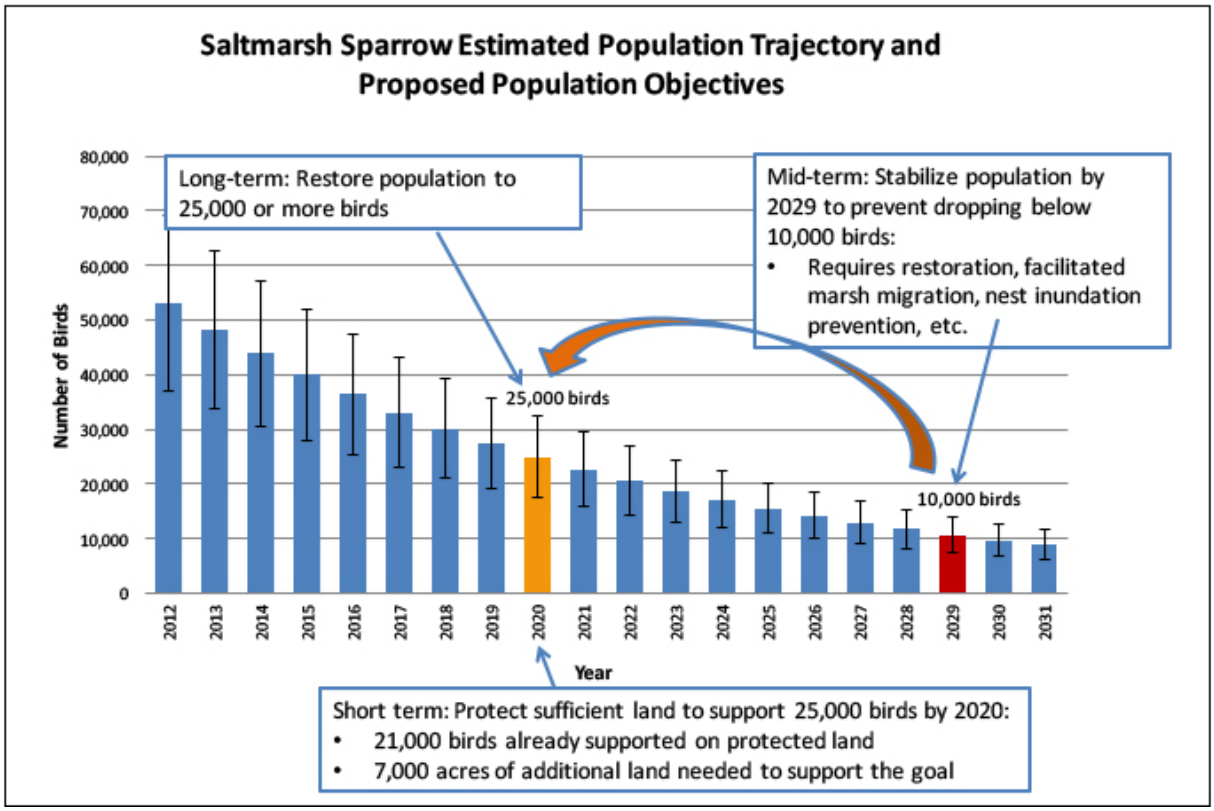

Figure 2-7 Saltmarsh Sparrow population trajectory and proposed population objectives. Credit: Atlantic Coast Joint Venture.

Shorebirds

Sandy beaches, rocky shores, ponds, impoundments, salt marshes, and tidal flats are used by migrating shorebirds as refueling stops before continuing their long travels to wintering areas (Helmers 1992). For this reason, Parker River NWR and the surrounding Great Marsh were designated a Western Hemisphere Shorebird Reserve Network Site of Regional Importance in 2004. Shorebirds headed north arrive on the refuge in April through May and again from July through September on their southward migration. Sanderling and Ruddy Turnstone (highest priority species in BCR 30); Semipalmated Sandpiper, Greater Yellowlegs, Dunlin, Short-billed Dowitcher, White-rumped Sandpiper, and Black-bellied Plover (high priority species in BCR 30); and Semipalmated Plover and Lesser Yellowlegs (moderate priority species in BCR 30) use the refuge during migration (Steinkamp 2008). Four shorebird species breed on the refuge: the federally threatened Piping Plover occupies the beach and foredunes, Willets (BCR 30 high priority) nest in the salt marsh, American Woodcocks (BCR 30 highest priority) use the refuge's early successional and shrubland habitats, while Killdeer nest in a variety of open habitats including the beach, roadsides, dikes, and gravel areas.

Red Knot

The Red Knot, federal and State-listed as threatened, is a medium-sized shorebird known for long flights during migration and large concentrations at major stopover sites. Plum Island is one of five stopover areas in Massachusetts with significant flocks of Red Knots. Harrington and Leddy (1982) documented peak numbers of 200 Red Knots on Plum Island in August of 1972 and 50 to 150 birds each year for the remainder of the 1970s. Recreational bird watchers reported more than 100 birds in the years 1990, 1994, 1995, 2019, and 2021. In 2011 and 2020, a total of over 1000 Red Knots were reported on Plum Island by refuge staff and recreational birders from mid-July to mid-November. Most were concentrated at the south end of the island at Emerson Rocks and Lot 7, with a peak count of 260, and at Sandy Point with a peak count of 93 (in 2011). Over many years, Bill Forward Pool also saw moderate-sized flocks of Red Knots (peak count of 30), with less usage of Stage Island Pool (eBird 2022).

Knots that migrate through Plum Island may be of two distinct wintering populations: one winters in Patagonia and Tierra del Fuego (Argentina and Chile), the other in the Southeast U.S. (Harrington et al. 2010). The two populations are distinguished by body molt and timing of migration. Argentina-bound birds tend to move through in July and August and retain their breeding plumage. Those bound for southeastern U.S. continue to be seen in Massachusetts through October and even early November, and molt during migration (Harrington et al. 2007). Although Red Knots do not consistently use Plum Island from year to year, protecting these migratory flocks from human disturbance when present is critical to the recovery of this species.

Piping Plover

The Piping Plover is a federal and State-listed threatened species (USFWS 1996). Massachusetts supports the largest population of breeding Piping Plovers along the Atlantic Coast, and within the State, Plum Island supports the second largest population north of Boston (Vitz et al. 2021). Up to 50 pairs of Piping Plovers nest on approximately six miles of refuge beach. Plovers return to Plum Island in late March or early April when they begin to establish nesting territories; their nesting season can extend to mid-August. High quality nesting habitat generally consists of wide, flat, sparsely-vegetated barrier beaches; and may be located near or within areas containing abundant moist sediments associated with blowouts, washover areas, spits, unstabilized and recently closed inlets, ephemeral pools, and sparsely vegetated dunes (USFWS 2009; Zeigler et al. 2019b). Plovers forage along the waterline, on the mudflats, and among the wrack line.

Habitat loss from development and recreation has drastically reduced the Piping Plover population along the Atlantic Coast, which highlights the value of Parker River NWR for this species. However, even on undeveloped beaches, there are still threats to successful nesting; predators (e.g., coyote, fox, skunk, raccoon, weasel, crow, and gull) and flooding are two major causes of nest loss. In addition, beach recreation can displace plovers from prime nesting habitats, reduce foraging opportunities, and increase predator pressure.

Piping Plover management on the refuge began in 1986 following federal listing of the species. The first record is of two pairs attempting to nest in 1980. In subsequent years, between two and five nests were recorded annually on the refuge beach. Then, in 1990, the refuge closed the beach to public use during the breeding season to increase nesting pairs, and the birds responded with a dramatic increase in the number of breeding pairs. There was a plateau around 2000 followed by steady growth and a recent peak of 50 pairs in 2019 and 2021 (Figure 2-8).

The Piping Plover recovery plan has a productivity objective of having 1.5 chicks per pair survive to fledging (able to fly), on average, over 5 years (USFWS 1996). The average fledgling rate on the refuge beach for 2018 to 2022 is 1.1 chicks per pair, which is below the recovery goal. In the past ten years, only 2014 and 2016 had productivity above the recovery goal (Figure 2-8). The refuge historically managed plovers at Sandy Point State Reservation and the towns of Newburyport and Newbury. However, since 2013, either the Massachusetts Audubon Society or the Massachusetts Department of Conservation and Recreation have monitored plovers at those sites.

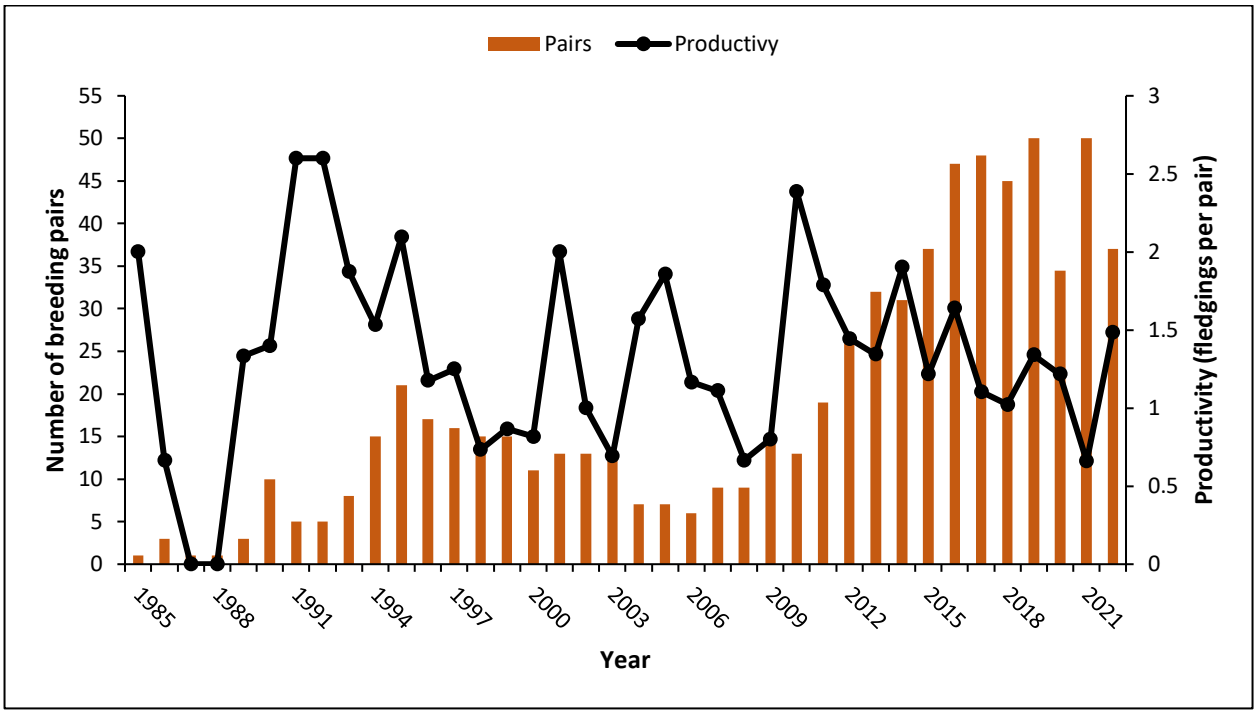

Figure 2-8 Piping Plover nesting data on Parker River NWR beach, 1985-2022.

Least Terns

The Least Tern, a State-listed species of special concern, has declined in Massachusetts in recent years (MassWildlife 2022b). The Least Tern is also a high priority for conservation in BCR 30 (Steinkamp 2008). Between 7 and 106 breeding pairs of Least Terns have nested each summer at Parker River NWR since recent records began in 1991. Least Terns nest in colonies on the beach and require similar habitat to Piping Plovers, but they require a larger patch size and only nest within the upper beach that has a mix of sand, pebbles, shells, and minimal vegetation (Thompson et al. 2020). The birds arrive at the refuge in early May; nesting continues through late August. Least Tern numbers on the beaches vary annually, depending upon beach geomorphology. Nest failure is moderate to high due to overwash and predation.

In the late 1800s, the Least Tern was a common bird in Massachusetts but was decimated at the turn of the century by the millinery trade (Nisbet 1973). Like many other seabirds, populations rebounded after the passage of the Migratory Bird Treaty Act of 1918. After initial recovery, populations declined in many areas between 1950 and the early 1970s due to displacement by humans, predation, and organochlorine pesticides (Hall & Kress 2004). Today, Least Terns face threats from development, predation, expanding gull populations, and recreational beach use.

In Massachusetts, the Least Tern population has fluctuated during the past 40 years. Since 1985, numbers have ranged from 2,109 to 4,309 pairs with a mean of 3,013 pairs (Mostello et al. 2019). In 2019, the three largest colony sites supported 32.3% of pairs, while the top ten colonies supported 63.5% of pairs, which suggests an increasing vulnerability in the State population overall.

Roseate Terns

Roseate Terns, a federal and State-listed endangered species, benefit from Parker River NWR shorebird management strategies. Although the refuge supports no breeding pairs, Roseate Terns use the refuge during migration and for foraging during the breeding season. Refuge beach closures help minimize human disturbance at roosting sites during spring migration (May) and during the breeding season. Protection of the refuge beach, intertidal zones, and salt marsh provides foraging habitat for Roseate Terns breeding at Seavey Island at the Isle of Shoals, thus helping to increase productivity for that colony.

Gulls and Other terns

Annual counts for Common Terns in the surrounding salt marshes typically detect between 70 and 130 pairs in four to six colonies, although counts have been much reduced in the past six years with counts ranging between 0 and 50 pairs. Roseate, Forster's, and occasionally Caspian Terns are present on the refuge during migration. More than seven species of gulls have been documented on the refuge annually; Great Black-backed, Herring, Ring-billed, and Bonaparte's Gulls are the most common. There is no confirmed nesting of gulls at Parker River NWR, but they use the refuge for foraging and resting.

Marsh and wading birds

Marsh and wading birds are present on the refuge throughout the summer months, with Great Egrets, Snowy Egrets, and Great Blue Herons being the most abundant species. Glossy Ibis and Black-crowned Night Heron are also regularly present. These birds take advantage of the plentiful fish found within the salt marsh pools and the shallower areas of the impoundments. Nesting on the refuge is not confirmed, although rookeries can be found in the surrounding area, including in Salisbury, just north of Plum Island and on Kettle Island in Cape Ann.

The refuge salt marshes support rails and bitterns during migration, and the refuge impoundments, particularly North Pool, support breeding secretive marsh birds (i.e., rails and bitterns). Over the past decade, we have recorded American and Least Bittern (both State-listed endangered), King Rail (State-listed threatened), Common Gallinule (State-listed species of concern), Virginia Rail, and Sora (MassWildlife 2022a). Although many of these are rare in Massachusetts and State-listed, these species are classified as species of least concern in North America and world-wide due to their relatively common distribution and steady population trends (NABCI 2023, ICUN 2023). Both the number and diversity of marsh and wading birds have decreased since a peak in 2006 (6 species totaling 26 individuals). Surveys conducted by MassWildlife staff in 2019 and 2020 found only least bitterns (3) and Virginia rails (5) breeding in North Pool. These are birds that require dense stands of robust vegetation, such as cattail or *Phragmites* to nest and are more regularly heard than seen. Based on eBird reports, visitors have continued to observe Least Bitterns in North Pool during the breeding seasons since 2020. A nest of the Black Rail, a federally listed threatened species, was documented on high marsh habitat just north of the refuge in 2005 (Reilly, pers. comm. 2005).

Raptors

The abundant population of Meadow Voles in the refuge grasslands and salt marshes attract numerous raptor species during the winter including Rough-legged Hawk, Short-eared Owl (State endangered), and Northern Harrier (State threatened). Bald Eagles (State-listed species of concern) and Snowy Owls readily feed upon ducks within the refuge's salt marshes and coastal waters during the winter months while Peregrine Falcons hunt over the dunes and salt marshes, chasing flocks of shorebirds. The refuge is one of the top locations for hawk watching during spring migration. The most abundant species seen are American Kestrel, Sharp-shinned Hawk, Northern Harrier, and Merlin. Red-tailed Hawks use the refuge year-round.

Waterfowl

In October and November, dabbling ducks feed in the impoundments and salt marsh, and diving ducks congregate in deeper waters. Gadwall (BCR 30 moderate priority), Canada Goose, Mallard (BCR 30 high priority), and American Black Duck nest in the salt marsh and three impoundments. Refuge impoundments, large salt marsh pools, and tidal creeks host a suite of waterfowl species during fall migration including Atlantic Brant (BCR 30 highest priority), Bufflehead (BCR 30 high priority), American Wigeon, Northern Pintail, Green-winged Teal, and Hooded Merganser (BCR 30 moderate priority) (Steinkamp 2008). In winter months, Common Loon (State-listed species of concern) and Red-throated Loon, Horned and Red-necked Grebes, Red-breasted Merganser, and sea ducks (Common Eider, White-winged, Surf, and Black Scoters, and Long-tailed Duck) are present along the ocean side of the refuge. Northern Gannets are observed offshore from mid-October through November.

American Black Duck

Parker River NWR was established, in part, to benefit American Black Ducks, which use the refuge during fall migration and in winter. The refuge is one of the most important wintering sites for this species in New England, with more than 2,500 ducks at peak times. It is not particularly selective in its habitat, using both freshwater and salt marshes during breeding; coastal salt marshes, estuaries, and sheltered coves are especially important to migrating and wintering individuals (Longcore et al. 2020). Black ducks use salt marsh, tidal creeks, sound, and impoundment habitats at Parker River. Land use changes as well as hunter exploitation led to widespread population declines, followed by harvest restrictions, beginning in 1983. Changes in hunting regulations are believed to be the primary reason that populations have now stabilized or increased (Longcore et al. 2020).

Thacher Island birds

The Gulf of Maine watershed includes a network of offshore islands that support colonial nesting birds. Thacher Island historically supported a large colony of nesting terns, with a record of 1,125 pairs of nesting Common and Roseate Terns in 1956 (RSPB 2021), but nesting Herring and Great Black-backed Gulls have since displaced the tern colony. Canada Geese, Mallards, Common Eiders, Double-crested Cormorants, and American Oystercatchers are documented as breeding in small numbers on the island.

Several species of songbirds have been documented breeding on Thacher Island NWR, including Mourning Dove, Willow Flycatcher, Tree and Barn Swallows, Gray Catbird, European Starling, Yellow Warbler, Chipping and Song Sparrows, Northern Cardinal, Red-winged Blackbird, Common Grackle, Orchard Oriole, and American Goldfinch.

Mammals

Terrestrial mammals

More than two dozen species of terrestrial mammals use Parker River NWR, including White-footed Mouse, Meadow Vole, Common Muskrat, Meadow Jumping Mouse, Eastern Chipmunk, Eastern Gray Squirrel, Red Squirrel, Woodchuck, and American Beaver. Carnivores found at Parker River NWR include Eastern Coyote, Red Fox, Gray Fox, Striped Skunk, Fisher, Ermine, American Mink, Northern River Otter, Long-tailed Weasel, and Raccoon. Other terrestrial mammals on the refuge include White-tailed Deer, Eastern Cottontail, Masked Shrew, and Virginia Opossum. No mammal surveys have been conducted at Thacher Island, although Thacher Island Association volunteers have seen rats on the island.

Eight species of bats are documented at Parker River NWR: Big Brown, Little Brown, Eastern Small-footed, Northern Long-eared, Tricolored, Eastern Red, Hoary, and Silver-haired. All but the Hoary Bat have been documented as infected with the white-nose syndrome (WNS) caused by the fungus *Pseudogymnoascus destructans*, which was introduced from Europe. Population declines of bats due to WNS has been one of the most critical wildlife-related crises in the twenty-first century (Warnecke et al. 2012).

Some bat species are more severely affected by WNS than others, including the Northern Long-eared Bat, which is the first species of bat to be federally listed due to impacts from WNS (USFWS 2016a). The Tricolored Bat is currently under review for listing as threatened. Little Brown and Eastern Small-footed Bats have also been heavily impacted, and are listed as endangered by the State of Massachusetts, along with the Northern long-eared and tri-colored bats (MassWildlife 2022b).

Solitary tree bats, including Eastern Red, Silver-haired, and Hoary Bats, migrate to southern locations to spend their winters instead of clustering into large hibernaculum (Bat Cons. Int. 2020). This has mostly spared these species from the severe impact of WNS, but proposed wind turbines in their key migratory routes (mountain ridges and coastal habitat) are becoming a major concern.

Marine mammals

Marine mammals such as Harbor Porpoise and White-sided Dolphin can often be seen in the water off the Parker River NWR beach. Harbor Seals and Gray Seals commonly use the refuge beach and dunes as haul-out areas, especially during late winter when juveniles leave the breeding colony in the mouth of the Merrimack River. Other seals using the refuge include Hooded Seal, and on rare occasions Harp Seal and Ringed Seal.

Fish

The waters surrounding the refuge in the Parker River-Plum Island Sound Estuary have been identified as essential fish habitat by NOAA, and the Gulf of Maine is essential fish habitat for Cod, Haddock, Red Hake, Silver Hake, Winter Flounder, and Yellowtail Flounder (NOAA 2020). The fin-fisheries of Parker River-Plum Island Sound were historically very important to the local economy, although their commercial importance declined in the early 1900s and remains low today (Buchsbaum et al. 2005). Dams on area rivers reduced the amount of habitat available for spawning by Alewife and Blueback Herring (collectively called River Herring) and smelt, thus reducing their populations. Fishways, constructed in the 1930s at six dams along the Parker River, were repaired in the 1990s to increase access to available habitat for anadromous fish species.

Plum Island Estuary is an important foraging ground for Striped Bass. Overfishing and pollution of their spawning grounds caused population levels of this fish to hit all-time lows in the 1980s, but a rebound of the population in the 1990s has been touted as one of fishery management's success stories (Buchsbaum et al. 2005).

Plum Island Sound is an important foraging area for the federally threatened and State endangered Atlantic Sturgeon. In 2021, many breaching sturgeon were documented in the mouth of Plum Island Sound (Kieffer 2021) and Steele Associates (2021) found important hibernating grounds for thousands of sturgeon in the Merrimac River.

The Parker River salt marsh and associated tidal flats are nursery habitats for many fish species, including most prey fish for the commercially important species. The most abundant fish species found in the salt marsh ecosystem (mainly pools and ditches) is the Mummichog. Other common species include Atlantic Silverside, Three-spined Stickleback, Four-spined Stickleback, Nine-spined Stickleback, and American Eel.

Since 2001, the Mass Audubon Salt Marsh Science Project has collected fish data in North and Bill Forward Pools and in the adjacent salt marsh (Mass Audubon 2020). Species diversity is typical of a salt marsh environment. In addition, Yellow Perch were recorded in Bill Forward pool in 2001 and 2002 and a few Green Sunfish were recorded in this pool in 2002. In 2004, the refuge began managing the North Pool as a closed system, leaving the water control structure closed year-round. This led to a drop in salinity levels and a rise in Pumpkinseed, a fish more typical of freshwater ponds and lakes, and a decline in Mummichogs (Duff et al. 2013). White Perch were only caught in two years (2004 and 2014) but electroshocking in 2015 revealed numerous individuals within North Pool, along with American Eel.

The non-native Eurasian Common Carp migrated to the Bill Forward and North Pools during an extreme rain event in 2006. While we were able to remove carp from the Bill Forward Pool in 2009, North Pool has been a bigger challenge. Carp have continued to proliferate in this pool despite attempts to eliminate them, including an electroshocking attempt in 2015. Short of restoring tidal flow, North Pool's large size, deep water, and low salinity levels makes elimination of carp there unlikely.

Reptiles and Amphibians

Frog-call surveys conducted by refuge staff from 1999 to 2006 documented Eastern Spadefoot Toad, Spring Peeper, American Toad, Fowler's Toad, Bullfrog, Wood Frog, and Green Frog all breeding on the refuge. Northern Leopard Frog, Gray Treefrog, and Eastern Red-backed Salamander are also documented on the refuge.

Reptile coverboard surveys conducted on the refuge in 2010 only detected Common Gartersnake. In addition, Snapping Turtle, Painted Turtle, Ringneck Snake, Smooth Green Snake, Milk Snake, and Brown Snake are documented on the refuge.

No reptiles or amphibians have been documented on Thacher Island, although no formal surveys have been conducted.

Invertebrates

Roughly 97% of all animal species are considered invertebrates (Center for Biological Diversity 2020), and include insects, spiders, earthworms, bivalves (e.g., mussels and clams), shellfish and snails, among others. Invertebrates are the main prey base for many wildlife species, and in estuaries are the primary consumers that transfer energy up the food chain, feeding on phytoplankton, plants, and detritus. On the beach, invertebrates break down organic matter and serve as a primary food source for foraging birds.

The Soft-shell Clam is the most important shellfish fishery in Plum Island Sound. However, pollution, overharvesting, and predation (primarily by Moon Snails, Horseshoe Crabs, and invasive Green Crabs) affect their populations. Within the Sound, the most common macroinvertebrates are Sand Shrimp, Grass Shrimp, Green Crab, Rock Crab, White-fingered Mud Crab, and Ribbed Mussel (Buchsbaum et al. 1998). The most common macroinvertebrates in the refuge's salt marsh and tidal creeks include Grass Shrimp, Sand Shrimp, Green Crab, Horseshoe Crab, and Coffee Bean Snail (Mikula et al. 2019). Common mollusks using the beach intertidal zone include Bay Scallop, Razor Clam, Common Periwinkle, Dogwinkle, New England Dog Whelk, Lagillerts Whelk, Stimpsons Whelk, Horse Mussel, Black Clam, and Purplish Tagelus.

In 2004, the refuge started an inventory of terrestrial insects; more than 300 species in 60 families and 13 orders have been recorded. Additionally, staff and volunteers have conducted focused inventories of bees, dragonflies, butterflies, and moths. The species lists can be found *here* in Table 4.

Globally, Insect pollinators are in decline due to loss and fragmentation of habitat and extensive pesticide use (Xerces Society 2020). Viable populations of these important insects can be sustained in small habitat units, which means that refuges are important places for pollinator conservation. Additionally, Parker River NWR hosts many exemplary barrier island habitats that have been lost throughout much of New England, many of which support endemic species of insects and pollinators (Swain 2020). Three species of moths found on the refuge are listed as species of special concern for Massachusetts: Sandplain Euchlaena, Dune Noctuid, and Coastal Heathlands Cutworm (MassWildlife 2022a). Additionally, bee surveys in 2011 and 2012 found six uncommon species (Bradley's Andrena, Canada Andrena, Trident Miner Bee, Orange Cuckoo Nomad Bee, Common Little Leaf-Cutter Bee, and Smallpox Sculptured Mason Bee) as well as three rare species (Schwarz's Masked Bee, Similar Mason Bee, and *Lassioglossum izawsum*). Insects are also sensitive to climate change impacts, as they have closely evolved with their host plants and can be used as early indicators of climate change response.

CLIMATE AND CLIMATE CHANGE

Local Climate

Parker River and Thacher Island NWRs experience a coastal climate that is more moderate than that of nearby inland locations because of their proximity to the ocean.

The weather around the refuges is cool and wet for much of the year, with the average annual precipitation of 50 inches evenly distributed throughout the year. Prevailing winds are from the west, with an average velocity of 5.3 to 10.5 miles per hour, depending on the season. High winds are most prevalent from October to April, with average wind speeds of more than 7.9 miles per hour. February is the windiest month with an average hourly wind speed of 10.4 miles per hour.

Winters are generally cold, cloudy, and snowy from November into March, with average temperatures of 28˚F in January. Snowfall is moderate, with an annual average of 35 inches. Summers are generally warm and sunny from late-May through September, reaching the warmest temperatures in July.

Changes in Extreme Events – Heat Waves, Cold Events, Rainstorms

The total number of hot days in Essex County is expected to increase as this century progresses (Commonwealth of MA 2022). The frequency and duration of heat waves, defined as three or more consecutive days with maximum temperatures at or above 90˚F, are also expected to increase. In contrast, extreme cold events, defined as the number of days per year with a minimum temperature at or below 32˚F, are expected to decrease as average temperatures rise. In general, the climate of the northeast and Massachusetts is expected to become warmer, with shorter, warmer winters (Dupigny-Giroux et al. 2018; Karmalkar & Bradley 2017; Runkle et al. 2022).

Precipitation is projected to continue to increase, with more intense rain events occurring more frequently. Monthly precipitation in the northeast is projected to be about 1-inch greater for December through April by the end of the century (2070 to 2100) (Runkle et al. 2022). This is expected to result in more flood events. Although precipitation is expected to increase, short-term droughts are projected to occur more frequently. This is projected to result in low streamflow conditions lasting an additional month. These conditions are already occurring in the Ipswich River and Parker River.

Photo 2-5 Peggotty Beach and Kent Street marshes in Scituate, Massachusetts are overrun by coastal flooding during a midday high tide on March 4, 2018. Credit: Karl Swenson/SKYWARN Spotter.

Sea Level Rise, Metonic Cycle and Storm Surges

Boston's mean sea level has risen greater than 25 millimeters between 1950 and 2022 (NOAA 2022a) (Figure 2-9). In recent decades (1990 to 2018), sea level rise rates within Plum Island Estuary have increased to 4.8 mm per year compared to the historic rate of 2.83 mm per year (1921 to 2018) (Langston et al. 2020).

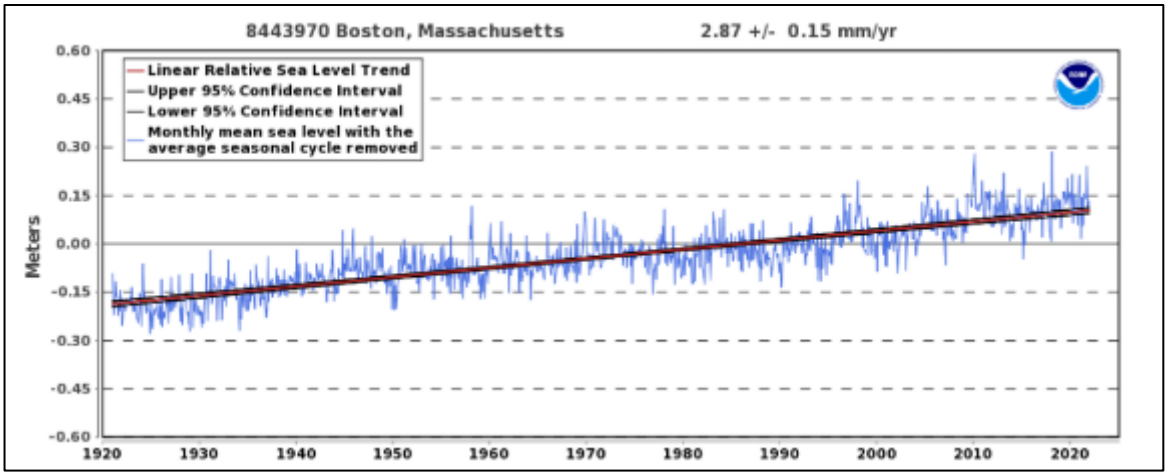

Figure 2-9 The relative sea level trend at Boston, MA.

Note: Sea level is increasing by approximately 2.87 millimeters/year, based on data from 1921 to 2020. This is equivalent to a change of 0.94 feet in 100 years. Figure taken from NOAA (2022b).

As illustrated in Figure 2-9, there is a high variation in sea level from year to year. Mean sea level is a way to track change over long periods. Sea level rise, coupled with an increase in storm frequency and intensity are leading to increased storm surge amplitude and occurrence (Murdukhayeva et al. 2013).

The orbit of the earth, moon, and sun repeats every 18.6 years—known as the Metonic Cycle—whereby the gravitational pull of the celestial bodies influences the tidal amplitude on earth. Because the moon influences ocean tides, this cycle causes tides to be higher or lower, depending on where the moon is in the cycle (Szabados 2008). Figure 2-10 represents the observed tide data from the NOAA Boston tide gauge from 1984 to 2020 showing the interaction of sea level rise and variations in tidal amplitude due to the Metonic cycle. The years 2005 to 2017 show a period of increasing tidal amplitude, and 2017 to approximately 2025 is a period of decreasing tidal amplitude. We are in the "down phase" of a 19-year *tidal pattern* which may cause sea level to appear to go down, but that is a temporary phenomenon.

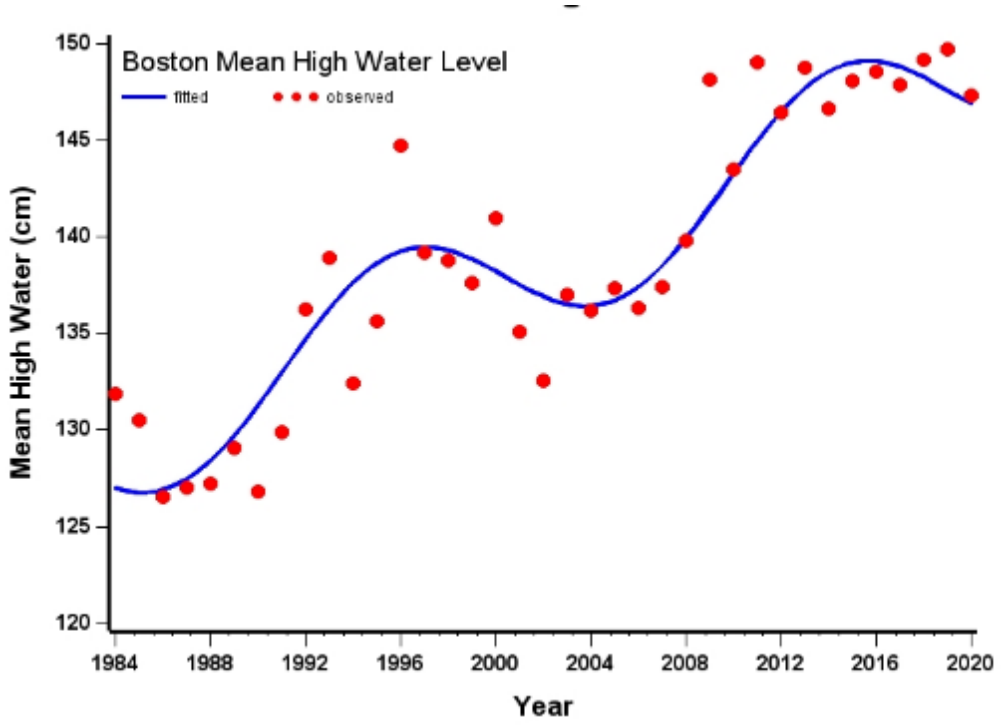

Figure 2-10 Observed tides from NOAA Boston tide gauge from 1984 to 2020.

Note: Observed tides from NOAA Boston tide gauge from 1984 to 2020, compiled by Jim Morris, University of South Carolina. The blue line indicates predicted tides based on the 19-year Metonic cycle; 2007-2016 was a period of increasing flooding due to higher lunar gravity. Red dots are actual observed tides. Noticed the increased tides from 2009 to 2019. The next period of increased tides starts in 2026.

Rising Sea Temperature

Since 2012, the *Gulf of Maine* has warmed seven times faster than the rest of the Atlantic Ocean and all the other oceans on the planet. In fact, this area is experiencing more rapid temperature increases than 99% of the world's oceans (GMRI).

While sea surface warming has been documented as occurring during all seasons, it has been strongest during the summer months, with the duration of summer-like sea surface temperatures (SST) expanding (Thomas et al. 2017). From 1982 to 2021, summertime SST in the Gulf of Maine has warmed at an average rate of 0.55°C per decade. For the last 10 years of this period (2011 to 2021), though, the average warming rate increased nearly 15% to 0.63°C per decade (Figure 2-11).

This accelerated warming has been linked to both atmospheric and ocean circulation changes (Chen & He 2015; Chen et al. 2014). Gulf Stream meanders and possible detached eddies, creating warm-core rings, can create significant anomalies in these seasonal temperature means (Andres 2016; Gawarkiewicz et al. 2012). Warming ocean temperatures also increase storm intensity and frequency (Saunders & Lea 2008).

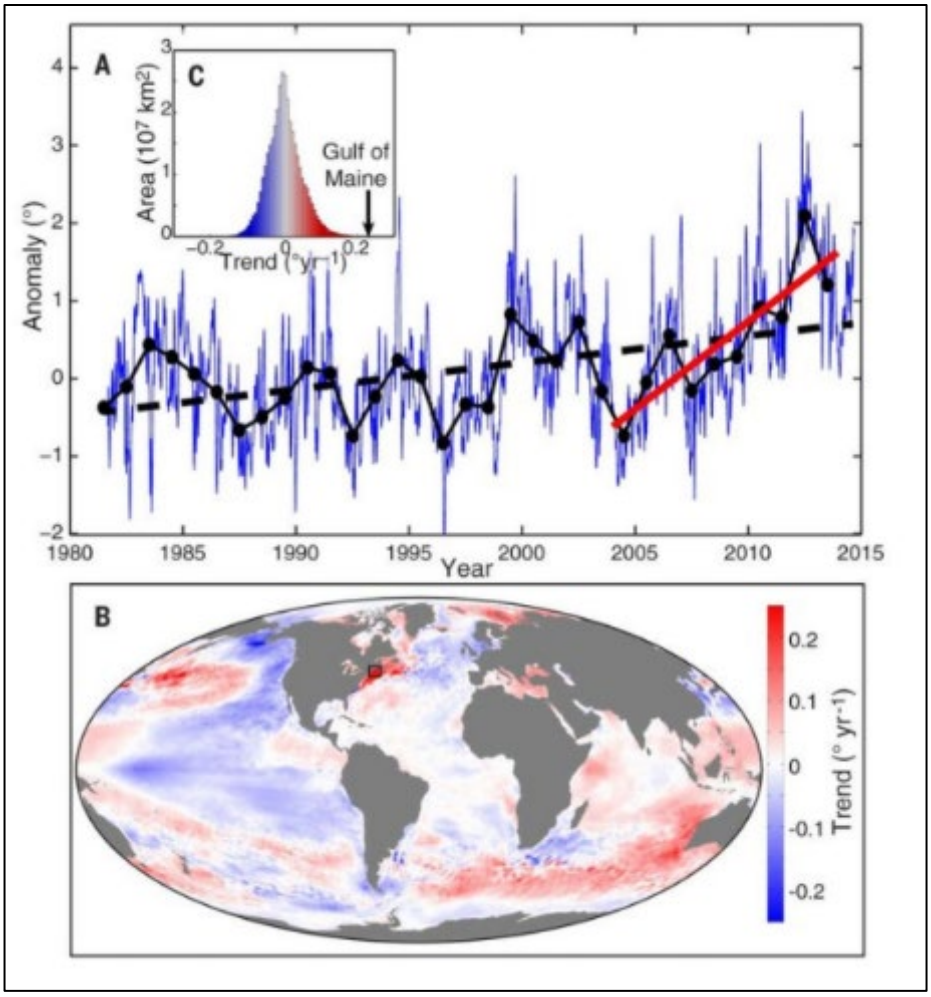

Figure 2-11 Graph of sea surface temperature trends from the Gulf of Maine and the global ocean.

Note: Daily (blue, 15d smoothed) and annual (black dots) sea surface temperature (SST) anomalies from 1982-2013 with the long-term trend (black dashed line) and trend over the last decade (2004-2013) (red solid line). (B) Global SST trends (° per yr.) over the period 2004-2013. The Gulf of Maine is outlined in black. (C) Histogram of global 2004-2013 SST trends with the trend from the Gulf of Maine indicated at the right extreme of distribution. Figure and caption taken from Pershing et al. (2015).

Effects of Climate Change on Ecosystems and Species

Warming weather

As the climate of the Northeastern U.S. continues to warm and winters become shorter and milder, ecosystems and their species are being impacted. Early emergence from winter dormancy, followed by late frosts, stresses trees and other vegetation, and negatively affects fruit production that supports a wide variety of wildlife (Rai et al. 2015). Warmer winters are also contributing to earlier insect emergence and expansion in the geographic range and population size of nuisance tree pests, such as the Hemlock Woolly Adelgid, Emerald Ash Borer, Spotted Lanternfly, and Southern Pine Beetle (Dukes et al. 2009).

Increased drought events

Increased drought events can increase stress on both natural and managed ecosystems and on water supplies in Massachusetts (Frumhoff et al. 2007). Altered freshwater flows into Plum Island Sound, including heavier runoff in early spring and reduced flows in summer could exacerbate water quality problems such as low dissolved oxygen events and harmful algal blooms (Minchinton 2002).

Increased precipitation and frequency and intensity of rain events

Increased precipitation and frequency and intensity of rain events is leading to more flood events. Increases in flood frequency or severity can increase the spread of contaminants into soils and waterways, resulting in increased risks to the health of nearby ecosystems, animals, and people—a set of phenomena well documented following Hurricane Sandy (Erickson et al. 2019). Increased freshwater flows into the Sound will also leave the estuary more susceptible to invasion by non-native plants such as *Phragmites australis* and perennial pepperweed (Minchinton 2002).

Sea level rise and storm surges

Thirty-two percent of open-coast North and Mid-Atlantic beaches are predicted to overwash during an intense future nor'easter type storm, a number that increases to more than 80 percent during a Category 4 hurricane (Dupigny-Giroux et al. 2018). When coupled with storm surges, sea level rise can pose severe risks of flooding.

Because of the diversity of the Northeast's coastal landscape, the impacts from storms and sea level rise will vary at different locations along the coast. Rocky and heavily developed coasts have limited infiltration capacity to absorb these impacts, and thus, these low-elevation areas will become gradually inundated. However, more dynamic environments, such as mainland and barrier beaches, bluffs, and coastal wetlands, have evolved over thousands of years in response to physical drivers. Such responses include erosion, overwashing, flooding and vertical accretion (increasing elevation due to sediment movement), and landward migration over the longer term as sea level rises. Uplands, forests, and agricultural lands can provide transitional areas for these more dynamic settings, wherein the land gradually converts to a tidal marsh. Marshes and beaches serve as the first line of defense for coastal property and infrastructure in the face of storms.

Photo 2-6 Coastal erosion occurring near Plum Island Center, Newbury, MA in April 2013. Credit: Bryan Eaton, Newburyport Daily News.

Built infrastructure along the coast, such as seawalls, bulkheads, and revetments, as well as natural barriers, such as coastal bluffs, limit landward erosion; jetties and groins interrupt longshore sediment transport; and culverts and dams create tidal restrictions that can limit habitat suitability for fish communities. An estimated 26 percent of open ocean coast from Maine to Virginia contains engineering structures (Dupigny-Giroux et al. 2018).

Long-term coastal erosion, as driven by sea level rise and storms, is projected to continue, with shorelines eroding inland at rates of at least 3.3 feet (1 m) per year along 30 percent of sandy beaches along the U.S. Atlantic coast (Gutierrez et al. 2014). The eastern tip of Crane Beach in Ipswich has narrowed by 5 feet since the 1950s, a loss of 112 acres. The northern section of Plum Island has lost nearly 300 feet of beach due to storm surge and erosion (TTOR 2020).

Two Plum Island beach studies indicate that there is no westward migration of the barrier island beach (Figure 2-12). The swash line is the upper limit of the active beach that is reached during a normal monthly tide. Annual surveys of the swash line at Parker River found dynamic movement of the shoreline from season to season and year to year (Psuty et al. 2017). Hein et al. (2019) found a similar cyclic erosion and accretion cycle on the north end of Plum Island, recurring on a multi-decadal time period.

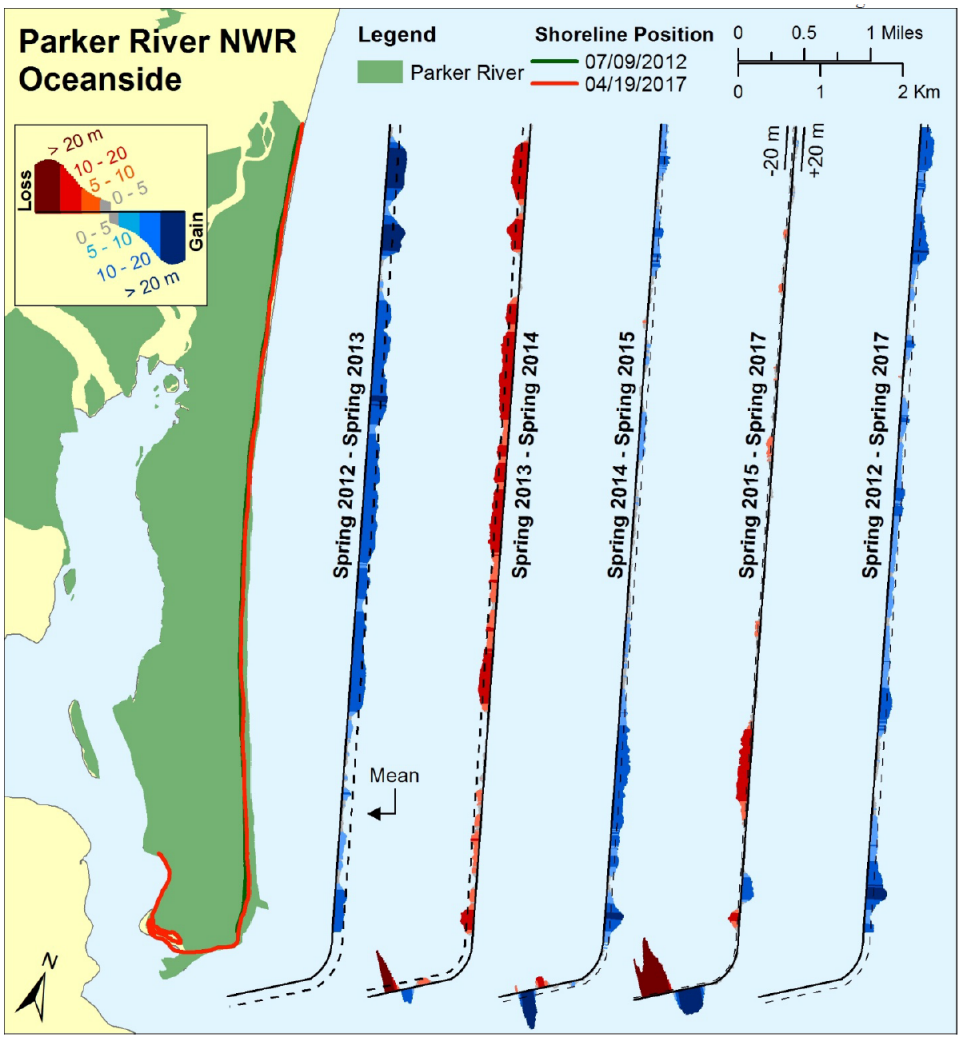

Figure 2-12 Seasonal shoreline change (mean low tide) at Parker River NWR from 2012 to 2017.

Note: Blue indicates accretion, and red indicates erosion.

Coastal habitats such as marshes and beaches may be able to accommodate moderate changes in sea level rise, at least to some extent, by migrating inland or increasing in elevation through accretion. The lands around Parker River NWR provide some of the best opportunities (~1,300 acres) for marshes to migrate inland (Runkle et al. 2022) (Figure 2-13). However, human infrastructure, such as berms, dams and roads may limit the ability of these marshes to migrate.

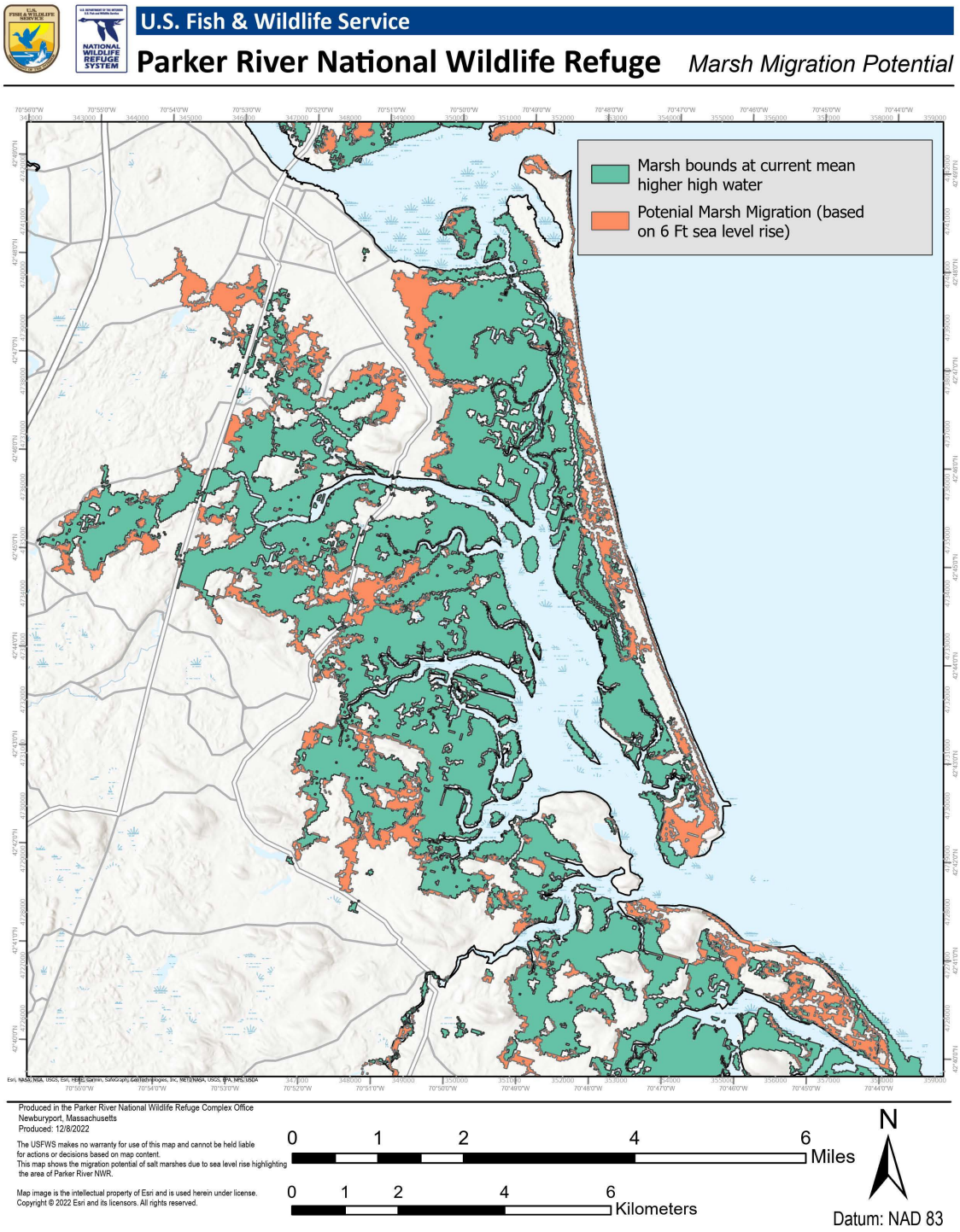

Figure 2-13 Map of existing salt marsh, showing potential future marsh migration. Credit: TNC Coastal Resiliency mapping tool.

Note: The marsh migration potential is based on landforms, and do not consider man-made barriers, like hardened structures, road and train tracks that restrict tidal flow.

Increasing sea level rise is expected to alter the extent and composition of coastal marshes within the refuge. The Plum Island salt marsh sits high on the tidal elevation range, with 82% of the marsh classified as high marsh (flooded once a month) and 10% classified as low marsh (flooded twice daily) in 2011 (Langston et al. 2020). Low marshes accrete two to five times faster than high marshes, driven by higher biomass production (*Spartina alternilfora* growth) and sediment capture (more frequent flooding). Langston's model (2020a) predicts that high marsh will persist in Plum Island Estuary until 2070, when it will rapidly convert to low marsh. Langston's model predicts that as sea level increases, accretion rates in the salt marsh will increase proportionally (7.02 mm per year by 2100), but ultimately not sufficiently to keep up with sea level rise. However, her model does not incorporate the haying infrastructure (embankments and ditches) (Adamowicz et al. 2020), which is impounding water in some areas and causing subsidence in other areas, accelerating the conversion of high marsh to low marsh or open water. Ganju et al. (2020) estimates that the Plum Island Estuary has one of the longest life spans on the East Coast (~1,100 years), due to its high current elevation. The ability of the marsh to keep up with sea level rise is largely dependent on its sediment supply. Human infrastructure, such as roads, dams, and berms may limit natural sources of sediments flowing into the estuary, reducing the ability of salt marshes and beaches to adapt.

Photo 2-7 Example of salt marsh erosion at Plum Island Sound, MA. Credit: Nicoletta Leonardi and Lacopo Carnacina.

Continued sea level rise threatens ecologically important salt marshes and estuaries that serve as breeding habitat for endemic Saltmarsh Sparrows, Clapper Rails, Seaside Sparrows, and Common Terns, migrating and wintering habitat for waterfowl and shorebirds, and nursery habitat for many marine fish species (Erwin et al. 2006). The most severe losses of intertidal habitat for shorebirds are likely to occur where habitats are unable to move inland due to natural or human barriers (Galbraith et al. 2002). This region's narrow, low-profile barrier islands are likely to experience a high degree of storm-induced change, including overwash events and erosion caused by wind and waves. Seavey et al. (2011) predict increasing storms to increase more favorable habitat for coastal species such as nesting Piping Plover, when natural sand movement is allowed to occur. The five-year average of nesting pairs on 6 miles of the refuge beach has increased from 16.6 pairs in 2012 to 43.3 pairs in 2022, seemingly supporting this prediction (Kirkey & Pau 2022).

Climate change is also likely to have an impact on the habitat quality and management of coastal impoundments throughout the Atlantic Coast, including those at Parker River NWR (i.e., North Pool, Bill Forward Pool, and Stage Island Pool). The current elevations of the impoundments are 1 foot to 1.5 feet below their adjacent salt marsh counterparts (Fitzgerald et al. 2017). This elevation deficit will increase and is expected to make drawdowns difficult or infeasible in the future. As the salt marsh bordering the impoundment dikes shrink or flood, the dikes are more vulnerable to breaching in major storms. Such unplanned breaches cause dramatic change in marsh elevation and massive die-off of vegetation and aquatic resources, as documented at Prime Hook NWR during Hurricane Sandy (Neckles et al. 2019). A more detailed assessment of the Refuge impoundments is described in Chapter 4.

Our management strategies need to be flexible to accommodate any future ecosystem alterations due to climate change. Climate change impacts and ways to address them through management have been considered throughout this HMP and are incorporated into the habitat goals, objectives and strategies outlined in Chapter 4 and Chapter 5.

Increased ocean temperatures

Increased ocean temperatures have been shown to affect some species' abundances, distributions, productivity, and phenology (Dupigny-Giroux et al. 2018). The warming trend is causing some fish and invertebrate species to move northward and to greater depths within the ocean (Pershing et al. 2015). Species such as Atlantic Cod, American Lobster, and Rainbow Smelts are undergoing range shifts towards the north, while more southern species, such as Black Bass, Smooth Hammerhead Shark, Fiddler Crab, Blue Crab, and the invasive Lion Fish are establishing populations in the Gulf of Maine and its estuaries (Dupigny-Giroux et al. 2018; Johnson 2014).

Warming ocean temperatures can affect marine species distributions and disrupt the fisheries industries. Scopel et al. (2019) found sea birds shifted their diets because of warming ocean temperatures in the Gulf of Maine, resulting in poorer productivity of young. Welch (2015) found similar diet shift and lower productivity in tern colonies on offshore islands. These distributional shifts have resulted in communities of marine organisms changing substantially, impacting species interactions and trophic transfer.

Several studies have also noted that the composition and timing of phytoplankton blooms are shifting, and dominant algal species are changing, potentially resulting in bottom-up changes in food web structure (Pershing et al. 2015; Barton et al. 2016; Chivers et al. 2017). Additionally, researchers have also found that warming ocean temperatures have been linked to increased disease incidence and parasite loads in some taxa (Burge et al. 2014; Maynard et al. 2016).

Combined effects

As coastal areas face rising sea levels, storm surges, and temperature changes, human responses to such changes could lead to reduced adaptive capacity of these natural systems. For example, if warmer, drier summers contribute to shortages of water for human consumption, increased withdrawals upstream may reduce available water resources for fish and wildlife. In addition, rising sea levels and more-intense coastal storms may compel coastal property owners to armor their shorelines, which would limit the adaptive capacity of coastal habitats by exacerbating erosion and reducing important sources of sediment that could help in the adaptation of both beach and marsh habitats.

Fitzgerald et al. (2017) suggest that as sea level rise overtakes marsh accretion, leading to lower elevation and smaller marshes, the increasing tidal prism will increase the size of the tidal inlets. These geomorphological processes will increase wave energy in the back barrier, change sediment flux between front barrier and back barrier systems, and may lead to fragmentation of the stable barrier island system.

Miselis and Lorenzo-Trueba (2017) studied barrier islands in New Jersey similar to Plum Island where the north end of the island was developed, and south end was natural and protected. Their models suggested that the narrower island width, deeper estuarine depth (due to channel dredging), and lower barrier island height in the developed portion of the island made it six times more vulnerable to SLR and storms.

The conceptual model below captures inter-related processes between the front and back barrier, such as sediment movement, shoreline erosion, and tidal exchange (Figure 2-14).

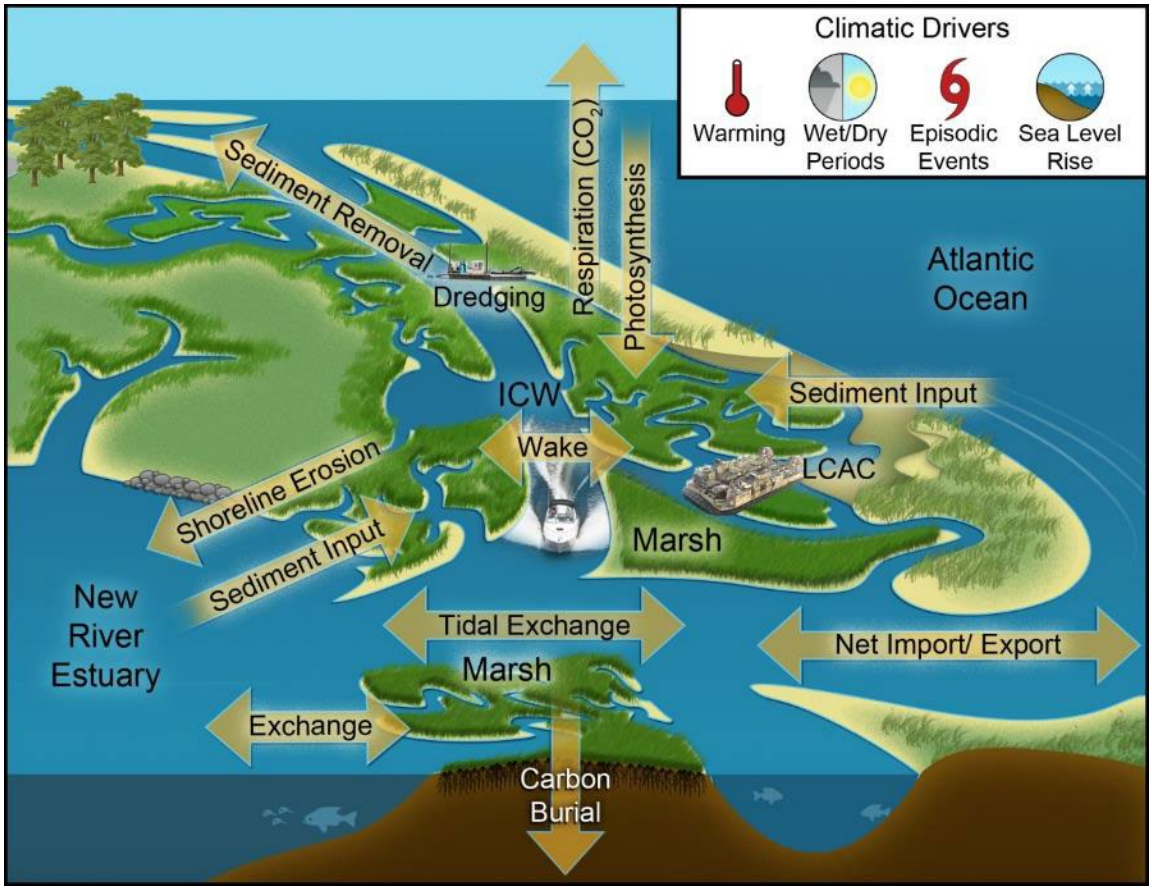

Figure 2-14 Conceptual model of a barrier island developed for Marine Corps Base Camp Lejeune ecosystem. Credit: Christensen (2021).

Chapter 3. RESOURCES OF CONCERN

RESOURCES OF CONCERN

Congress entrusts the Service to protect migratory birds, federally listed threatened and endangered species, inter-jurisdictional fishes, and certain marine mammals, as well as the biological integrity, diversity, and environmental health of the ecosystem that these animals rely on. Further, each refuge has one or more purposes for which it was established; these purposes guide its management goals and objectives. These species are collectively known as Resources of Concern.

Resources of Concern are a central aspect of an HMP. The HMP policy (620 FW 1) defines Resources of Concern as:

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

Identifying Resources of Concern allows us to identify management units and refuge-wide objectives aimed at maintaining, increasing, and/or improving the habitats required by the species or habitats identified in the refuges' purpose. Concurrent with the Inventory and Monitoring Plan (IMP) process, the Resources of Concern selection process facilitates a targeted approach to identify priority areas and gaps in management that may require additional resources, such as information (data collection and monitoring) or staff and equipment. Resources respond to habitat management differently; identifying Resources of Concern allows us to focus management activities at the level that yields the greatest benefit to trust resources, maintains biological diversity, integrity, and environmental health, and fulfills the refuge purposes.

From an operational standpoint, a large, diverse refuge requires managers to set priorities. What follows is a description of the process that Parker River and Thacher Island refuge staff used to identify Priority Resources of Concern and develop habitat goals, objectives, and strategies to benefit these species.

The Priority ROC Selection Tool was employed to prioritize the comprehensive list of species and arrive at the priority ROCs for Parker River and Thacher Island (Casey et al. 2021). The Selection Tool considers several criteria such as the priorities set by federal and state agencies as well as taxa-specific working groups (e.g., Atlantic Flyway Shorebird Initiative). The species and species groups that received the highest scores on the following criteria in the Selection Tool were selected as priority ROCs:

- Species/species groups that are most in need of help (High Conservation Priority in Regional or National Conservation Plans or Initiatives)
- Species whose individuals are reliant on unique refuge resources not common elsewhere
- Species whose individual fitness is likely to benefit from habitat management efforts
- Species whose fitness is strongly associated with overall ecosystem health

Management to benefit resources of concern typically focuses on managing habitat, as healthy habitats support resilient populations of wildlife. Thus, the prioritized ROC are grouped into habitats that support life history attributes (migratory, breeding, wintering, etc.). We further evaluated whether the prioritized ROCs represent most species that use those habitats and add other benefiting species to ensure we manage for the needs of all species using that habitat. By managing habitats to benefit a suite of species rather than single-species focus management, we benefit other species that use those habitats that may not currently be identified as high priority for management (Table 3-1 and Table 3-2).

Table 3-1. Priority Resources of Concern for Parker River NWR, associated habitat requirements, and other benefitting species.

Proposed Habitat Objective Name	Priority Resources of Concern	Habitat Requirements	Life History Requirement	Other Benefitting Species
1.1 Beach and Rocky Shore	Piping Plover	Nest above the high tide line on open sand, gravel, or shell-covered beaches, especially on sand spits and blowout areas in the dunes. Forages in the intertidal zone, sand flats, along pool edges or the wrack line. Diet: invertebrates such as polychaete worms, fly larvae, beetles, crustaceans, and mollusks.	Breeding, Migrating	Least tern; Migrating shorebirds (e.g., Sanderling, Black-bellied Plover, Ruddy Turnstone, Red Knot)
1.1 Beach and Rocky Shore	Semipalmated Sandpiper	Uses sandy beaches, foraging in intertidal zones and in wrack. Roosts on upper beach and wrackline in the hundreds. Diet: amphipods, small crustaceans, polychaete worms, small mollusks, and other insects.	Migrating	Least tern; Migrating shorebirds (e.g., Sanderling, Black-bellied Plover, Ruddy Turnstone, Red Knot)
1.2 Dune Grassland, Sandplain Grassland, Interdunal Swales	Eastern Spadefoot Toad	Breeds in vernal pools; rest of year in sandy or loose soils in sparse shrub or tree growth and sparse leaf litter; nocturnal; fossorial. Diet: Adults–a wide variety of arthropods, earthworms, snails, and small vertebrates. Larvae–phytoplankton, zooplankton, periphyton, dead plants and animals (e.g., earthworms, tadpoles), and anuran eggs.	Breeding	Wintering Ipswich Savannah Sparrow; migrating and wintering raptors (e.g., Northern Harrier, American Kestrel, Merlin, and Peregrine Falcon); rare beetles; breeding amphibians; rare plants (e.g., seabeach needlegrass)
1.2 Dune Grassland, Sandplain Grassland, Interdunal Swales	Rare Lepidoptera (e.g., Sandplain Euchlaena, Dune Noctuid Moth, Coastal Heathlands Cutworm)	Inhabit open coastal habitats, including sandplain grasslands, dune grasslands, and heathlands. Moth flight period from late May through August. Diet: larval host plants are undocumented, although low growing shrubs such as blueberry and shadbush are suspected.	Year Round	Wintering Ipswich Savannah Sparrow; migrating and wintering raptors (e.g., Northern Harrier, American Kestrel, Merlin, and Peregrine Falcon); rare beetles; breeding amphibians; rare plants (e.g., seabeach needlegrass)

Proposed Habitat Objective Name	Priority Resources of Concern	Habitat Requirements	Life History Requirement	Other Benefitting Species
1.3 Maritime Shrubland and Maritime Forest	Eastern Towhee	Dense, brushy dry areas, pitch pine-scrub oak forests; nests on or near ground in well-developed litter layer. Diet: insects and fruit.	Breeding, Migrating	Shrub-nesting songbirds (e.g., Willow Flycatcher, Blue-winged Warbler); migrating songbirds; New England Cottontail; migrating tree bats (e.g., Hoary and Silver-haired Bats).
1.3 Maritime Shrubland and Maritime Forest	Brown Thrasher	Dry thickets, brushy areas, forest edges; Low, dense, woody vegetation. Diet: insects, fruit, and seeds.	Breeding, Migrating	Shrub-nesting songbirds; American Woodcock; migrating songbirds; New England Cottontail
1.3 Maritime Shrubland and Maritime Forest	Eastern Red Bat	Migrants use coastal sites in the fall when performing long-distance migrations. Often feeds among forest trees and in open areas adjacent to forests and can migrate along barrier island on the East Coast during fall. Breeding has been documented at Parker River NWR. Diet: insects.	Breeding, Migration	Tree nesting songbirds (e.g., Eastern Kingbird, Baltimore Oriole); New England Cottontail; migrating songbirds; migrating tree bats (e.g., Hoary and Silver-haired bats).
1.4 Dune Pine Forest	Eastern Whip-poor-will	Prefers dry deciduous or mixed (evergreen-deciduous) forests with little or no understory growth, near open areas. Avoids large, uninterrupted forest with dense canopy. Diet: insects.	Breeding	Rare Lepidoptera
2.1 Old Fields	Bobolink	Requires a minimum of 5-10 acres; nests in mixed grass (8- 12”) fields with tall forbs and scattered shrubs; nest placed on the ground often at the base of large forbs. Diet: insects, spiders, and seeds.	Breeding, Migrating	American Woodcock, Northern Harrier, Short-eared Owl, Whimbrel, Savannah Sparrow.

Proposed Habitat Objective Name	**Priority Resources of Concern**	**Habitat Requirements**	**Life History Requirement**	**Other Benefitting Species**
2.1 Old Fields	Pollinators (e.g., Monarch butterfly, native bees)	Nectar sources are vital to Monarchs during fall migration, providing carbohydrates to fuel flight and to convert to the lipid reserves that support individuals during the winter. Important nectar plants include goldenrods, climbing hempweed, smooth bur-marigold, groundsel-tree, and horsemint. Critical night-roosting sites are in thickets of northern bayberry, groundsel-tree, and eastern red cedar. The larval stage of Monarchs is exclusive to milkweed plants. Native bees use a wide variety of flowering plants.	Breeding, Migrating, Wintering	American Woodcock, Northern Harrier, Short-eared Owl, Whimbrel, Savannah Sparrow.
2.2 Impoundments	Migrating shorebirds (e.g., Semipalmated Sandpiper, Red Knot, Black-bellied Plover)	Shallow (< 15 cm water depth) to mudflat habitat with sparse to no vegetation (<15% cover), at the time of peak shorebird migration (late May and mid-August).	Migrating	Foraging areas for breeding waterfowl (e.g., Gadwall, Mallard, Canada Goose), secretive marsh birds (e.g., Virginia Rail, American Bittern, Least Bittern), Marsh Wren.
2.2 Impoundments	Migrating waterfowl (e.g., American Black Duck, Northern Pintail, Green-winged Teal)	Shallow flooded (< 12” water depth) seed producing moist soil vegetation *(Cyperus, Echinochloa, Polygonum, Bidens*) during peak migration (late Oct). Diet: seeds, roots, tubers, stems, aquatic invertebrates, mollusks, crustaceans, small fish.	Migrating	Foraging areas for breeding waterfowl (e.g., Gadwall, Mallard, Canada Goose), secretive marsh birds (e.g., Virginia Rail, American Bittern, Least Bittern), Marsh Wren.

Proposed Habitat Objective Name	Priority Resources of Concern	Habitat Requirements	Life History Requirement	Other Benefitting Species
2.3 Salt Marsh	Saltmarsh Sparrow	Restricted to tidal salt marshes throughout the year. For nesting, they generally prefer higher-elevation, drier portions farthest removed from the reach of the tide. Nests are built just above the ground in *S. patens*, short-form *S. alterniflora,* saltmarsh rush, or saltgrass. Prefers dense vegetation cover (> 100%), with thatch layer. Diet: opportunistic-- insects, amphipods, spiders.	Breeding, Migrating	Nesting birds (e.g., Nelson's Sparrow, Seaside Sparrow, Black Rail, Clapper Rail, Willet); migrating shorebirds (e.g., Greater Yellowlegs, Short-billed Dowitcher, Least Sandpiper); foraging wading birds (e.g., Snowy Egret, Glossy Ibis); migrating and wintering raptors (e.g., Northern Harrier, Snowy and Short-eared Owls, Bald Eagle, Peregrine Falcon).
2.3 Salt Marsh	American Black Duck	Uses marshes for nesting, brooding, and molting. Open water and emergent vegetation are important for migration and wintering. In New England, uses tidal habitats exclusively in winter. Dabbles for food at surface and tips in shallow waters. Diet: seeds, roots, tubers, stems, aquatic invertebrates, mollusks, crustaceans, small fish.	Breeding, Migrating, Wintering	Nesting birds (e.g., Nelson's Sparrow, Seaside Sparrow, Black Rail, Clapper Rail, Willet); migrating shorebirds (e.g., Greater Yellowlegs, Short-billed Dowitcher, Least Sandpiper); foraging wading birds (e.g., Snowy Egret, Glossy Ibis); migrating and wintering raptors (e.g., Northern Harrier, Snowy and Short-eared Owls, Bald Eagle, Peregrine Falcon).

Table 3-2 Priority Resources of Concern for Thacher Island NWR, associated habitat requirements, and other benefitting species.

Proposed Habitat Objective Name	Priority Resources of Concern	Habitat Requirements	Life History Requirement	Other Benefitting Species
3.1 Rocky Intertidal Shore	Roseate Tern (currently absent)	Colonial nester, almost exclusively on islands. Nest typically sheltered by tall, rank vegetation or structure (<30% visibility from above). May nest under debris or rocks. Diet: primarily American Sand Lance.	Breeding, Migrating	Common and Arctic Terns; Common Eider
3.1 Rocky Intertidal Shore	American Oystercatcher	Nests are primarily on sand and shell beaches, dunes, salt marsh, and occasionally rock or other surfaces. Typical nests are placed in areas with little to no vegetation well above mean high water. Diet: Bivalves, mollusks, crustaceans, worms, and other marine invertebrates that inhabit intertidal areas.	Breeding	Common and Arctic Terns; Common Eider
3.2 Maritime Shrubland	New England Cottontail (extirpated)	Live in dense areas of shrubs and young forests, which are necessary for predator avoidance. Winter survival requires a stem density of more than 20,234 stems per acre. Diet: herbaceous plants in summer; bark, twigs, and buds of woody plants in winter.	Breeding	Willow Flycatcher; Eastern Kingbird; migrating songbirds

BIOLOGICAL INTEGRITY, DIVERSITY, AND ENVIRONMENTAL HEALTH

The *Refuge System Improvement Act of 1997* states that, in administering the Refuge System, the Service shall "…ensure that the biological integrity, diversity, and environmental health of the System are maintained".

The Service defines biological integrity, diversity, and environmental health (BIDEH, Service Manual 601 FW3) as:

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

Fulfilling the BIDEH policy requires consideration and protection of a broad suite of native plants and animals, as well as the habitats and ecosystem functions that sustain them. The native wildlife, plants, and habitats found on the Parker River and Thacher Island NWRs serve as the representative elements of BIDEH. The importance of BIDEH has been highlighted by the response of refuge and other habitats to climate stressors. Where natural processes are intact, such as the beach, dune, and maritime shrub habitats on the refuge, the barrier island is relatively free of invasive plants (salt spray and wind keeping many invasives at bay), and able to withstand large storms, adapting and changing and recovering after disruptive events. Trust resources, such as Piping Plovers and migrating shorebirds have benefited from these dynamic conditions, as demonstrated by a rapidly increasing breeding population of plovers. Similarly, in salt marsh systems where hydrology is un-impeded, the salt marsh is keeping up with SLR, receiving much needed sediment in larger storm events. In areas where natural processes are interrupted (e.g., hydrology alterations in salt marsh, diked impoundments, refuge road), we're seeing signs of impounding and plant dieback, and areas starved of sediments, which are signs of ecosystem stress.

In developing this HMP, we focused on identifying and maintaining and restoring the individual components of each habitat and ecosystem, as well as the interactions among those components. We consulted a variety of sources to assemble a holistic picture of the refuges' historic conditions, current conditions and site capabilities, species distributions, and predicted future conditions. We list the major habitats found on the refuge, Tables 3-3 (Parker River) and 3-4 (Thacher Island), along with the names of the corresponding Massachusetts Natural Communities and National Vegetation Classification System (NVCS) Associations for each refuge. Each habitat is described by its component plant and animal populations and attributes, and the relevant natural processes and limiting factors and threats. While the habitat types, and population and habitat attributes describe current conditions, the natural processes identify components important for maintaining the diversity and ability of these systems to adapt to future climate stressors. Management to protect and enhance these habitats and the wildlife that they support often involves addressing the limiting factors and threats that are identified in the tables below.

Table 3-3 Habitat types and associated natural communities that represent BIDEH at Parker River NWR, including attributes, natural processes, and limiting factors.

Habitat Type	**Massachusetts (State Rank)***	**NVCS****	**Populations and Habitat Attributes**	**Natural Processes**	**Limiting Factors & Threats**
Rocky Intertidal Shore	Marine Intertidal Gravel / Sand Beach / (S4)	Yellow Tang – Black Tang Tidal Algal Nonvascular Vegetation [CEGL006341]	Occurs within the intertidal zone with a rocky or cobble substrate and is characterized by alternating tidal submergence. Dominated by rockweed, blue mussels, and brown algae. Protected areas of shoreline may include other species such as *Spartina alterniflora*. These are biologically diverse features that support a variety of marine life.	Large boulders and rocks deposited by the last glaciation. Most are edges of eroding drumlins. Subject to daily inundation of salt water and constant pounding by waves.	Shoreline exposed to the ocean receives high energy wave action, causing erosion. Sea level rise will reduce exposure at low tide.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Sandy Beach	Maritime Beach Strand (S3)	Northern Maritime Beach Strand [CEGL006106] North Atlantic Upper Ocean Beach [CEGL004400]	Strand: Sparsely vegetated sandy habitat seaward of the foredune but above the low tide. Vegetative cover is variable and seasonally dynamic. Above the high tide line, vegetation includes annuals and biennials including American beachgrass, sea-rocket, seabeach saltwort, dusty miller, and seabeach orache. Upper Beach: This upper beach supports nesting habitat for Piping Plover and Least Tern. Expansive sandy beach and strands of wrackline support abundant invertebrate populations and provides vital feeding areas for a variety of shorebirds. Below the high tide line, the beach is composed of unvegetated sand that is flooded twice daily. This intertidal zone supports sand burrowing clams and other invertebrates.	Semi-diurnal tides sustain this habitat. Wind and wave action constantly shift sand within this foredune habitat. Larger storms and Nor'easters transport large sand volumes, and change the shape, slope, width, and elevation of the beach. Generally, the winter season brings erosive forces while the summer season brings sand accretion.	Jetties and groins disrupt the natural processes of erosion and sand deposition. Climate change may influence habitat abundance as the sea level rises and increased storm frequency reshape this habitat with increasing frequency. Human structures such as stairs, overlooks and paths can alter the sand movement.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Dune Grassland	Maritime Dune (S3)	Northern Beach Heather Dune Dwarf-Shrubland [CEGL006143] Northern Beachgrass Dune [CEGL006274]	Beachgrass Dune: This community occurs west of the foredunes. Wind deposited sands are the primary substrate and vegetative composition is variable and patchy; exposed bare sand is common. Much of this habitat is dominated by American beachgrass with associated species of beach pea, dusty miller, seaside goldenrod, and rarely seabeach needlegrass. Heather Dune: Beach heather can form sporadically dominant patches, and where it occurs it will stabilize sands, helping other species to establish in low numbers. Associated species can include coastal jointweed, beach pinweed, bunchgrasses, and seaside sandmat. Reindeer lichen can be found throughout.	Wind and salt spray, especially during large storms, facilitates the movement of sand. Sandy soils, along with exposure to persistent winds and salt spray will limit succession and stunt the growth of many species, particularly woody vegetation. Variations in topography and wind constantly shifts sand, maintaining the sparse vegetation found in this habitat.	Invasive plants such as spotted knapweed and beach rose. Current and future visitor infrastructure can inhibit the free movement of sand, including the westward migration of the dunes across the refuge access road. Visitor trespass causes erosion and vegetation die-offs.

Habitat Type	**Massachusetts (State Rank)***	**NVCS****	**Populations and Habitat Attributes**	**Natural Processes**	**Limiting Factors & Threats**
Sandplain Grassland	Sandplain Grassland (S1)	North Atlantic Coast Backdune Grassland [CEGL006161] Sandplain Grassland [CEGL006067]	This community may intermix with the dune grassland habitat but is usually located in more sheltered areas. Older successional stages of this habitat can include shrubs and stunted trees, comprised of small bayberry, beach plum, and pitch pine. Field sagewort, little bluestem, beach pinweed, Pennsylvania sedge, and reindeer lichen are common. There are multiple robust populations of the State-listed species seabeach needlegrass. This habitat also supports rare and endemic Lepidoptera and other insects.	Dry, nutrient-poor sandy substrate prohibits growth of other species. The stabilized sands where this habitat persists allow for development of graminoid and soil crust communities that differ from the adjoining dune grassland community.	Susceptible to invasion by spotted knapweed, cypress spurge, Morrow's honeysuckle, black locust, Japanese knotweed, and beach rose. Historically, fire has set back succession, allowing sandplain grasslands to expand. Fire suppression has eliminated this mechanism for proliferation, allowing shrubs to encroach.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Interdunal Swale	Interdunal Swale (S2)	Northern Interdunal Shrub Swale [CEGL006339] Northern Interdunal Cranberry Swale [CEGL006141]	Interdunal depressions within the dune system that range from unvegetated freshwater pools to seasonally flooded shrublands. These swales may have a shallow layer of peat overtopping the sandy substrate; vegetation will vary depending on soil and hydrology. Large cranberry tends to dominate this habitat along with various rushes, sedges, clubmoss, and *Sphagnum* species. Shrub dominated swales may include small bayberry, winterberry holly, highbush blueberry, speckled alder, and willow species. Open areas between the shrubs will contain herbaceous species such as Virginia marsh-St. John's-wort and woolgrass. Some of these swales act as vernal pools and support amphibians and reptiles including the State-listed Eastern Spadefoot Toad, and support rare plants (sundews, dragon's mouth) and insects.	Flooding duration varies, and some swales may remain permanently inundated, but the water table always intersects the ground surface for at least part of the growing season. Cranberries and *Sphagnum* moss perpetuate acidic and inundated conditions that impede succession. Infrequent storms that breach the foredune create new swales by eroding sand down to the groundwater.	Swales are susceptible to invasion by *Phragmites*, purple loosestrife, glossy buckthorn, and rusty willow. Well-developed foredunes prohibit breaching thus new swale creation. This may change with an increase in storm intensity predicted with climate change. If breaches do occur, saltwater intrusion in existing swales will likely cause diebacks of the less salt tolerant vegetation. Drought has the potential to reduce the health and extent of swale habitat.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Maritime Shrubland	Maritime Shrubland (S3)	Northern Bayberry Dune Shrubland [CEGL006295] Northern Tall Maritime Shrubland [CEGL006379] North Atlantic Coastal Plain Dune Vine [CEGL003886]	This self-sustaining shrubland occurs in the interface between stabilized dunes and salt marsh on protected slopes and hollows of dry, stabilized maritime backdunes. Dominant species include small bayberry, beach plum, serviceberry, chokeberries, winterberry holly, arrowwood, eastern red cedar, shining and staghorn sumac. Typical vine associates are greenbrier, Virginia creeper, and poison ivy. The herbaceous layer tends to be sparse and low, particularly where shrub growth is dense, and can include dune grassland or adjacent upland species such as American beachgrass, seaside goldenrod, beach heather, beach pinweed, beach sedge, coast jointweed, annual saltmarsh aster, common yarrow, northern evening primose, Gray's flatsedge, little bluestem, and others. High-stem density associated with this habitat provides important cover for breeding and migratory songbirds and other wildlife. The dominant shrub species are heavy producers of berries, which are a vital food source for fall migrating landbirds.	Development of organic duff layer allows the development of woody vegetation. Infrequent wind and salt spray inhibits succession to tall forest. Groundwater levels vary and have a strong influence on vegetation composition and structure.	Exposure to wind and salt spray prevents expansion of this habitat seaward, and succession to forest limits expansion westward. Depth of freshwater lens is strongly correlated with barrier island and constrains this habitat. Continued invasion by multiple species, including glossy buckthorn, Morrow's honeysuckle, common barberry, and Asiatic bittersweet. Dense invasive understory has probably eliminated wildflower species that are present at several sparser shrub habitats and pitch pine forests on the refuge.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Successional Maritime Forest	Maritime Forest / Woodland (S2)	Northeastern Maritime Forest [CEGL006145] Northern Tall Maritime Scrub Forest [CEGL006379]	In more protected areas, maritime shrubs succeed to tall forest and allow the establishment of tree species such as black cherry, serviceberry, eastern black oak, quaking aspen, and the occasional sassafras and eastern red cedar. Stratification of the understory layers include shrub species such as blueberry, small bayberry, Virginia creeper, and arrowwood. The herbaceous layer includes wild sarsaparilla, Canada mayflower, and false Solomon's seal. In the Hellcat area, the substrate tends to remain saturated for extended periods, especially through the growing season. Red maple and blackgum are the dominant canopy species and often differ from the surrounding upland habitat. The shrub layer contains winterberry holly, highbush blueberry, and others. *Sphagnum* species are a typical component of this system.	Additional protection from wind and salt spray allows the establishment of tree species. Micro-topography and variation in groundwater levels create a mosaic of dry and wet forest patches. The red maple-blackgum swamp is influenced by spring floods and high groundwater. This community probably expanded with the creation of the North Pool, which holds freshwater. If impoundment is removed this community will likely shrink, and there may be some tree die-off.	Tidal flooding from adjacent salt marsh and the amount of salt spray from the ocean limit the expansion of this habitat. Sea-level rise and increased flooding may further restrict this habitat. Habitat is susceptible to already established invasive species such as honeysuckle, glossy buckthorn, common barberry, and black locust.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Dune Pine Forest	Maritime Pitch Pine Woodlands on Dunes (S1)	Pitch Pine Dune Woodland [CEGL006117] Black Pine	The maritime pitch pine woodland community occurs on stabilized backdunes influenced by wind and salt spray. The substrate is dry, acidic, nutrient-poor sand. There is generally a significant cover of bare sand, but where more stabilized, species diversity tends to increase. Pitch pine is the dominant canopy tree, with occasional eastern black oak and eastern red cedar. The shrub layer when present includes beach heather, small bayberry, black huckleberry, or blueberry. Scarce vines include greenbrier, Virginia creeper, and poison ivy. The herbaceous layer is sparse but can include wild sarsaparilla, goldenrod, beach pinweed, bracken fern, starflower, Canada mayflower, crinkled hairgrass, and common bearberry. Densely planted non-native black pines form a second pine community that contains little to no understory. Pitch pine communities support the highest concentration of rare and endangered Lepidoptera in Massachusetts. Forty one percent of state-listed moths and butterflies are associated with these communities, although studies have not yet been done on the refuge.	Storm winds, salt spray, and dry sandy soils maintain this habitat type and reduce species richness. Beginning in the 1950s non-native black pines were planted by refuge staff for erosion control and reforestation after an escaped fire burned through the dunes. The density of plantings prevents the development of an understory layer. Black pines are spreading through the dunes via wind dispersal of seeds.	Invasive black pine and honeysuckle continue to spread and outcompete native species. As the pitch pine community is fire adapted, fire suppression has likely limited the spread of this community. Pitch pines are outcompeted by other shrub and tree species on soils with increased nutrient levels. In the absence of fire, a thick duff layer precludes germination of pitch pine seedlings.

Habitat Type	**Massachusetts (State Rank)***	**NVCS****	**Populations and Habitat Attributes**	**Natural Processes**	**Limiting Factors & Threats**
Old Fields	Cultural Grassland (NR)	Northeastern Old-field Meadow [CEGL006107]	This habitat is a remnant of old farm fields and historic refuge management for goose browse. The fields continue to be maintained for wildlife viewing opportunities. Soils support graminoid to shrubby species. Examples include Pennsylvania sedge, fescue species, little bluestem, creeping bentgrass, common timothy, quack grass, Virginia rose, poison ivy, and northern dewberry. Other patchy or scattered species vary by location and include common milkweed and goldenrod.	Annual mowing maintains the short vegetation and prevents succession to maritime shrubs and forest.	As these are not natural habitats, they are limited by refuge management. Due to disturbance, these areas are highly susceptible to invasive species that already occur on or surround the site including glossy buckthorn, Morrow's honeysuckle, Asiatic bittersweet, spotted knapweed, cypress spurge, multiflora rose, black swallowwort, and Canada thistle.
Impoundments	Deep Emergent Marsh (S4)	Eastern Reed Marsh [CEGL004141] Eastern Cattail Marsh [CEGL006153]	Emergent, lacustrine, marsh systems with a mucky substrate; likely covering thick salt marsh peat. Cattail and *Phragmites* form monotypic stands in shallowly flooded brackish to freshwater areas. Other species present in the impoundments include sedges, bulrushes, grasses such as creeping bentgrass, switchgrass, and red fescue, dwarf spikerush, saltmarsh aster, beggarticks, marsh orach, red goosefoot, salt sandspurry, marsh fleabane, fireweed, and others. Aquatic vegetation includes common duckweed and pondweed.	Flooding regime and soil salinity influence vegetation composition. Areas closer to the water control structures have higher salinity levels. Maintaining full-pool conditions early in the growing season slows the spread of cattail and *Phragmites* into shorebird and duck foraging areas. If invasive control is successful, water level drawdowns in May through August expose mudflats, allowing for the germination and growth of short-lived annual plants.	Conflicts with clammers limits draw down ability in Stage Island Pool. Subsidence and rising seas threaten future management capabilities and restoration potential. The altered system creates conditions that promote invasion by non-natives such as *Phragmites* and purple loosestrife. Forging habitat for shorebirds and water is difficult to achieve with existing resources and invasive persistence.

Salt Marsh	Salt Marsh (S3)	North Atlantic Low Salt Marsh [CEGL004192] North Atlantic High Salt Marsh [CEGL006006] Salt panne [CEGL004308] Salt panne pool [CEGL006370] Eastern Tidal Salt Shrubland [CEGL006848] Northern Brackish Meadow [CEGL006368]	Strongly influenced by diurnal tides, this habitat occurs in the protected back barrier between astronomical low and high tides. The plant community is determined by tidal inundation and micro-topography. Low salt marsh is diurnally flooded by tides, occurring between mean high tide and mean sea level. *Spartina alterniflora* forms nearly monotypic stands. Brown algae can form extensive mats at the bases of the grass. High salt marsh occupies the irregularly flooded zone extending from mean high tide landward to the limit of spring tides. Vegetation is typically dominated by *Spartina patens*, with patches dominated by spikegrass and black grass. Other characteristic associates that occur in low abundance include saltmarsh aster, sea lavender, seaside goldenrod, bushy knotweed, silverweed, marsh orach, sea milkwort, seaside plantain, northern seaside arrow-grass, and seaside gerardia. Prominent within the high marsh are salt pannes and pools, which are characterized by poor drainage creating hypersaline conditions. Salt pannes are very shallow depressions dominated by glasswort and short-form *S. alterniflora*. Bare peat and/or mucky soils are prevalent with a variable vegetative cover, ranging from near total absence to a dense cover. Micro-algal mat	Soil salinity levels and fluctuating hydroperiod limits marsh system to halophilic (salt tolerant) species. Tidal flooding dictates the extent and type of salt marsh habitat. The low marsh is dominated by *S. alterniflora* due to its ability to withstand longer submergence compared to other salt marsh grasses. It is outcompeted by *S. patens* in the higher marsh, which sees less flooding from daily tides. Formation of salt pannes and pools may result from ice-scouring, rafting flotsam, peat compaction, mosquito ditch levees, or lack of sedimentation associated with distance to creek. Salt panne depressions and salt pools are regularly to irregularly flooded by high tides. Some pools or pannes are legacies of deteriorating embankments and ditches from the salt hay era, holding water on the marsh surface and causing vegetation dieback or conversion to *S. alterniflora marsh.*	Marsh migration is constrained by steep changes in topography further inland. Some marsh migration is possible both westwards and eastwards from the refuge marsh in some areas. Human infrastructure, such as roads, culverts, dams, and sea walls, that restrict tidal flooding and sediment flow significantly impede marsh accretion potential. Extensive ditches and embankments have replaced the natural creek hydrology in many of these marshes. Subsequent abandonment and clogging of these ditches and the embankments have caused impounding of flood waters on the marsh, accelerating conversion to *S. alterniflora* marsh, and creation of open water and mudflats. Many of these densely ditched marshes have subsided artificially, creating high marshes at lower elevations. Expansion of the invasive perennial pepperweed and *Phragmites* threaten the ability of the marsh to adapt to rapidly changing conditions.

Habitat Type	Massachusetts (State Rank)*	NVCS**	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
			communities are common and diverse. Salt pools are deeper than pannes, remaining permanently or semi permanently flooded. Vegetation is characterized by aquatic widgeongrass. Pools provide habitat for "marsh minnows" including Mummichog and sticklebacks. Two communities lie between the high salt marsh and the upland. The northern brackish meadow occurs as a narrow band where the marsh is irregularly flooded by spring tides and storm surges. This allows for the colonization by oligohaline or mesohaline vegetation, including creeping bentgrass, New York aster, red fescue, prairie cordgrass, and salt marsh bulrush in addition to high marsh plants.		

*Note: *Natural Communities of Massachusetts. Swain (2020); State Rank: Ranking reflects the community's rarity and threat within Massachusetts.*

- *S1 = Critically imperiled in the state due to extreme rarity. Typically, 5 or fewer occurrences, very few remaining acres or miles of stream, or especially vulnerable to extirpation in Massachusetts for other reasons.*
- *S2 = Imperiled in the state due to rarity. Typically, 6-20 occurrences, very restricted range, few remaining acres, or miles of stream, or very vulnerable to extirpation in Massachusetts for other reasons.*
- *S3 = Vulnerable in the state due to a restricted range, relatively few occurrences (typically 21-100), limited acreage or miles of stream, recent and widespread declines, or vulnerable to extirpation in Massachusetts for other reasons.*
- *S4 = Apparently secure in Massachusetts. Uncommon, but not rare.*
- *S5 = Demonstrably secure in Massachusetts. Common, widespread, and abundant.*
- *SU = Status unknown in Massachusetts.*
- *SNR = Status not ranked in Massachusetts.*

***National Vegetation Classification System (Associations), available via NatureServe Explorer (NatureServe 2020).*

Table 3-4 Habitat types and associated natural communities that represent BIDEH at Thacher Island NWR, including attributes, natural processes, and limiting factors.

Habitat Type	*Massachusetts 2020 (State Rank)	**NVCS	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Rocky Intertidal Shore	Marine Intertidal Rocky Shore	Yellow Tang – Black Tang Tidal Algal Nonvascular Vegetation [CEGL006341]	Occur on ocean shores between the high tide splash zone and the subtidal limits of light penetration. Intertidal communities consist of non-vascular plants and invertebrates. Marine brown algae (seaweed), especially bladder wrack and rockweed, dominate. Sea-lettuce, a green alga, is common throughout. Irish moss, a red alga, is common in tide pools.	Occurring on high-stress environment along exposed ocean shores, this community is alternately covered by tides and exposed to desiccation and thermal stress.	Shoreline exposed to the ocean receives high energy wave action. Sea level rise will reduce exposure at low tide.

Habitat Type	*Massachusetts 2020 (State Rank)	**NVCS	Populations and Habitat Attributes	Natural Processes	Limiting Factors & Threats
Maritime Shrubland	Maritime Shrubland (S3)	Northern Bayberry Dune Shrubland [CEGL006295] Northern Tall Maritime Shrubland [CEGL006379]	Occur along the coast within direct influence of the ocean and salt spray, such as on barrier beach dunes, next to tidal marshes or on bluffs or rocky headlands. Dominant species include small bayberry, beach plum, serviceberry, chokeberries, winterberry holly, arrowwood, eastern red cedar, and staghorn sumac. Typical vine associates are greenbrier, Virginia creeper, and poison ivy. The herbaceous layer tends to be sparse and low, particularly where shrub growth is dense. High stem density associated with this habitat provides important cover for breeding and migratory songbirds and other wildlife. The dominant shrub species are heavy producers of berries, which are a vital food source for fall migrating landbirds.	Development of organic duff layer allows the development of woody vegetation. Infrequent wind and salt spray inhibits succession to tall forest. Groundwater levels vary and have a strong influence on vegetation composition and structure.	Exposure to wind and salt spray prevents the succession to forest. Depth of freshwater lens may constrain this habitat. Continued invasion by multiple species, including glossy buckthorn, Morrow's honeysuckle, common barberry, and Asiatic bittersweet.

*Note: *Natural Communities of Massachusetts. Swain (2020); State Rank: Ranking reflects the community's rarity and threat within Massachusetts.*

- *S1 = Critically imperiled in the state due to extreme rarity. Typically, 5 or fewer occurrences, very few remaining acres or miles of stream, or especially vulnerable to extirpation in Massachusetts for other reasons.*
- *S2 = Imperiled in the state due to rarity. Typically, 6-20 occurrences, very restricted range, few remaining acres, or miles of stream, or very vulnerable to extirpation in Massachusetts for other reasons.*
- *S3 = Vulnerable in the state due to a restricted range, relatively few occurrences (typically 21-100), limited acreage or miles of stream, recent and widespread declines, or vulnerable to extirpation in Massachusetts for other reasons.*
- *S4 = Apparently secure in Massachusetts. Uncommon, but not rare.*
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***National Vegetation Classification System (Associations), available via NatureServe Explorer (NatureServe 2020)*

PRIORITY HABITATS

With a limited budget and staff time, the refuge also needed to prioritize the habitats for planning and management purposes. Each habitat was classified as a Priority I or Priority II habitat on the Parker River (Table 3-5) and Thacher Island (Table 3-6) NWRs. Priority 1 habitats are:

- sufficient in extent and/or quality to contribute to the refuge's highest priority ROCs, AND
- are experiencing a high threat or urgent need for management to support the refuge's highest priority ROCs (Casey et al. 2021)

Some habitats, such as maritime shrubs, contribute to the highest priority ROC but are classified as Category II because no active management is needed to support those species.

Table 3-5 Priority habitats for Parker River NWR.

Habitat Objective Name	**Priority Level**	**Reasons for Ranking**	**Limiting Factors and Threats**	**Management Needs**
1.1 Beach and Rocky Shore	I	Presence of nesting federally listed species; Importance to fall migrating shorebirds including highest priority species in BCR 30; Active management results in positive, measurable impact on trust resources.	Human disturbance. Climate change (sea-level rise, increased storm intensity). Erosion. Jetties, groins, dredging, beach nourishment.	Limit human-caused erosion. Work with towns to decrease impacts from human-made structures and sediment augmentation projects. Allow for dynamic movement of habitat spatially.
2.3 Salt marsh	I	Salt marsh habitat is limited within the northeast; high potential for greatest refuge contribution; presence of several highest priority birds in BCR 30 (Saltmarsh Sparrow, Seaside Sparrow, and Am. Black Duck); At 2,660 acres, it is the largest habitat type on the refuge and part of Great Marsh, the largest contiguous salt marsh north of Long Island.	Historic human alterations impacting natural hydrology. Impediments to sediment input and transport. Invasive species. Climate resiliency from sea level rise and increased inundation. Mercury contamination. Human disturbance.	Invasive plant management. Management to restore natural hydrology and sediment transport. Monitor ecosystem process changes in response to climate stressors. Monitor habitat suitability changes for species of concern.

Habitat Objective Name	Priority Level	Reasons for Ranking	Limiting Factors and Threats	Management Needs
1.2 Dune Grassland, Sandplain Grassland, Interdunal Swales	II	Sandplain Grasslands and Interdunal Swales are both rare (S1) natural communities in Massachusetts and host locally rare plants. Sandplain Grasslands support rare moths and beetles, and Interdunal Swales host vernal pool species. The extent of these habitats is limited on the refuge, while management of these, along with Dune Grasslands, is very limited.	Climate change (sea-level rise, increased storm intensity). Human disturbance/recreation. Invasive species. Succession. Requires periodic disturbance.	Limit recreational access. Allow natural processes to reset succession and create new habitat. Invasive plant management. Fire or mowing to reduce encroachment from shrubs.
1.3 Maritime Shrubland and Maritime forest	II	Many high priority bird species in BCR 30 in this habitat; potential habitat for New England Cottontail; important for fall migrating songbirds; Requires little management.	Saltwater impacts from salt marsh and salt spray. Invasive plants.	Invasive plant management. Explore the role of prescribed fire in controlling invasive and promoting native plant regeneration.
1.4 Dune Pine Forest	II	Supports uncommon plant species, but the refuge contains only a small portion of this community type, scattered throughout the dunes. Much of this habitat is dominated by non-native black pine, which was planted by the refuge in the 1970s.	Lack of disturbance (i.e., fire). Invasive plants.	Invasive plant management (e.g., remove black pine). Prescribed fire.

Habitat Objective Name	Priority Level	Reasons for Ranking	Limiting Factors and Threats	Management Needs
2.1 Old Fields	II	Cultural habitat type that supports nesting Bobolinks, Monarchs, and other pollinating insects, foraging raptors, and migrating birds; managed mainly for wildlife viewing opportunities. Field sizes are too small to support many BCR 30 high priority species.	Requires regular mowing or other management to deter succession to woody vegetation. Invasive plants.	Annual mowing, burning, or grazing. Invasive plant management
2.2 Impoundments	II	Supports breeding wading and marsh birds, breeding and migrating waterfowl, and migrating shorebirds in BCR 30. Many species of waterfowl and shorebirds would benefit from the conversion of this habitat to salt marsh. Restoration to salt marsh would also benefit BCR 30 species of highest priority, including the Saltmarsh Sparrow.	Requires intensive management and maintenance. Invasive plants. Subsidence. Sea level rise and increased storm intensity threaten the integrity of the impoundment, increasing the chances of a catastrophic failure. Water quality issues (e.g., anerobic conditions). Restoration to salt marsh would create a healthier, resilient habitat with reduced management needs.	Manage water levels. Maintain water control structure (WCS) and dike. Invasive plant management. Monitor changing processes (accretion rates, dike vulnerability, WCS capability) and plan to restore prior to vulnerability threshold. Develop detailed salt marsh restoration design.

Table 3-6 Priority habitats for Thacher Island NWR.

Habitat Objective Name	Priority Level	Reasons for Ranking	Limiting Factors and Threats	Management Needs
3.1 Rocky Intertidal Shore	II	Historically supported large colony of Common, Arctic, and Roseate terns. Nesting habitat for American Oystercatcher.	Human disturbance. Expanding Great Black-Backed and Herring Gull populations.	Gull population management.

Habitat Objective Name	Priority Level	Reasons for Ranking	Limiting Factors and Threats	Management Needs
3.2 Maritime Shrubland	II	Potential habitat for New England Cottontail breeding colony; important for fall migrating songbirds; requires little management.	Saltwater impacts from salt spray. Invasive plants.	Invasive plant management.

Chapter 4. HABITAT GOALS AND OBJECTIVES

This chapter's intent is to describe the habitat management direction for the refuge, and to provide links between habitat objectives and the refuge's priority ROCs (see Chapter 3) that are expected to benefit from management. Further, it outlines specific objectives for each habitat type, which will guide refuge staff to create conditions needed by the ROCs.

CREATING HABITAT GOALS

The planning team developed habitat management goals that are intentionally broad, descriptive statements of purpose, with greater specificity deferred to the objectives. The Goals and Objectives are organized by the barrier island ecosystem setting: front barrier and back barrier. In general, front barrier habitats are more exposed to ocean forces (wind spray, storms), and plant community succession is limited by these forces. Habitats included in front barrier ecosystems include beach, dunes, maritime shrublands and forests, interdunal swales and dune grasslands. Back barrier ecosystems are not directly exposed to ocean forces but are influenced by tidal hydrology and dune roll-over events. Habitats included in the back barrier ecosystems include fields, impoundments, and salt marsh. In general, the refuge road, which runs between the maritime shrubs and the salt marsh, separates the front barrier and back barrier ecosystems.

> **Goal 1. Front Barrier Ecosystems** – Protect, enhance, and restore the BIDEH of Parker River NWR's front barrier beach habitats to support native wildlife and plant communities, including species of conservation concern.
>
> **Goal 2. Back Barrier Ecosystems** – Protect, enhance, and restore the BIDEH of Parker River NWR's back barrier habitats to support native wildlife and plant communities, including species of conservation concern.
>
> **Goal 3. Rocky Shore and Shrubland** – Perpetuate the BIDEH of coastal habitat on Thacher Island NWR to sustain native wildlife and plant communities, including species of conservation concern.

DEVELOPING SMART OBJECTIVES

Nested under these goals, we developed objectives and strategies for each of the ecosystems present throughout the refuge.

The refuge's priority ROCs were used to develop a set of biological goals and objectives for each habitat type. In addition, five fundamental management objectives are defined for each habitat where they apply. The fundamental objectives are:

- Sustain the habitat or ecosystem and natural processes over time.
- Support migratory bird populations.
- Support recovery of federally threatened and endangered species.
- Support refuge priority ROCs.
- Maintain BIDEH.

Each objective is described by a set of SMART (Specific, Measurable, Attainable, Results oriented and Time-fixed) attributes that provide clarity about the desired future conditions for the respective objective (Powell & Casey 2019; USFWS 2021c). Each attribute has a measurement unit (e.g., 4 miles of beach) and a direction of preference (more, less, or within a range), which then guide the development and selection of management strategies (chapter 5) and monitoring tools (Inventory and Monitoring Plan). The objective statements describe what the refuge hopes to achieve and are 'aspirational' (i.e., they represent the desired future condition of the habitats, not necessarily what they look like today).

Each objective begins with a set of *desired conditions* that will sustain the ecosystem and natural processes over time and help meet the other fundamental objectives (i.e. to benefit wildlife).

SMART objectives facilitate the development of habitat work plans that direct specific management activities, including adaptive management strategies for the year. The format of the habitat goals and SMART objectives is standardized across all national wildlife refuges, which provides consistency when identifying future inventory and monitoring needs.

We use the terms habitat, natural community, plant association, ecosystem, and natural process to describe different levels of ecological complexity or condition, defined as follows:

- National Vegetation Classification (NVCS) Association – NatureServe Explorer (2020) references the NVCS as a standardized hierarchical system to provide a common language for the management and conservation of plant communities. The most fine-grained level is the Association, based on the diagnostic or dominant species and composition reflecting local environmental factors.
- Natural Community – a recurring assemblage of species found in specific physical environments. Most states, including Massachusetts, have created a classification of natural communities (Swain 2020), which are analogous to the NVCS Association.
- Habitat – a set of environmental conditions (abiotic, biotic, ecological interactions) that an organism needs to survive throughout its life processes, often described as food, water, cover, and space. We crosswalk habitat types with the Massachusetts natural community classifications and the NVCS Associations (see Chapter 3).
- Ecosystem – a community of organisms interacting with the physical environment. An ecosystem can be an assemblage of habitats or natural communities, or a given habitat may be considered an ecosystem. At times, the term is used interchangeably with habitat.
- Natural Processes – a complex mix of interactions among plants, animals, and their environment that contributes to the maintenance of an ecosystem's full range of biodiversity. Examples include succession, predator-prey interactions, nutrient cycling, and shifting beach extent.

Figures 4-1 and 4-2 show the desired future conditions for Parker River and Thacher Island NWR management units. In the case of Thacher Island, the desired condition is for the current habitat to remain the same. For more detailed maps of specific habitat types and management units, refer to the maps in sections 1.1 to 3.2.

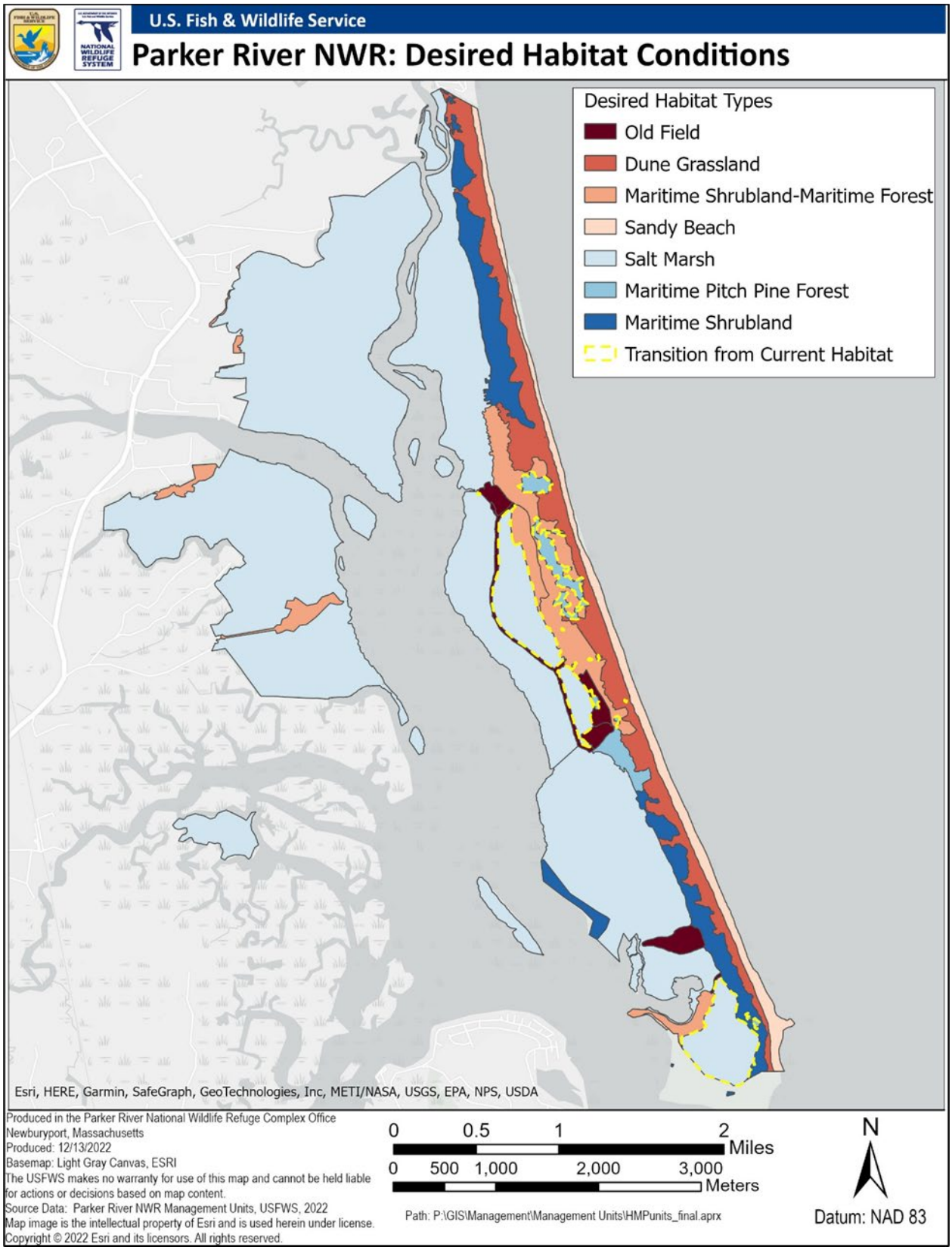

Figure 4-1 Desired future habitat conditions for management units at Parker River NWR.

Figure 4-2 Current and future habitat conditions at Thacher Island NWR.

GOALS AND OBJECTIVES

Goal 1—Parker River NWR: Front Barrier Ecosystems

Protect, enhance, and restore the BIDEH of Parker River NWR's front barrier ecosystem to support native wildlife and plant communities, including species of conservation concern.

Objective 1.1 Beach and Rocky Shore

Manage 6.7[1] miles of beach and rocky shore habitat on Parker River NWR by maintaining the natural processes (e.g., total extent, geomorphic stability, and transgression) over time, to support migratory shorebird populations (Semipalmated Sandpiper), restore populations of federal threatened and endangered species (e.g., Piping Plover, Red Knot), and maintain BIDEH (e.g., eradicate invasive species), with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- A range of intact dynamic geomorphic settings, including foredunes, dune slopes, upper beach, wrack, intertidal zones, and washovers.
- Maintain a minimum of 4 miles of upper beach habitat (highest high tide to base of dunes) communities greater than 50 feet in width, with < 30% native vegetation, including American beachgrass, sea-rocket, seabeach orache, seaside sandwort and seaside sandmat.
- Primary dune face (top of primary dune to the foot of the dune) is 30 to 70% vegetated with American beach grass and native forbs (including beach pea and seaside goldenrod).
- Allow for natural geomorphic changes to the Stage Island beach shoreline in response to climate change, including natural erosion and deposition cycles, and the development of a new salt marsh unit in response to sediment movement.

Restore breeding populations of federal and state listed threatened and endangered species

- Over a 5-year period, an average of 30 nesting pairs of Piping Plovers producing an average of 40 fledglings annually.
- Greater than 4 miles (out of a total of 6 miles) of suitable nesting habitat for Piping Plover and the state listed Least Tern comprised of sandy, shell, gravel, or cobble substrate, with sparse vegetation (less than 20% cover); located on the beach front, foredunes, washover, or backshore geomorphic setting.
- Minimize human-caused disturbance to federal and state threatened and endangered species, including breeding shorebirds and terns (e.g., Piping Plover, Least Tern), with visitors along 6 miles of available breeding habitat.
- A wrack line consisting of a variety of plant matter (e.g., seaweeds) and shells is present over 90% of the beach shoreline from March through November.

Support migrating shorebirds and wintering waterfowl

- Minimal disturbance to migrating shorebirds (early July through November 15), with minimal foot traffic (< 3 per hour) along 3.5 miles of the refuge beach between Lot 3 and Lot 6.

[1] *All numbers, including 1-9, are written as numerals in the objective statements.*

- Minimal disturbance for wintering waterfowl from Nov 15 to March 15.

Maintain BIDEH

- Eradicate and prevent establishment of any invasive plant species that colonize refuge or Plum Island beaches. Early Detection species include Asian sand sedge, yellow horn-poppy, and saltwort.

Rationale

The refuge beach is important nesting habitat for the federally listed Piping Plover and State listed Least Tern (Kirkey & Pau 2022), and for foraging and resting by thousands of shorebirds, including the federally listed Red Knot, during fall and spring migration (Baker et al. 2020; USFWS 2019). The intertidal zone, wrack line, and unvegetated upper beach above daily high tide are used by shorebirds. Natural tidal fluctuations and wrack deposits are necessary to maintain this ephemeral foraging habitat for shorebirds.

Increased storm frequency in the last five years has often benefited shorebirds, as it creates new, high-quality nesting and foraging habitat by reshaping beach and dunes and from migration of the intertidal zone. A severe storm is a short-term phenomenon that may erode a sand spit or reduce or move a dune, a process that leads to continually shifting sands, reshaping of topography, and plant communities adapted to these dynamic conditions. The ability of beach to shift and migrate is critical to the persistence of this habitat (Zeigler et al. 2019a).

Beach habitat shaped by natural, dynamic processes is limited in coastal Massachusetts. The Parker River NWR barrier beach ecosystem (dune, maritime shrubs, and salt marsh) is wide and resilient to storm-related impacts. However, other activities threaten the resilience and integrity of these ecosystems in other locations. Dams on tributary rivers result in a steady decline of sand that reaches the coast. Infrastructure, such as jetties, groins, and seawalls, can magnify erosive forces and disrupt the transport of sediment to beaches. Raking, beach nourishment, and intensive recreational beach use on other beaches reduces their value as wildlife habitat. In other locations, including Plum Island north of the refuge, beach front houses or other infrastructure interferes with the natural processes of beach migration.

Human disturbance is a threat to both breeding and migrating shorebirds (Mengak & Dayer 2020; Mengak et al. 2019). Refuge studies found shorebirds using the beach were disturbed by visitors up to eight times an hour (Drilling & Harrington 1996) and 11 times an hour (refuge data 2009 to 2011, *unpublished*). Shorebirds rarely use an area if there are more than 15 people within 200 meters (Hunt et al. 2019). Parker River NWR hosts over 300,000 visitors annually. Due to the narrow beach and steep foredunes, the potential for visitor disturbance to wildlife is higher than on other nearby beaches (such as Crane Beach, Sandy Point, and the north end of Plum Island) where the beach is wider and the transition to back dunes is more gradual. Refuge area closures are effective in lowering visitor disturbance and increasing shorebird abundance and reproductive success (Hunt et al. 2019). The strategic location of beach access points to provide a long stretch of beach with lower visitor disturbance is important to migrating shorebirds.

Off-road vehicle (ORV) use for fishing was discontinued on the refuge beach in 2022. Detailed impacts of human disturbance and ORV use can be found in the 2022 Compatibility Determination for Fishing (USFWS 2022a).

We have documented significantly more frequent erosion and accretion cycles on the refuge beaches since 2011 and we expect these to increase based on climate projections (Psuty et al. 2017). The refuge may need to rebuild and adapt our recreational infrastructure (boardwalks, stairs, and viewing platforms) to accommodate these changes, but we do not anticipate major habitat alteration strategies to benefit wildlife, such as beach nourishment or sand fencing in the next 15 years. Future beach management actions off-refuge at the north end of Plum Island, such as nearshore dredging and seawalls, would affect the sediment supply and thus the natural resiliency of the refuge beach.

Objective 1.2 Dune Grassland, Sandplain Grassland, Interdunal Swales

Manage 516 acres of dune grassland, sandplain grassland, and interdunal swales on Parker River NWR by maintaining the natural processes (e.g., storm surges, fire) over time, to support ROCs (e.g., rare plants, Eastern Spadefoot Toad, rare Lepidoptera) and maintain BIDEH, with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- 445 acres of dune grassland communities, with $>$ 95% dominance by native plants (American beachgrass, beach pea, seaside goldenrod, seabeach needlegrass, beach heather, coastal jointweed, beach pinweed, bunchgrasses, seaside sandmat, and reindeer lichen).
- 24 acres of sandplain grassland communities, with $>$ 95% dominance by native plants (small bayberry, beach plum, pitch pine, field sagewort, little bluestem, beach pinweed, Pennsylvania sedge, reindeer lichen, and seabeach needlegrass).
- 48 acres of interdunal swale plant communities, with $>$ 95% dominance by native plants (large cranberry, small bayberry, winterberry holly, highbush blueberry, speckled alder, and various rushes, sedges, and clubmoss).
- Maintain a range of intact dynamic geomorphic settings, including a mosaic of dune grasslands, sandplain grasslands, interdunal swales, and maritime shrubs, through maritime forces (storms, overwash, salt spray, winds).
- Disturbances (natural or managed, e.g., fire) occur frequently enough (e.g., every 3 to 5 years) to sustain a grass-dominated system.

Maintain BIDEH

- Eradicate and contain existing non-native invasive plants (black pine, spotted knapweed, beach rose), and prevent establishment of new invasives (perennial pepperweed, Japanese knotweed, cypress spurge).
- Sustain population of rare plants (seabeach needlegrass), lepidoptera, and Eastern Spadefoot Toad and reintroduce rare plants (dragon's-mouth), if feasible.
- Evidence of breeding activity by Eastern Spadefoot Toads in the interdunal swales.

Rationale

Dunes may occur as a single ridge or a series of parallel ridges that extend back through shrub and forest thickets to salt marsh (Swain 2020). The back dunes are sparsely vegetated with patches of herbaceous or low shrubby plants interspersed with areas of bare sand, and often grade into shrubland or woodland communities in more sheltered areas. Vegetation in wet areas between dunes supports vernal pools and unique wetland habitat. Natural dune grassland is limited in Coastal Massachusetts, New England, and the East Coast of the United States, with houses and other human infrastructure developed at or near the foredune along most of the coast.

Sandplain grassland occurs on protected back dunes as small openings within pitch pine or shrub communities, maintained by salt spray and coastal storms. Sandplain grassland is a rare vegetative community that supports rare plants, moths, and ground beetles. Interdunal swale communities are scattered throughout low depressions in the dunes and provide the only source of natural freshwater on the refuge in an otherwise saline environment. Many of the interdunal swales on the refuge support natural cranberry bogs.

Dune grasslands provide an important habitat for the Ipswich Savannah Sparrow, a subspecies of the Savannah Sparrow that breeds on Sable Island, Nova Scotia. It winters along the Atlantic Coast from Massachusetts south to Georgia (Wheelwright & Rising 2020). This subspecies overwinters in the dune grassland on the refuge, likely foraging on small seeds, fruits, and insects. Dune grasslands also provide habitat to the Massachusetts State-threatened seabeach needlegrass.

Other species of concern that use the refuge's dune grassland include the state-listed Dune Noctuid Moth, nesting Piping Plovers, and a diverse suite of native insects. In addition, several species of raptors migrate along the coast in large numbers including American Kestrel, Peregrine Falcon, and Northern Harrier, all listed as species of conservation concern in Massachusetts (MassWildlife 2022b). Parker River NWR supports the greatest concentrations of raptors during the spring migration for Massachusetts, with over 600 American Kestrels migrating through in April and May (EMHW 2022). They are commonly seen hunting the dune grasslands during their migration.

Some interdunal swales function as vernal pools, holding freshwater long enough to enable successful breeding of amphibians and invertebrates, including the Eastern Spadefoot Toad, a state-listed threatened species. Plum Island is at the northern limit of the toad's range (MassWildlife 2022b). With only 32 current populations verified in Massachusetts, the refuge hosts one of the more abundant and stable populations in the State (MassWildlife 2022b). This primitive amphibian exhibits colonial breeding that is initiated by heavy rain between April and September. During winter and dry summer periods the toads burrow up to eight feet below ground in dry sandy soils.

Beginning in the 1950s non-native black pines were planted by refuge staff for erosion control and reforestation after an escaped fire burned through the dunes (Pau 2017). In recent years, we noted the invasion of black pines into the dune grassland community. Mapping in 2017 identified 29 acres of mature black pine trees and six acres of seedlings and saplings. Over 600 individual infestations were found scattered throughout the dunes and maritime shrublands. Manual removal was piloted, and appears effective, but routine mapping and removal will be required to ensure that the black pine forests do not expand (see Objective 1.4 for details).

Barrier beach and dune communities occur in mosaics that shift location over time as the dunes move. The ability of dunes to move is an important disturbance process that maintains these ecosystems. Winds move and carry salt; wind-blown sands prune and bury plants. Together, the salt and shifting sand limit succession to climax communities, preventing trees and shrubs from dominating this landscape. Climate change may have some beneficial effects on dune grassland habitats, as increased storm forces will move sand and set back succession, helping to form new and maintain existing sandplain grasslands, dune grasslands, and internal swales. Negative impacts from climate change include increased invasive species vigor and disease outbreaks. Adaptation and mitigation strategies for sandplain grasslands include controlling invasive plants to increase resiliency and monitoring ecological processes and advance planning and outreach to allow natural processes to occur (e.g., prescribed, and natural fires, storm surges, etc.).

Objective 1.3 Maritime Shrubland, Maritime Forest

Manage 440 acres of maritime shrubland and forest on Parker River NWR by maintaining the natural processes over time, to support migratory birds (e.g., breeding Eastern Towhee and Brown Thrasher, migratory songbirds), support ROCs (e.g., Eastern Red Bat), and maintain BIDEH (e.g., reduce invasive plant species), with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- In general, maritime shrubland has a more open canopy, with more berry-producing shrubs such as bayberry and roses, with serviceberry or black cherry as the dominant tree species. Maritime forests have more closed canopy (50 to 80%), with black cherry, red maple, and oaks as dominant tree species, and fewer berry-producing shrubs due to shading.
- A minimum of 221 acres of maritime shrubland with $>$ 70% cover of fruit-bearing native shrubs (small bayberry, beach plum, serviceberry, chokeberries, winterberry holly, arrowwood), with $<$ 25% tree canopy.
- A minimum of 218 acres of maritime forest with $>$ 70% native species composition (black cherry, serviceberry, eastern black oak, quaking aspen, sassafras, eastern red cedar (trees); blueberry, small bayberry, Virginia creeper, and arrowwood (shrubs); wild sarsaparilla, Canada mayflower, and false Solomon's seal (herbs).
- Maintain maritime processes (such as salt spray, winds, shifting sands, and fire) that sustain the primary and secondary dunes as an open, grass- and shrub-dominated system.
- Disturbances (natural or managed, e.g., fire) occur frequently enough to sustain a shrub-dominated system.
- Natural processes and invasive plant control are used to create the native plant community, rather than active management of forest/shrub layer composition.

Support migratory birds and other ROCs

- Brown Thrasher and Eastern Towhee will be present annually during the breeding season.
    - Shrub habitat with 4,000 to 12,000 woody stems per acre, tree canopy cover is 10 to 30%, and 80% of the litter layer is at least 1 inch deep for breeding Brown Thrashers.
- Eastern Red Bat will be annually present during summer (pupping) and fall (mating) season.
    - Retain large hardwood trees with relatively open understory as maternity roosts for bats.

- At least 250 acres of shrub consisting of > 75% native species (e.g., arrowwood, bayberry, black cherry) that produce fruits during fall migration (late August through October) for songbirds.

Maintain BIDEH

- Less than 10% cover of invasive species in maritime shrubland (e.g., glossy buckthorn, Morrow's honeysuckle, common barberry, and Asiatic bittersweet) and less than 30% invasives (e.g., honeysuckle, glossy buckthorn, common barberry, black locust, black pine) in maritime forest.
- Eradicate early detection plant species, such as beach rose, autumn olive, rusty willow, and tree of heaven; These are plants that are not yet widely established, and thus more easily control with early detection and rapid response (EDRR).

Rationale

The loss and degradation of naturally self-sustaining shrublands has been extensive throughout the Northeast due to development. Parker River NWR supports persistent maritime shrublands that occur as a thin band of vegetation that transitions to salt marsh. Salt spray and constant ocean wind allow salt-tolerant shrub species to dominate and prevent the establishment of trees. Without regular disturbance, the community may succeed to maritime forest and invasive species such as honeysuckles, buckthorn, and Asiatic bittersweet can outcompete native shrubs.

Maritime shrubs and forests co-occur with other maritime communities (dune grasslands, salt marsh) in varying stages of succession. Although we expect these communities to shift over time due to succession and disturbance (fire, wind, storm), for the purposes of management, staff is differentiating maritime shrubs from maritime forests. Community compositions are described in the Objectives above. As noted under Objective 1.2, the refuge maritime shrublands and forests have imbedded within the interdunal swales and patches of sandplain grassland and pitch pine and black pine forests.

Maritime shrublands support a high concentration of fruit-bearing species (e.g., bayberry, beach plum, serviceberry, winterberry, chokecherry, Atlantic white cedar) that provide migrating birds easy access to a high energy food source (Parrish 2000). This habitat is particularly important for young birds, as, on average, more than 85% of the birds banded on the refuge at the joint Parker River NWR/Mass Audubon Banding Station during the fall migration are hatch year birds (Flemer & Moon 2019). More than 150 species of songbirds use shrub habitats on the refuge, such as Eastern Towhee and Brown Thrasher, two BCR 30 high priority species. Both species nest in low shrubs and in leaf litter of the shrubby habitat. Other BCR 30 species of concern using shrub habitat on the refuge, especially during migration, include Willow Flycatcher, Blue-winged Warbler, Canada Warbler, and Prairie Warbler. Every August, hundreds of thousands of tree swallows congregate on the refuge, attracted by abundant berries and insects of the Maritime Shrub.

Maritime forests are primarily located in more protected zones on either side of the refuge road, and west of Plum Island sound, between salt marshes and residential houses along the refuge boundary. Dominant tree species vary depending on location and include red and black oaks, black cherry, sassafras, and the invasive black locust. Wetter areas in the Hellcat Forest are dominated by black gum and red maple.

Maritime forests provide nesting and migratory stopover habitat for birds of BCR 30 conservation concern, including Baltimore Oriole, Brown Thrasher, Eastern Kingbird, and Eastern Whip-poor-will. Parker River NWR is also a significant migratory route for bats, including the federally endangered Northern Long-eared Bat, and State endangered Small-footed Bat and Little Brown Bat, as well as Eastern Red Bat, Hoary Bat, and Big Brown Bat (Yates & Meattey 2010). All bats breed in the late summer or fall. Tree bats (e.g., Eastern Red Bat, Hoary Bat, Silver-haired Bat), being solitary in both the summer and wintering range, breed at coastal sites where they congregate in large numbers. Based on observations, we believe that Eastern Red Bats may breed and have maternity roosts on the refuge.

Predicted climate change patterns, such as hotter and drier summers, may lead to more frequent fires in maritime shrubs. More frequent and intense storms will also help set back succession for this community, which has not had a major disturbance in decades. These changes may result in increased vigor of invasive plants and increased disease outbreak. Shifts in phenology may also affect the synchrony of insect emergence and fruit production with bird nesting and migration (Mayor et al. 2017).

Objective 1.4 Dune Pine Forest

Manage 37 acres of dune pine forest on Parker River NWR by maintaining the natural processes (e.g., fire) over time, to support migratory bird species (e.g., breeding Eastern Whip-poor-will) and maintain BIDEH (e.g., reduce invasive species), with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- A minimum of 37 acres of dune pine forest, dominated by pitch pine, eastern black oak, beach heather, small bayberry, blueberry, common bearberry, Pennsylvania sedge, Canada mayflower, reindeer lichen, and star-flowered Solomon seal.
- Forest densities typical of a dune pine forest, with $<$ 70% canopy and mid-canopy closure, allowing $>$ 30% sun exposure to ground layer.
- Transition non-native black pines to pitch pine forest over time.
- Disturbances (natural or managed, e.g., fire) occur frequently enough (e.g., every 3 to 5 years) to sustain the habitat.

Support migratory birds

- Eastern Whip-poor-will will be present annually during the breeding season.
    - Presence of early successional, dry deciduous or mixed forests (e.g., pitch pine, oak-northern hardwoods), with a sparse ($<$ 30% cover) understory and ground cover for breeding Eastern Whip-poor-will, with proximity ($<$ 65 ft) to open areas for foraging, such as roads, trails, and canopy gaps.

Maintain BIDEH

- Sustain and restore pitch pine partial canopy cover to support desired habitat for rare Lepidoptera (e.g., Coastal Heathlands Cutworm, Sandplain Eucheana, Frosted Elfin) and pine snags for Northern Long-Eared Bat roost habitat during migration.
- Less than 30% cover of invasive species (e.g., black pine, Morrow's honeysuckle, black locust, glossy buckthorn) in dune pine forest.

- Sustain and restore native ephemerals (wild sarsaparilla, starflower, false Solomon's seal, Canada mayflower, and common bearberry) by removing non-native invasive plants and increasing canopy cover.

Rationale

The classic pitch pine dune woodland is dominated by scattered pitch pines often with little or no shrub layer (USDA FS 2020). The understory vegetation, if present, is typically beach heather, bearberry, lichen, or sandplain grassland species (Swain 2020). The refuge's pitch pine forest has a closed canopy and a mid-layer of non-native, invasive shrubs (e.g., honeysuckle, autumn olive) adjacent to existing trails.

Pitch pine communities support the highest concentration of rare and endangered Lepidoptera in Massachusetts (Wagner et al. 2003). Among the State-listed moths and butterflies, 41% are associated with these communities. Three state species of special concern (Sandplain Euchleana, Dune Noctuid Moth, and Coastal Heathlands Cutworm) were found within or adjacent to pitch pines on the refuge. The Eastern Whip-poor-will, a BCR 30 and State species of concern, prefers a dry forest with little or no underbrush and should thrive within the pitch pine forest; the species thus serves as an indicator of the integrity of the woodland.

Non-native black pines were planted in several refuge locations between 1953 and 1980 for erosion control and reforestation. In 1953, 6,500 black pine seedlings were planted in the dunes after an escaped prescribed fire burned a sizable portion of the dunes across from the North Pool. In 1958, 20,000 pines were planted in the Stage Island Pool area, and in 1980, 70 pines were planted on Grape Island. Today, black pines dominate 29 acres and seedlings have recently colonized another 6 acres of dune habitat, although some of the native plant community and ecological function is retained in these forests.

The refuge initiated a small pilot (< 1 acre) in 2009 to remove black pine and restore a pitch pine dominated community. We removed 90% of the black pines and planted pitch pine seedlings. Seedlings had ~80% survival after 10 years, with smaller seedlings (< 4 ft in height) having higher survival. Both native and invasive woody species germinated in the understory. Lack of funding and concerns about potential damage to a fragile ecosystem by heavy equipment have limited larger-scale restoration. Another small-scale effort was launched in 2017 to remove black pines through mechanical cutting and herbicide injection after mapping efforts showed a significant spread of the species into the dune system. Success using the injection system was low; it was successful on some large saplings but had no effect on mature trees. Preventing further spread of black pines has been identified as a priority through periodic mechanical removal.

Hotter and drier summers caused by climate change will likely result in natural fires, which are important for regeneration of pitch pines and promoting understory species. Negative impacts from climate change include increased invasive species vigor and disease outbreaks. The Southern Pine Beetle is a small bark beetle native to the southeastern United States but moving north due to warmer winters. This species has reached southeastern Massachusetts with the potential to cause mortality in all pine species. Adaptation and mitigation strategies for pitch pine woodlands include early detection of disease vectors, treating invasives to increase resiliency, monitoring ecological processes, and advance planning and outreach to allow natural processes to occur (e.g., prescribed fires).

Goal 2—Parker River NWR: Back Barrier Ecosystems

Protect, enhance, and restore the BIDEH of Parker River NWR's back barrier habitats to support native wildlife and plant communities, including species of conservation concern.

Objective 2.1 Old Fields

Manage 69 acres of old fields on Parker River NWR, to support migratory birds, support ROCs, and maintain BIDEH, with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- 60 to 80% of the habitat is dominated by grasses and forbs (< 2 ft in height) (e.g., Pennsylvania sedge, fescue species, little bluestem, creeping bentgrass, common timothy, quack grass, and scattered common milkweed, stiff aster, and goldenrod).
- 5 to 15% is dominated by shrubs (2 to 6 ft height) (e.g., bayberry, Virginia rose, poison ivy, chokeberry)
- Less than 5% is dominated by trees (6 to 16 ft height) (e.g., black cherry, serviceberry, eastern red cedar).
- Disturbances (mowing, fire) occur at least once a year to sustain the system as an open, grass and herbaceous dominated system.

Support migratory birds

- Bobolink will be present annually during the breeding season on all management units.
    - Presence of graminoid species (common timothy, hard fescue, meadow fescue, quack grass, and Canada bluegrass at Cross Farm Hill; Pennsylvania sedge and drooping brome grass at Sub-Headquarters Field; common timothy, spike-rush, and creeping bentgrass at Bill Forward Field) for nesting and feeding and >30% cover for resting during migration (September to October) for Bobolinks.
- Savannah Sparrows will be present (2 of 5 years, as they tend to be sporadic nesters from year to year) during the breeding season at the Cross Farm management unit.
    - Presence of graminoid (common timothy, hard fescue, meadow fescue, quack grass, and Canada bluegrass) and herbaceous plant (common milkweed and goldenrods) species that support invertebrate communities for feeding. The presence of graminoid species that develop a thick thatch layer for nesting. > 30% cover for resting during migration (September to October).

Support other ROCs

- Bill Forward Field, Dikes, Sub-HQ field with > 200 milkweed stems/acre and > 30% cover of nectar-producing forbs (e.g., violets, milkweeds, asters, goldenrods, yarrow) blooming from April through September for Monarchs and other lepidoptera and bees.
- Bare earth (5% open ground) and downed wood (> 2% ground cover) on all management units for shelter and nesting of native bees.

Maintain BIDEH

- Containment of Asiatic bittersweet, Morrow's honeysuckle, and glossy buckthorn with no new areas occupied (2035 occupancy = 5%) and 70% of occupied areas not exceeding 10% cover. Reduce spotted knapweed and multiflora rose to less than 10% cover.
- Eradicate black swallowwort (i.e., zero areas occupied) from Cross Farm and HQ fields.

Rationale

Historically, the refuge managed many fields to increase populations of Canada geese. Stage Island and Cross Farm Fields had been farmed prior to refuge ownership and were the first areas to be intensely managed (e.g., tilled, seeded, burned). By 1961, 100 acres across five fields were under cultivation of rye, millet, buckwheat, or winter wheat. Beginning in 1968, the refuge began converting the fields from crop cover to grasslands. By 1996, all fields were established grasslands that were mowed annually with occasional seeding and fertilization.

A 2006 assessment (Hoy 2006) found that the soils and hydrology in the refuge fields supported maritime shrub species. Although annual mowing kept the vegetation short, the grasslands were increasingly becoming dominated by shrub species, which the soil characteristics favored. Most fields were less than 20 acres in size, the minimum patch size required to support many grassland-breeding species, and an analysis of breeding bird data confirmed this. To meet Joint Venture Bird Conservation priorities (highest priority is shrub-depending species in our area) and to reduce maintenance needs, the refuge allowed some fields (North Pool, Stage Island, Nelson Island) with more mesic soils to naturally revert (succeed) to shrubs from 2008 to 2014. These units are discussed under the Maritime Shrub objective.

To continue providing wildlife viewing opportunities, the refuge continued to manage three old field units (Cross Farm [Figure 5-7], Sub-HQ, and Bill Forward [Figure 5-8]) that provide nesting habitat for Bobolink and Savannah Sparrow, migration feeding areas for Eastern Meadowlark and Whimbrel, wintering foraging areas for Northern Harrier and Short-eared Owl, and habitat for Field Sparrow, Eastern Kingbird, and American Woodcock, among other high priority bird species. The dikes surrounding North Pool and Bill Forward Pool will also continue to be mowed and support nesting Bobolinks, Red-winged Blackbirds, and Willets.

These fields still require periodic disturbances (e.g., mowing, burning, grazing, herbicide) to maintain an open habitat and to increase the proportion of native grass and forb species that support pollinators. Invasive plant species are the major threat to old fields, especially colonization by multiflora rose, Asiatic bittersweet, glossy buckthorn, Morrow's honeysuckle, and black swallow-wort. The vegetative composition is a mix of cool season grasses, broadleaf herbaceous plants, and small woody seedlings. This shrub encroachment dictates the current designation of "old fields" instead of traditional grasslands.

Although old fields are human-created habitats in the northeast, they diversify wildlife viewing opportunities for visitors, and can have significant value to Bobolinks, Savannah Sparrows, other migratory birds, pollinators and other insects, including the Monarch butterfly (USFWS 2016b). Common milkweed (essential to Monarch larvae), goldenrods and asters (nectar sources for migrating Monarchs) are present in the old fields. Bumble bees are an important group of native pollinators, with significant range-wide population declines. Parker River NWR bee surveys from 2010 through 2012 documented 109 species (*USFWS 2012*), including seven species of bumble bee. The undeveloped and unmanaged nature of much of the refuge provides ideal habitat for native bees.

Cross Farm Hill (24 acres) has the greatest potential to support grassland nesting birds such as Savannah Sparrows and Eastern Meadowlarks. As a glacial drumlin surrounded on three sides by salt marsh, it provides the visual openness area-sensitive grassland nesting birds seek in suitable nesting habitat. This openness also provides expansive views for refuge visitors, and attracts other watchable wildlife, such as Northern Harriers and Short-eared Owls. Two invasive plant species, black swallow-wort and porcelain

berry are found in Cross Farm and nowhere else on the refuge. Preventing the spread of these two species is a high priority in the management of Cross Farm.

Objective 2.2 Impoundments

Manage 266 acres of impoundments on Parker River NWR across 3 units: North Pool (110 acres), Bill Forward (31 acres), and Stage Island Pool (105 acres) by restoring to salt marsh, to support migratory bird species and restore ecological integrity and function of the system to be resilient to climate change in the long term.

The impoundments are not sustainable over time. Restore to salt marsh. The timing of restoration aims to balance benefits to bird use and wildlife observation opportunities with long-term sustainability. Post-restoration the *objectives* and *strategies* for salt marshes will apply.

Desired conditions after the dikes are breached

- By 2027, restore Stage Island to a tidal estuary marsh with a planned dike breach; the current 1.5-meter culvert will be restored to a 40-meter opening.
- By 2035, restore Bill Forward to a tidal estuary marsh with a planned dike breach to support estuarine fish, wading birds, shorebirds, waterfowl, and rails; the current 1.5-meter culvert will be restored to a 6-meter opening.

  The following attributes will guide the decommissioning of these two impoundments and the restoration to salt marsh:

  - Tidal amplitude as close as possible to unrestricted marsh to promote sedimentation and marsh accretion.
  - A vegetated platform comprised primarily of *S. alterniflora* post restoration, with a gradual conversion to *S. patens* and other high marsh species as marsh platform gains elevation.
  - Single channel hydrology sufficiently sized to flood and ebb 90% of the management unit during a lunar cycle, and at equilibrium to the volume of water as to minimize erosion potential at tidal opening.
- By 2035, restore North Pool to tidal estuary marsh with a planned dike breach to support estuarine fish, wading birds, shorebirds, waterfowl, and Saltmarsh Sparrows the current 1.5-meter culvert will be restored to a 16-meter opening, with the following attributes guide restoration:
  - Tidal amplitude that promotes sedimentation and marsh accretion and restores a mix of high marsh and low marsh post-restoration.
  - A minimum of 25% high marsh, with increasing percentage of high marsh as marsh accretes elevation post-restoration.
  - Single channel hydrology sufficiently sized to flood and ebb 90% of the management unit during a lunar cycle, and at equilibrium to the volume of water as to minimize erosion potential at tidal opening.
- **Note: Exact timing of North Pool and Bill Forward restoration to salt marsh may be adjusted based on results of the Stage Island restoration and vulnerability of the impoundments to breach and relative elevation difference between the impoundments and adjacent salt marsh.**

Desired conditions before the dikes are breached

Support ROCs

Prior to decommissioning, Bill Forward and Stage Island Impoundments will be managed to support migrating shorebirds (e.g., Semipalmated Sandpiper, Red Knot, Black-bellied Plover) and waterfowl, (e.g., American Black Duck, Northern Pintail, Green-Winged Teal) while optimizing BIDEH (i.e., reduce invasive species).

- Shallow flooded (< 12 inches depth) habitat with 20 to 40% cover by native emergent wetland plants (sedges, bulrushes, dwarf spikerush, saltmarsh aster, beggarticks, marsh orach, red goosefoot, salt sandspurry, marsh fleabane, fireweed); and aquatic plants (common duckweed and pondweed; 10 to 30% cover) from September to November to support migrating waterfowl.
- Mudflat and shallow water (< 4-inch water depth) with sparse vegetation (< 15% cover) and food resources (e.g., aquatic invertebrates) are present once every 2 years for spring and fall-migrating shorebirds, mid-May to late September.

Prior to decommissioning, the North Pool Impoundment will be managed to support breeding marsh and wading birds (least bitterns, American bittern, Virginia rail, sora rails).

- Maintain water levels high, at least 6" above marsh surface, from April to July, to promote cattail and support breeding marsh birds.
- Draw down sporadically for invasive *Phragmites* control and for other administrative or biological needs, such as overwintering *Galerucella* beetles that control purple loosestrife, preventing flooding of the Hellcat boardwalk and certain monitoring needs.

Maintain BIDEH

- Less than 30% invasive *Phragmites* cover and minimize marsh subsidence.

Rationale

Three impoundments--North, Bill Forward, and Stage Island Pools--were constructed by installing berms in the salt marsh in the 1940s and 1950s to provide waterfowl breeding habitat, especially for American Black Duck and Canada Goose. The impoundments were intensely managed for many years to benefit breeding waterfowl, with prescriptions including discing, plowing, mowing, flooding, seeding, planting, burning, herbicide application, and drawdown. Nationally, the focus for nesting waterfowl habitat has shifted to the prairie pothole regions of the U.S. and Canada, though the Northeast remains important for nesting American Black Duck. The Atlantic flyway continues to provide important migration and wintering habitat for waterfowl.

Since creating the impoundments, refuge objectives have broadened to include migratory shorebirds and breeding marsh and wading birds. The refuge has been managing the three impoundments for migratory shorebirds and waterfowl since the 1990s. In the late-2000s, we started managing North Pool for breeding marsh and wading birds due to its importance to the State (USFWS 2007).

However, persistent problems in managing the impoundments, including aging water control structures, eutrophication, silting of channels and ditches, subsidence, poor water quality, lack of fresh water, and invasive plants, have prevented the refuge from achieving desired wildlife objectives. These issues are

detailed in the *2007 HMP* and in the *North Pool Restoration Feasibility Study report.* The risk of catastrophic (unplanned) failure of Pool dikes during storm surges, ongoing maintenance issues, and the high habitat value of salt marsh has prompted the refuge to pursue decommissioning the impoundments and restoring them to salt marsh. Studies begun in the early 2000s that assessed existing conditions and vegetation and the creation of hydrological models deemed restoration feasible [Parker River NWR Annual Habitat Work Plan (*2007*)], (Louis Berger Group 2004; Konisky 2004).

In 2019, hydrological models were developed for all three impoundments to provide a range of alternatives for restoration to salt marsh (Fitzgerald et al. 2017; Woods Hole Group 2019b, 2018). To compare the cost and benefits of waiting to decommission the impoundments, we selected North Pool to model on two timeframes: breach the dike Immediately (2015) or wait until 2050. Based on these models, North Pool is more likely to retain high marsh if tidal flow is restored immediately compared to initiating in 2050. With decommissioning, Bill Forward Pool will primarily become low marsh and Stage Island will be mostly low marsh with fringing high marsh (Woods Hole Group 2018, 2019b).

Restoring the currently impounded waters to tidal estuaries will allow these systems to keep up with sea level rise, adapt to climate stressors, and protect adjacent habitat and infrastructure (i.e., Hellcat Swamp and the refuge road). With the restoration of tidal flow, we expect a flush of sediment import, an increase in marsh elevation (Oosterlee et al. 2020; Oosterlee et al. 2018; Virgin et al. 2020), and a succession of low marsh to high marsh over time (Roman et al. 2002; Virgin et al. 2020). These restored marshes have the potential to provide important habitat for imperiled species, such as Saltmarsh Sparrow and Black Rail (Hartley & Weldon 2020; ACJV 2020).

Restoration to tidal flow will result in a system better suited for adaptation and resilience in the face of climate change and sea level rise. The refuge recognizes that the current values of the impoundments to wildlife and wildlife-viewing opportunities are important to the State and refuge visitors. To ensure the restoration is successful, we plan to first restore Stage Island, and use monitoring data from this restoration to inform subsequent projects. We will also learn from similar tidal restoration projects currently in Canada (Virgin et al. 2020), Belgium (Oosterlee et al. 2020), and the Herring River estuary restoration in Wellfleet and Truro, Massachusetts (*National Park Service 2018*). Bill Forward provides shorebird foraging during migration while North Pool is important to breeding marsh and wading birds. For these two impoundments, we will time restoration to salt marsh to balance the need for ecological function with current wildlife values.

The details of the restoration modelling and analysis and impact for bird use are described in the Environmental Assessment (Appendix A).

Objective 2.3 Salt Marsh

Manage 3,001 acres of salt marsh (includes 266 acres transitioned from impoundments by 2037) on Parker River NWR by maintaining natural processes (e.g., total marsh extent, vegetation communities, vegetated and non-vegetated marsh, elevation relative to sea level rise, and migration) over time, to support migratory birds (e.g., Saltmarsh Sparrow and American Black Duck), and maintain BIDEH (e.g., reduce invasive species), with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- 80% of marsh units will have a natural wetting and drying cycle associated with diurnal and monthly tides that provide needed sediment and hydroperiod.
- A shifting mosaic of habitats in response to changing tidal flooding, sedimentation rates, and marsh vegetation response.
- The ratio of un-vegetated (e.g., pools, pannes, creeks, and mudflats) to vegetated marsh is less than 0.15.
- By 2037, target composition of vegetation communities is as follows:
    - Approximately 15% of the total marsh acreage is 'low marsh', typically dominated by *S. alterniflora* and regularly flooded twice on a daily cycle.
    - Approximately 80% of the total marsh acreage is 'high marsh', typically dominated by *S. patens* (> 50%), co-dominated by *S. alterniflora* short-intermediate form, saltgrass, and blackgrass, and irregularly flooded on a daily cycle, with a thatch layer (dead standing plants underneath live plants) in > 50% patches, < 15% bare ground, and high peat strength.
    - Approximately 5% of the total marsh acreage is 'upper salt marsh', typically dominated by marsh elder and seaside goldenrod, and flooded only on astronomic tides, with:
        - Approximately 90% vegetation cover, no bare ground, and no open water at low tide.
        - Migration of upper salt marsh zone into adjacent upland habitat, with minimal impediments from *Phragmites*, legacy agricultural berms, and road structures.

Support migratory birds

- At least 1,000 acres of suitable breeding habitat for Saltmarsh Sparrow, with at least 775 adults (median 5-year refuge-level abundance), with at least 45% annual nest success (i.e., at least 1 chick present before expected fledge date).
- American Black Ducks will be annually present during the non-breeding season (September to April) on all salt marsh management units.
- Migratory shorebirds (e.g., Greater Yellowlegs, Short-billed Dowitcher, Least Sandpiper, Red Knot) will be annually present in foraging habitat (e.g., salt pannes, mudflats) during spring (April to June) and fall migration (July to November) on all salt marsh management units.

Maintain BIDEH

- Reduce perennial pepperweed in 8,000 acres of Great Marsh currently infested.
- Increase the portion of eradicated pepperweed in treatment area to 60% by 2037.
- Prevent the spread of pepperweed to the currently uninfested areas (22,000 acres) of Great Marsh and increase this area to 25,000 acres by 2037.
- Containment of *Phragmites* in the upper salt marsh, with no new spread of *Phragmites* from 2020 levels.

Rationale

Over one-third of the world's tidal marshes are located along the Atlantic and Gulf Coasts of the US (Greenberg et al. 2006). Salt marshes protect shorelines from erosion caused by strong wave dynamics and storm surges, provide areas for flood storage, filter water pollutants, and serve as nursery habitat for terrestrial and marine organisms (Greenberg et al. 2006). Flooding tides bring inorganic sediment to and promote vegetation growth in salt marsh (Langston et al. 2020; Morris et al. 2002); both are critical for vertical marsh accretion. This ability of salt marshes to maintain dynamic equilibrium with sea level rise has maintained this ecosystem for the past 4,000 years.

Bird populations

Eastern U.S. marshes support the highest level of vertebrate biodiversity of any tidal marsh region in the world, supporting 56% of the world's endemic salt marsh species (Greenberg et al. 2006). However, population trends for many salt marsh birds are declining and sea level rise threatens loss or conversion of much of this ecosystem (ACJV 2019).

Parker River NWR was established with the purpose of benefitting American Black Ducks and is one of their most important wintering habitats in New England, with more than 2,500 ducks at peak times. Coastal salt marshes, estuaries, and sheltered coves are especially important to migrating and wintering black ducks (Longcore et al. 2020).

The Saltmarsh Sparrow, a highest priority species in BCR 30 and a species of concern in Massachusetts, is an obligate tidal-marsh specialist. Parker River NWR hosts a large contiguous nesting site and a relatively large population of Saltmarsh Sparrows. The Great Marsh supports 5% of the global population and 50% of the State population, for a species that has declined more than 80% over 15 years, down to less than 30,000 individuals (ACJV 2022; Hartley & Weldon 2020). Trend analysis of the refuge population does not show the population decline seen throughout the *rest of the range* (Hartley & Weldon 2020; Walker & Pau 2021).

The Saltmarsh Sparrows at Parker River NWR also show elevated levels of blood mercury (Hg) (Lane et al. 2011; Lane et al. 2020). This is of particular concern as Parker River NWR appears to be an important source population to other New England sites (Walsh et al. 2012). Due to these population pressures, the Saltmarsh Sparrow is currently under review for potential federal listing (USFWS 2022c).

Tidal hydrology, elevation, and resilience

The salt marsh at Parker River NWR is part of the Great Marsh, the largest contiguous salt marsh (25,500 acres) north of Long Island, NY, extending from Gloucester, Massachusetts to Hampton, New Hampshire. Salt marsh is the largest ecosystem type at Parker River NWR with approximately 2,653 acres (60% of the total refuge acreage). An additional 247 acres of historical salt marsh were impounded in the 1950s, and the refuge plans to eventually restore these impoundments back to salt marsh (see *Objective 2.2 Impoundments)*.

Tidal hydrology and elevation strongly dictate the zones of salt marsh vegetation communities. The refuge salt marsh is roughly 82% high marsh platform, flooded by < 20% of the tides during a monthly cycle, and dominated by *S. patens* and black grass. Low marsh habitat, dominated by *S. alterniflora*, is inundated daily by tides, and makes up less than 5% of the refuge marsh, mostly at the edge of large creeks or Plum Island Sound. Scattered throughout the saltmarsh are shallow pannes and deeper pools, which remain permanently or semi permanently inundated, and a network of tidal ditches.

Tidal creeks were the conduit for flooding water to the marsh platform. As a marsh floods, water rises in the creeks and ditches, eventually topping the banks and flooding the marsh surface. Throughout New England, tidal creek hydrology has been replaced by ditches (Burdick et al. 2020). In the 1700s and 1800s, farmers installed a network of berms, ditches, and culverts to facilitate the growth of "salt marsh hay" (*S. patens*), and these legacy structures continue to alter hydrology in salt marshes today (Adamowicz et al. 2020). Without regular maintenance, many ditches have collapsed, and the berms continue to hold water (Smith et al. 1989), resulting in conversion of high marsh (*S. patens* dominated habitat) to low form *S. alterniflora* and 'megapools.' Rising sea levels and increased inundation from storms has accelerated this marsh conversion process.

Through a series of pilot restoration projects, the refuge and partners have developed a set of restoration techniques to address the above-referenced legacy infrastructure and climate impacts. Our marsh management aims to restore flood-ebb tidal hydrology, reduce the impacts of past marsh alterations, and increase resilience to climate change and sea level rise. Current strategies include ditch plug removal, runneling, ditch remediation, and creating microtopography islands to increase sparrow nesting habitat. Ditch plug removal and runneling are restoration techniques involving the creation of narrow channels to mimic natural channels or breaches and drain areas with excessive pools. Ditch remediation involves cutting salt marsh grass and placing it in select ditches to encourage peat development and revegetation. These restoration strategies are used in combination to re-create single channel hydrology that will allow the entire marsh platform to flood and ebb, thereby increasing sediment capture, vegetation biomass, and marsh accretion.

The latest models indicate that the marshes on Plum Island may persist for many centuries due to its relatively high elevation in relation to mean sea level (Langston et al. 2020). Ganju et al. (2020) found that marshes on Plum Island are some of the most stable in the East Coast and will likely persist for over 1,000 years (Ganju et al. 2020). Langston et al. predict that the high marsh platform will persist until 2070 before rapid conversion to low marsh, while low marsh will persist well beyond 2100. Coastal Zone Management's Sea Level Affecting Marsh Model (SLAMM) (CZM 2023) finds a similar timeline for conversion, while identifying the highest marsh migration potential for the State just west of the Refuge. Plum Island has relatively high elevation relative to mean sea level, providing a higher buffer against marsh loss (Wasson et al. 2019; Kirwan et al. 2010).

Intertidal and subtidal habitats

The Refuge boundary extends to the Mean Low Water (MLW). Therefore, many of the tidal flats and submerged aquatic habitats are located within State waters, and not owned by the refuge. These habitats provide important habitats for clams, mussels, shorebirds, and waterfowl; and the refuge works with local towns and the State to minimize activities that may impact wildlife habitat or ecological health.

Eelgrass is a flowering underwater seagrass that serves as a vital food source and shelter for fish, crustaceans, and is strongly associated with waterfowl species. Eelgrass has been declining due to factors including disease, non-native crab herbivory, and pollution. According to the Eelgrass Habitat Suitability Model, the Nelson Island Marsh area is an ideal restoration site due to several factors, including historic presence of eelgrass beds, suitable substrate, adequate water quality and clarity, and lower wave energy (Novak & Short 2012). Experimental efforts to restore eelgrass have been successful in Essex Bay, but more challenging in Plum Island Sound (Novak & Short 2012).

Goal 3 – Thacher Island NWR: Rocky Shore and Shrubland

Perpetuate the BIDEH of coastal habitat on Thacher Island NWR to sustain native wildlife and plant communities, including species of conservation concern.

Objective 3.1 Rocky Intertidal Shore

Manage 12 acres of rocky intertidal shore habitat on Thacher Island NWR to sustain the ecosystem over time (e.g., community composition), support recovery of federally threatened and endangered species, and maintain BIDEH, with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- Rocky, gravel substrate dominated by rockweed, blue mussels, and brown algae.
- Dense maritime shrubs with stem density > 20,000 stems per acre, 3 to 15 feet high, comprised of >70% native shrub species, and less than 30% tree cover.

Support recovery of federal threatened and endangered species

- > 10 acres of suitable nesting habitat (rocky areas with sparse vegetation) for breeding terns, with access to marine or estuarine open water foraging areas within 15 km.
- Island free of mammalian predators and rats.
- Establish a breeding population of New England Cottontails, such that rabbits can be removed annually to augment mainland wild populations.

Maintain BIDEH

- Early detection of marine invasive species that have been observed on the mainland. These may include invasive tunicate species, European green and Asian shore crabs, and red algae (Wells et al. 2014).

Rationale

Thacher Island supports several colonial nesting species, including Double-crested Cormorant, Common Eider, Canada Goose, Herring Gull, Great Black-backed Gull, and American Oystercatcher. The Island historically supported breeding pairs of Common Tern, Arctic Tern, and Roseate Tern (Kress & Hall 2004), although no terns currently breed there. Past studies in the Gulf of Maine have shown declines in tern numbers and displacement of tern colonies can be attributed to increased egg and chick depredation by gulls (Drury 1973; Donehower et al. 2007). The presence of Common Terns appears to be the most important criteria for Roseate Tern nest site selection. The Roseate Tern is a federal- and state-listed endangered species (Nisbet et al. 2020); Common Tern is listed as a species of special concern in Massachusetts (MassWildlife 2022a).

Thacher Island is near the northern extent of the Roseate Tern breeding range (Nisbet et al. 2020). As of 2019, approximately 89% of the Atlantic Roseate Tern population is concentrated at just three nesting colonies: Great Gull Island, New York (2,200 pairs); Bird Island, Marion, Massachusetts (1,101 pairs); and Ram Island, Mattapoisett, Massachusetts (919 pairs) (USFWS 2020). The only other tern nesting colonies in Massachusetts are at Penikese Island, Gosnold (15 pairs), South Monomoy Island, Chatham (12 pairs), and Norton Point Beach, Edgartown [19 pairs; (Mostello et al. 2019)]. Nesting colonies north of Thacher Island include Seavey Island, Rye, New Hampshire (80 pairs) and Stratton Island, Portland, Maine (123 pairs) (USFWS 2020).

Given its geographic location between other tern nesting islands (Cape Cod nesting islands and coastal Maine islands), Thacher Island is an ideal tern restoration site. These active tern nesting islands offer source populations for the refuge. If re-established here, Thacher Island could then serve as a source population in the event of population declines elsewhere in the region.

Currently, the large population of gulls on Thacher Island is the greatest limiting factor to tern restoration. Population management since 2001 has reduced gull numbers on Thacher Island from approximately 1,735 nests in 2001 to 370 nests in 2019 (Refuge data 2001 to 2019, unpublished) (MassWildlife 2022b), and MassWildlife has indicated concerns for further gull depredation efforts.

Significant tern restoration efforts and gull population management at offshore islands like Thacher Island, in the Gulf of Maine and Long Island Sound, have increased tern numbers in the past 20 years (Elizabeth Craig, pers. comm., 2022). On White and Seavey Islands, 3,066 pairs of Common Terns, 147 pairs of Roseate Terns, and 1 pair of Arctic Terns were recorded during the 2022 breeding season; this represents a huge restoration success after the first 6 pairs of Common Terns settled there in 1997 (NHGF 2023). Similarly, in response to gull control beginning in the late 1990s and subsequent habitat management efforts at Monomoy NWR, Common Terns recolonized South Monomoy Island to such a degree as to now be the largest breeding colony of the species worldwide, exceeding 14,000 pairs, in addition to over a dozen nesting Roseate Terns (USFWS unpubl. data).

The limiting factor for reintroducing terns to Thacher Island is lack of consistent funding and staffing capacity. Once a tern breeding population is established, annual commitment of staffing is needed for 7 to 8 months to maintain and manage the population. It is difficult to implement this objective without confirmed long-term funding.

Objective 3.2 Maritime Shrubland

Collaboratively manage 27 acres of maritime shrubland habitat on Thacher Island (both on NWR and Town property) by maintaining the natural processes (salt spray, winds, storms) over time, to restore populations of ROCs (e.g., New England Cottontail), and maintain BIDEH, with the following attributes (measurements) and aspirational targets (values):

Desired conditions

- 50 to 70% is dominated by shrubs (2 to 6 ft height) (e.g., small bayberry, beach plum, serviceberry, chokeberries, winterberry holly, arrowwood, and staghorn sumac).
- 20 to 30% is dominated by young trees (6 to 16 ft height) (e.g., eastern serviceberry, black cherry, eastern red cedar).
- Maritime forces (salt spray, winds, storms, etc.) to sustain the system as shrub-dominated.

Restore populations of ROCs

- Establish an island breeding colony of New England Cottontails to support population augmentation in other parts of New England.
- Maintain the island free of mammalian predators.
- Assess Norway rat population and control and eradicate if needed.

Maintain BIDEH

- Containment of invasive plant species (bush honeysuckle, rusty willow, glossy buckthorn, and barberry), with 50 % of occupied areas not exceeding 10 % cover.
- Containment of invasive plant species (purple loosestrife and *Phragmites*) in wet swale habitats, with no new areas occupied and less than 25% cover where occupied.

Rationale

Located 1.5 miles off the coast of Rockport, MA, the maritime shrub community at Thacher Island is maintained by constant maritime wind and salt spray, preventing the succession to forest. Coastal islands are important resting locations for migratory songbirds and, if adequate resources are available, provide an opportunity to replenish their energy reserves (Ferretti et al. 2021). Maritime shrublands and forests support a high concentration of fruit-bearing species (e.g., bayberry, beach plum, serviceberry, winterberry, chokecherry, Atlantic white cedar), providing migrating birds easy access to a high energy food source (Parrish 2000). The island supports breeding birds as well, but no formal surveys have been conducted to date.

The New England Cottontail is a species endemic to New England and eastern New York and was a candidate for Federal listing. The New England Cottontail's range has contracted by more than 75%; where they persist, the populations are extremely small and fragmented by roads and development. They also face competition from the introduced Eastern Cottontail. Without intervention, the population is at high risk for extirpation in many parts of its remaining range (e.g., southern Maine, New Hampshire, Rhode Island).

In 2015, the FWS precluded listing under the Endangered Species Act due to a strong partnership of organizations and agencies committed to specific conservation actions to halt range-wide population declines (USFWS 2023). Although the cottontail is not listed, it is a species of high conservation concern for USFWS, and we work diligently with partners to restore shrub habitat and restore and increase wild populations through a captive rearing program. The current captive rearing facilities include two zoos, two outdoor breeding pens, and two offshore island facilities. To date, the existing facilities have the capacity to provide 90 rabbits annually for augmentation and reintroduction. The goal for the regional captive program is 250 rabbits annually (Holman 2022). The working group is actively seeking to add facilities to slow the population decline throughout NEC's range.

Thacher Island is a good candidate for establishing a breeding colony of New England cottontails due to its self-sustaining shrub habitat, lack of mammalian predators, and reliable access to the island. Early results from the Regional Captive Breeding Workshop group have suggested that zoos and enclosed breeding pens are not sufficient to provide the 250 rabbits per year needed to augment wild populations. Island nesting colonies in Rhode Island and Massachusetts have seen significantly higher breeding success, with researchers able to remove young for augmentation within 3 to 5 years of reintroduction (USFWS 2023).

Evaluating Thacher Island as a breeding colony for New England Cottontails would involve assessment and discussion with the NEC Captive Rearing Working Group and discussions with Thacher Island Association.

Chapter 5. MANAGEMENT UNITS AND STRATEGIES

This chapter describes how refuge staff intend to achieve the management objectives described in Chapter 4. A comprehensive literature review was conducted to identify all potentially useful strategies (e.g., burning, water-level manipulation, mowing, restoring, or allowing natural processes, etc.). In consultation with other refuge biologists, managers, and experts, we selected the most effective strategies for accomplishing the habitat objectives. Management techniques that are shared across multiple refuges and employed to restore and enhance the biological integrity of priority habitats are described in *General Strategies for HMPs* (Knutson 2021).

Being a 15-year plan, the prescriptions included in this document are broad and include all potential actions, even those that are not currently prioritized. Staffing levels, new priorities, environmental factors (e.g., weather), and logistics affect what management actions are employed each year. Therefore, more specific prescriptions (i.e., details of when, where, and how treatments will be applied) will be described in detail in Habitat Work Plans, where we evaluate the effectiveness of past management and adapt strategies as needed. Habitat Work Plans are completed every 2 years due to staffing constraints and the multi-year cycle of most biological projects.

CURRENT AND DESIRED HABITAT CONDITIONS

To meet the Objectives described in Chapter 4, some habitats at Parker River NWR will transition to different habitat types over 15 years, due to sea level rise, forest and shrubland succession, or planned management actions.

Table 5-1 and Figure 4-1 highlight the changes in habitat types at Parker River NWR from the 2007 HMP to today (2023), and what's proposed in this HMP (ending in year 2038). The acres used in the tables are derived from Geographic Information System (GIS) calculations of the habitat map and are not exact. Also note that incorrect acreage was recorded in the 2007 HMP. Table 5-1 shows the acreages used in the 2007 HMP, and the correct acreages in parenthesis underneath. No changes are proposed for Thacher Island NWR (Table 5-2 and Figure 4-2).

Table 5-1 Current and desired habitat types for Parker River NWR.

Objective	*Habitat Type*	*2007 HMP Acres*	*Current Acres (2023)*	*Desired Acres (2038)*	*Notes on Change in Acres*
1.1	Sandy Beach, Rocky Shore	182	182	182	No change
1.2	Dune Grassland	540 (444)	444	444	No change
1.2	Sandplain Grassland	24	24	24	No change
1.2	Interdunal Swale	48	48	48	No change
1.3	Maritime Shrubland and Forest	333 (372)	440 (Gain 68 acres)	440	Fields (see below) left to naturally succeed to shrubland
1.4	Dune Pine Forest	37	37	37	No change
2.1	Old Fields	130 (137)	69 (Lose 68 acres)	69	Ceased mowing of North Pool, Stage Island and Nelson Island fields between 2008 and 2012
2.2	Impoundments	266	266	0	Decommission all 3 impoundments
2.3	Salt Marsh	2,660	2,735	3,001	Acquired 75 acres in 2011. Gain 266 acres from former impoundments

Table 5-2 Current and desired habitat types for Thacher Island NWR.

Objective	*Habitat Type*	*2007 HMP Acres*	*Current Acres (2023)*	*Desired Acres (2038)*	*Difference between Current and Future Acres*
3.1	Rocky Intertidal Shore	12	12	12	0
3.2	Maritime Shrubland	10	10	10	0

MANAGEMENT UNITS AND PRIORITIES

The refuge is divided into management units (MU) to facilitate the planning and implementation of management actions, and to document and monitor outcomes. Management units are based on location, ecologically recognizable features, roads, trails, and other features. They closely correlate to habitat types, but many MUs contain multiple habitat types. As such, the sum of MU acres under each habitat objective does not equal the total habitat acreage in the table above. In Chapter 3 (Table 3-5), refuge staff prioritized the habitats to help guide annual work plans and provide flexibility for changes in staffing and resources. These priorities are carried through to the MUs below.

The highest priority units are those that provide the greatest opportunity for conservation of the ROCs (priority species and habitats) highlighted in Chapter 3 while considering the goals and objectives in Chapter 4. Ranking is based upon consideration of numerous factors, including (in general order of priority):

- Determined habitat priority.
- Value or contribution to ROC.
- Management capabilities, including access challenges.
- Use by federal and state-listed species.
- Habitat quality and potential.
- Spatial patch size and connectivity to similar habitat types.
- Intensity, frequency, and the type of management needed.
- Personnel availability and operating costs.

Factors such as the effects of climate change or the addition of resources for habitat management could shift the priority of these units.

Priority 1

These units will receive more management effort because they have higher value for ROCs, support the highest priority species in the region as well as federally endangered or threatened species, provide strong public opportunities for connection with nature, have larger habitat blocks, and require time-sensitive restoration to adapt to the effects of climate change. The land is under Service jurisdiction and management actions (e.g., invasive species control or vegetation management) are expected to have a beneficial impact or connect prioritized habitats.

Priority 2

These units still receive management attention but at a reduced level due to staffing and funding constraints. The reasons for lower priority vary. These units may have lower value for ROCs or they tend to be smaller and not spatially connected to larger habitat blocks (e.g., in the case of grassland nesting birds). Others have logistic challenges (difficult access) or high costs for recurrent management (old field habitat and black pine forests). Some units have intact, self-sustaining habitats and primarily require stewardship (such as dune grasslands). Priority 2 units still support many nesting bird species as well as regionally and locally rare habitats. If funding and staff become available to address logistic challenges or management capabilities, these units could be reclassified as Priority 1.

INVASIVE SPECIES

Invasive species threaten the biological diversity, integrity, and environmental health of refuge habitats and the wildlife they support. The threat to habitats and ROCs from invasive species varies by species and habitat condition, but affects all habitats and MU discussed below. The strategies below describe the priority invasive species by habitat and some specific parameters for success. Specific control methods for invasive plants are described in detail in *General Strategies for HMPs* (Knutson 2021). Invasive management strategies and priorities generally follow the process described in *Picking Our Battles*, a publication by University of New Hampshire Extension (Stevens et al. 2015).

Invasive management efforts at Parker River NWR generally focus on strategies that have long-term success, including:

(1) Focusing on species that are in early stages of invasion on the refuge or adjacent areas, as it provides the highest likelihood of success for eradication. These are referred to as early detection and rapid response (EDRR) species, and at Parker River NWR, include perennial pepperweed, rusty willow, beach rose, black swallowwort, Japanese knotweed, tree-of-heaven, and porcelain berry.
(2) Restoring natural processes and plant communities to provide natural resilience against new invasions. Examples include restoring hydrology in salt marsh habitats to control *Phragmites* or restoring native plant communities in shrub habitats to outcompete invasive plants.
(3) Reducing invasive pressure in sensitive habitats (pitch pine or interdunal swales) where they are likely to have negative consequences on rare species.

Table 5-3 describes the distribution, priorities, strategies, and history of invasive plant control on Parker River and Thacher Island NWRs.

Table 5-3 Distribution and treatment history of invasive plants at Parker River NWR.

Species	*Location*	*Priority (H, M, L or EDRR)*	*Spread (S, E, U)*	*Treatment History*
Asian sand sedge *Carex kobomugi*	No known established stands; may be found on sandy beaches	EDRR	-	EDRR species for refuge beaches. If found, eradicate.
Asiatic bittersweet *Celastrus orbiculatus*	Parker River (PKR): Mapped in 2003 (111 ac); Maritime shrublands and old fields including management units: North Pool Shrub, Dikes, Stage Island, Sub HQ, Cross-Farm, Nelson Island, Pink House, Pitch Pine Shrub	M	U	Occasional cutting and spot treatment (Garlon, Rodeo, or Escort) by the side of roads or trails; foliar and basal treatments in reverting fields, 2015-2017; 2018: Pink House treated with Escort/Rodeo mix

Species	*Location*	*Priority (H, M, L or EDRR)*	*Spread (S, E, U)*	*Treatment History*
Autumn olive *Elaeagnus umbellata*	PKR: Maritime shrublands and forests including along Refuge Road and in pitch pine forest	EDRR	S	Mechanical removal: In 2004 bulldozed all autumn olives mapped near the main road; monitoring regrowth along road and other disturbed areas; treat as needed
Beach rose *Rosa rugosa*	PKR: Mapped in 2003 (18 ac); Lot 1 Sandplain grasslands and dunes are susceptible to invasion	M	S	Spot treatment with Rodeo and Escort mix; Substantially controlled on refuge; yearly maintenance necessary; 2023 HMP proposes to eradicate within 10 years using mechanical, chemical, and fire strategies and educate public
Black locust *Robinia pseudoacacia*	PKR: Mapped in 2003 (35 ac); Maritime shrublands, successional maritime forests, pitch pine forest, and sandplain grasslands; Most found along Refuge Road	M	U	Girdle and treat with Garlon; In 2004, treated a small area (0.6 acres) across from the Salt Panne Observation Area; Extended treatment to 30 acres throughout the refuge in 2005 to 2012; 2023 HMP proposes to selectively treat in sandplain grasslands
Black pine *Pinus thunbergii*	PKR: Mapped in 2017 (29 ac mature, 6 ac seedling, 583 locations of seedlings); Maritime shrublands, maritime forests, dune grasslands, dune pine forests, and old fields including management units: Black Pine Forest, Bill Forward Shrub, Hellcat, Dune Grasslands	M	E	Pull seedlings, cut young trees, inject large trees with herbicide (E-Z Ject and Rodeo); Tree removal in small patch in 2009 and 2010; Seedlings pulled in 2011 and 2012; Cutting of young trees and injection with herbicide of large trees in 2017; 2023 HMP proposes to contain to existing areas and begin transitioning to pitch pine forest
Black swallowwort *Cynanchum louiseae*	PKR: Old fields including management units: Headquarters, Cross Hill Farm	H	S	Treated with herbicide since 2010; herbicides previously used include Garlon, Rodeo, and Roundup; most recently treated with Roundup Custom in 2022; 2023 HMP proposes to eradicate this species within 10 years using herbicide treatment

Species	*Location*	*Priority (H, M, L or EDRR)*	*Spread (S, E, U)*	*Treatment History*
Climbing nightshade *Solanum dulcamara*	PKR: Mapped in 2003 (12 ac); Shrub thickets and open ground including at Sub HQ Field.	L	U	None to date.
Common barberry *Berberis vulgaris*	PKR: Mapped in 2003 (6 ac) Thacher Island: Maritime shrublands.	L	U	None to date.
Common reed *Phragmites australis*	PKR: Mapped in 2003 (34 ac); Old fields, impoundments, interdunal swales, and salt marshes including in management units: North Pool, Bill Forward Pool, Stage Island Pool, Sub HQ Field, Cross Farm Field. Thacher Island: Wet swales	H	E	Treating since the 1960's using several methods: herbicide spray (aerial, ground), discing, mowing, and flooding in impoundments; targeted control (cut stem and drop) in interdunal swales; herbicides previously used are Rodeo, Habitat, and Polaris. Recent treatment: Creeks, Pine Island, Parker River treated in 2015; 2.5 acres (Sub HQ, Cross Farm) in 2016; 12 acres (Refuge Road, Sub HQ, Cross-Farm) in 2017 with Rodeo/Habitat; 50 acres (Newbury/Rowley) in 2019 and 2020 (Polaris). 2023 HMP proposes to continue using herbicides to reduce expansion and to control infestations in interdunal swales, while working to pilot innovative treatment that focuses on hydrology restoration as a long-term control method.
Cypress spurge *Euphorbia cyparissias*	PKR: Mapped in 2003 (12 ac); Old fields including management units: Sub HQ Field, Stage Island. Sandplain grasslands are susceptible to invasion	L	E	Garlon and hand pulling; Attempted treatment in 2005, but it was not effective; Very small treatment window; Incidental mowing occurs during maintenance of main road and grasslands

Species	*Location*	*Priority (H, M, L or EDRR)*	*Spread (S, E, U)*	*Treatment History*
Japanese barberry *Berberis thunbergii*	PKR: Mapped in 2003 (40 ac); Headquarters and Hellcat.	L	U	Present in multiple places on the refuge, mainly at Hellcat. No treatment has occurred.
Japanese knotweed *Fallopia japonica*	PKR: Mapped in 2003 (0.06 ac); currently not found on the refuge portion of Plum Island but is north and south (Sandy Point SP) of the refuge. Is found at at Headquarters site. Sandplain grasslands are susceptible to invasion.	H	S	Repeated cutting; Stem-injection and spot treatment; herbicides previously used include Escort, Habitat, and Rodeo; Treated at headquarters and Sandy Point State Reservation in 2017.
Mile-a-minute weed *Persicaria perfoliate*	No known established stands; however, has been documented in Essex County	EDRR	-	EDRR species for refuge beaches. If found, eradicate.
Morrow's honeysuckle *Lonicera morrowii*	PKR: Mapped in 2003 (324 ac); Maritime shrublands, successional maritime forests, dune pine forests, and old fields including management units: North Pool Shrub, Bill Forward, Stage Island, Sub HQ, Cross Farm, Hellcat, Pitch Pine Shrub, Nelson Island. Sandplain grasslands are susceptible to invasion. Thacher Island: Maritime shrublands	M	U	Herbicide treatment (foliar spray with Rodeo and Escort); Foliar and basal treatment in reverting fields in 2015 to 2017
Multiflora rose *Rosa multiflora*	PKR: Mapped in 2003 (< 0.01 ac); Old fields including management units: Cross Farm, Stage Island, Nelson Island, Headquarters, Sub HQ, North Pool Shrub, Bill Forward, Dikes. Thacher Island: Maritime shrublands	M	S	Spot treatment with Rodeo and Escort mix; Largely controlled on refuge; Maintenance spray of few roadside stands and in reverting fields

Species	*Location*	*Priority (H, M, L or EDRR)*	*Spread (S, E, U)*	*Treatment History*
Perennial pepperweed *Lepidium latifolium*	PKR: Mapped annually (~100 acres in 2022); To the west of Refuge Road in high marsh from Stage Island to Gatehouse; Nelson Island; Parker River marshes in Newbury and Rowley; headquarters	H	S	Annual monitoring and mapping; Annual spot treatment with herbicide (Escort XP) and hand pulling; Treating populations in the Great Marsh for watershed-wide control and eradication.
Porcelain-berry *Ampelopsis glandulosa*	PKR: Cross Farm	EDRR	S	Rodeo and Habitat mix; Single plant found and sprayed in 2017 in Cross Farm Field; 2023 HMP proposes to eradicate this species within 10 years using herbicide treatment
Purple loosestrife *Lythrum salicaria*	PKR: Mapped in 2003 (52 ac); Interdunal swales and impoundments	L	S	From 1996 to 2001, *Galerucella* and *Hylobrius* beetles were released in the Refuge impoundments to biologically control the species; Monitoring was completed from 1997 to 2000; 2023 HMP proposes to treat infestations in interdunal swales and to monitor impoundment infestations
Reed canary grass *Phalaris arundinacea*	PKR: Mapped in 2003 (6 ac); Bill Forward Dike	L	U	None to date.
Rusty willow *Salix cinerea*	PKR: Old fields, interdunal swales, and maritime shrublands including in management units: Cross Farm Field. Thacher Island: Maritime shrublands	EDRR	S	E-Z Ject system; A half-acre patch across from Cross Farm Field was treated with E-Z Ject system in 2017
Saltwort *Salsola kali*	PKR: Has been previously documented in refuge, but currently there are no known established stands May be found on sandy beaches	EDRR	-	EDRR species for refuge beaches. If found, eradicate.

Species	*Location*	*Priority (H, M, L or EDRR)*	*Spread (S, E, U)*	*Treatment History*
Spotted knapweed Centaurea stoebe	PKR: Old fields and dunes, including management units: Stage Island, North Pool/Bill Forward Dike, Sub HQ, Cross Farm, Dune Grasslands, Lot 1 Sandplain grasslands are susceptible to invasion	M	U	Spot treatment with herbicides Garlon, Escort, or Rodeo and hand pulling smaller infestations; Treated in 2011 to 2012 with 1.5% Garlon 4 solution; Treated in 2018 with Escort/Rodeo mix
Toringo crabapple Malus sieboldii	PKR: North Pool Field; roadside individuals near Lot 1, Sub HQ, Lot 6, Hellcat Thacher Island: Present in maritime shrublands	M	U	Rodeo and Escort mix or E-Z Ject system; Treatment in North Pool Field with Rodeo and Escort mix in 2017; E-Z Ject system used to treat roadside individuals and a dozen stem patch north of Hellcat parking lot
Tree-of-heaven Ailanthus altissima	PKR: Stage Island	EDRR	E	Spraying with Garlon; About 0.5 acres treated at former Goodwin Camp with Garlon in 2017; Saplings observed again in 2020
White poplar Populus alba	PKR: Mapped in 2003 (6 ac); Stage Island	L	S	Treatment in 2017 in the western part of field using herbicides Garlon and Escort
Wild garlic Allium spp.	PKR: Cross Farm Field	EDRR	-	None to date.
Yellow flag iris Iris pseudacorus	PKR: Stage Island	L	U	Herbicide treatment (Rodeo); Spot treatment in 2011 off Stage Island Overlook tower
Yellow horn-poppy Glaucium flavum	No known established stands; May be found on sandy beaches	EDRR	-	EDRR species for refuge beaches. If found, eradicate.

Notes: Priority rating: management priority based on level of spread, ecological threat, and management difficulty. If treatment is planned, treat High and Medium species first. High (H): High priority for treatment; Medium (M): Medium priority for treatment, treat High species first; Low (L): Low priority for treatment, little to no treatment planned; Early Detection, Rapid Response (EDRR): Vigilant observation for new infestations and rapid removal of plant.

Spread is the rate at which the species' infestation is expanding. Stable (S): The infestation is not expanding due to site conditions or slow growth, and/or is not entering new areas; Expanding (E): The infestation is increasing and/or spreading to other areas; Unknown (U).

CLIMATE CHANGE ADAPTATION

The effects of climate change on wildlife and habitats are expected to be location- and species-specific, with a predicted general trend of species' ranges shifting northward and sea level rise pushing habitats and the associated species inland, where possible. It is also possible that some habitat types will undergo transformation or total loss if conditions do not allow for adaptation or inland migration. For more specific climate change projections, see Chapter 2.

General strategies for adapting to climate change include maintaining genetic diversity, restoring ecological function and connectivity, manipulating disturbance regimes (e.g., fires, floods), and reducing other stressors (Mawdsley et al. 2009). Management strategies that reduce non-climatic stressors (e.g., habitat loss or fragmentation, altered hydrology or soils, human disturbance of wildlife, pollution, and invasive species) will increase the capacity of ecosystems and associated species to adapt to a changing climate. The Service and other conservation entities use a range of tools to implement these strategies such as land and water protection, ecological restoration, species translocation, invasive control, captive propagation, public education, and regulation. At Parker River NWR, where many ecological processes are still intact, our best climate adaptive strategy is to preserve or restore ecological function (hydrology, soils, sediment transport, natural plant communities) where feasible. We will continue to apply these tools in novel and innovative ways to meet the unprecedented challenges posed by climate change (Carroll & Noss 2021).

Managers at Parker River and Thatcher Island NWR will use adaptive management (e.g., monitoring outcomes, adjusting strategies, and updating management objectives) to maintain healthy ecosystems in the face of uncertainty about the future effects of climate change (Nichols et al. 2011). Climate change adaptation strategies are described below under the general category of Mitigate or Adapt to Climate Change.

MANAGEMENT STRATEGIES – PARKER RIVER NWR

This section focuses on the major habitat types found on the refuge and the general management direction for each priority habitat type, including proposed habitat improvements and increases or decreases in the acreage of a particular habitat. Each habitat type is represented by one or more management units (MU) with specific strategies listed.

1.1 Beach and Rocky Shore

- Habitat Priority 1 (Figures 5-1 to 5-4)
- ROCs: Piping Plover, Semipalmated Sandpiper
- Other benefitting species: Least Tern; migrating shorebirds (e.g., Sanderling, Black-bellied Plover, Ruddy Turnstone, Red Knot)
- No planned change in acreage

Sandy Beach and Rocky Shore MU (182 acres)

This unit encompasses the entire Parker River NWR beach from mean low tide up to and including the primary dunes. Constantly changing due to oceanic forces, it currently consists of bare intertidal sand and beach strand. Beach strand is a sparsely vegetated, long, narrow community occurring between the wrack line of the daily high tide and the foredunes. Beach strands are subject to overwash during storms and spring tides. Vegetation is lacking across much of this MU, except along the primary dune, where American beach grass begins to take root. Other salt-tolerant species may also be present, including beach pea, beach wormwood, and seaside goldenrod.

There are five beach parking lots and boardwalks that allow the public to access the beach. Between Lot 3 and Lot 6, there is over 3 miles of beach with no direct beach access. This long stretch with limited beach access is important to reduce disturbance pressure on migratory shorebirds and other species.

Three shoreline stretches are characterized by rocky boulders left by eroding glacial drumlins: Emerson Rocks north of Lot 6, Barhead at the southern border with Sandy Point, and Stage Island shoreline, protruding into Plum Island Sound. These rocky substrates provide habitat for blue mussels, fish, and diving ducks.

Sustain natural processes

- Allow the unrestricted and continual deposition and erosion of sand due to natural geological processes. The refuge will construct infrastructure (only when necessary) such that it will not interfere with the shifting of the barrier beach and dunes but will repair existing infrastructure as necessary and appropriate.
- If erosional hotpots develop, consider reestablishing geodetic beach surveys.
- At Stage Island, provide shoreline access for fishing and public viewing in a way that minimizes erosion.
- Study marsh formation and blue mussel reef development at Stage Island shoreline.

Support migratory birds, ROC, and T&E species

- Maintain natural dynamic shoreline that supports foraging habitat for sea ducks and other diving ducks, and fish, including Atlantic Sturgeon along the rocky shores.
- Allow natural erosion and accretion that maintain high-quality nesting habitat for Piping Plover and Least Tern. Monitor long-term trend of available nesting habitat on refuge beach and regionally.
- Consider habitat enhancement strategies, such as reducing dune vegetation or creating blow-out areas, only when New England plover population is below recovery goals and declining for 3 to 5 years, and available habitat is a limiting factor.
- Annually increase productivity of nesting birds:
    - Monitor Piping Plover and Least Tern activity along the refuge beach 2 to 3 times a week from April to August to assess productivity and monitor predator activity around nests.
    - Manage potential nest predators using non-lethal means first. Management methods include behavior modification, trapping, and shooting. When deemed necessary and when funding allows, contract with outside organizations to target problem individuals and reduce predation.

    - Install predator exclosures around plover nests using multiple designs and non-clustering approach. Coordinate with staff from adjacent beaches, including Crane Beach, to respond rapidly to avian predators targeting adult plovers at exclosed nests.
    - When practical, install an electric fence around Least Tern nesting colony to protect colony from mammalian predators.
- Minimize human disturbance and intrusions:
    - Beach closures April to August during peak shorebird breeding. Most of the refuge beach is closed during the plover nesting season, starting April 1; sections of the beach start opening in July or August, as plovers complete breeding in these sections. The entire beach typically opens in mid- to late August, at the peak of shorebird migration.
    - Keep Lot 1 open for public use, but close beach access if: (a) a 50-meter buffer for plover nests is not possible while maintaining beach access from Parking Lot 1, (b) chicks from nests in closed areas move onto the open beach, in which case we would monitor chick activity and provide for a maximum buffer by moving closure signs accordingly if chicks are disturbed more than four times per hour when foraging, and/or (c) chicks are not able to feed in closed areas due to competition from gulls.
    - Continue to maintain the beach between Lot 3 and Lot 6 (4.1 miles) as a low-disturbance beach use area for shorebirds by limiting beach access points. Install signs and increase outreach focused on ways visitors can reduce disturbance to shorebirds in this section (e.g., Walk around Flock campaign).
    - Recruit and train volunteer shorebird stewards to monitor human activity on the beach and educate the public about the closure and beach-nesting birds.
    - Develop and implement education and interpretive programs to foster stewardship among beach users for plovers and other beach wildlife and reduce the frequency and intensity of human disturbance.
    - Provide environmental education programming and informal outreach on the importance of the refuge as a migratory stopover for shorebirds, using local refuge data.
    - Continue to partner with other organizations to develop and implement effective outreach strategies that engage diverse beach users, with the goal of changing behavior to minimize shorebird disturbance (e.g., Walk Around Flock campaign).
    - Continue to work with FWS and other organizations to increase diversity and representation among staff that implement beach conservation and outreach, to ensure effective communication to an increasingly diverse beach audience.
    - Install symbolic fencing and seasonal signage with direct, positively framed guidance, and continue to monitor disturbance impact to migratory shorebirds.

Restore and maintain Biological Diversity, Integrity, and Environmental Health (BIDEH)

- Eradicate any new invasive plant species that may colonize refuge or Plum Island beaches. Early detection species include Asian sand sedge, yellow horn-poppy, and saltwort.
- Educate Town beach managers, Audubon plover monitors, and MA DCR on identification of these early detection species, and coordinate control and eradication if found on any Plum Island beach.
- Guide plant succession at the Stage Island bluff and remove invasive plants (tree of heaven, honeysuckle, etc.) to restore native plant community, while maintaining viewscapes.

Figure 5-1 Parker River NWR management units for beach, dune, maritime shrubland, and maritime forest habitats. This map shows the northern-most quarter of the refuge.

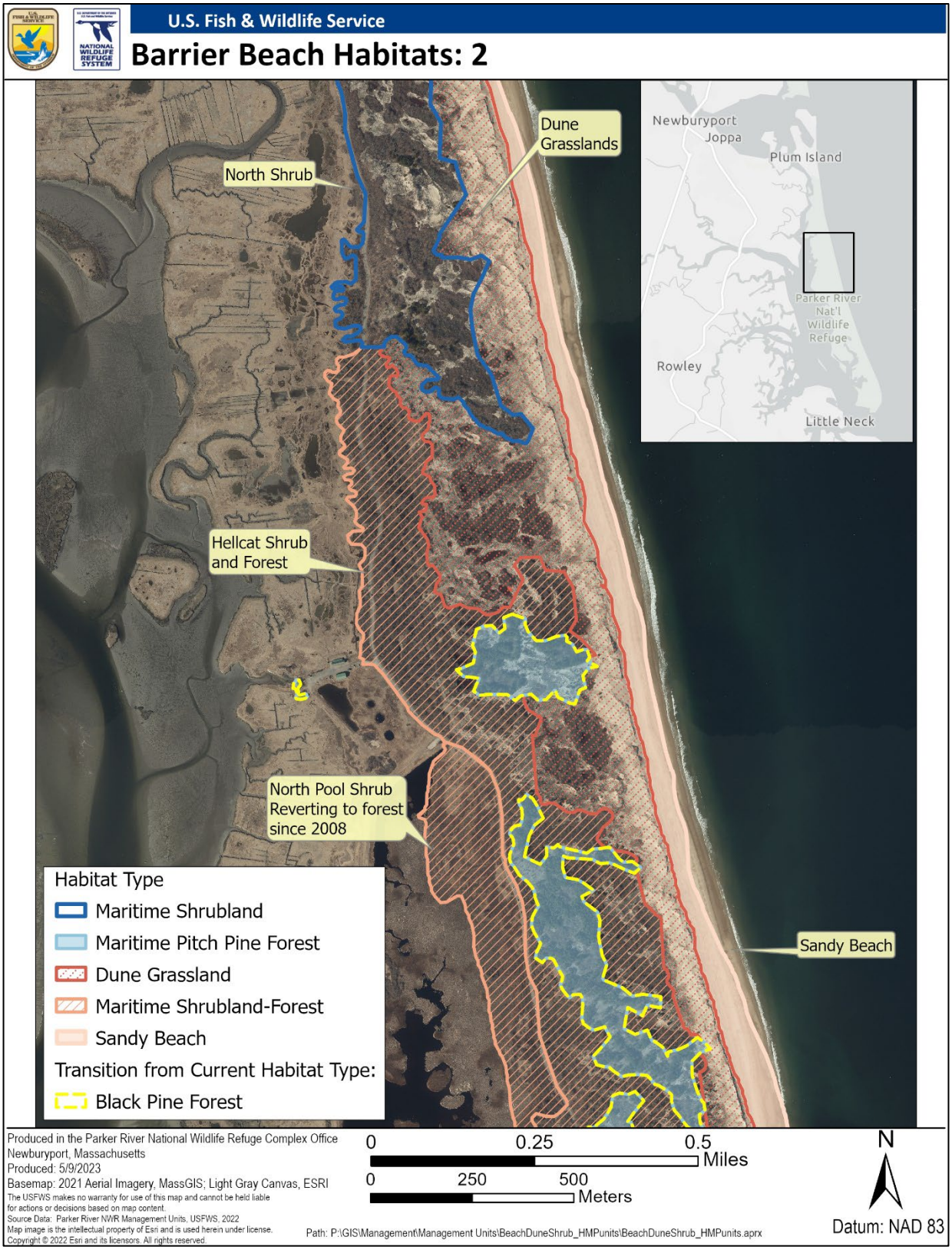

Figure 5-2 Parker River NWR management units for beach, dune, maritime shrubland, and maritime forest habitats. This map shows the north-central quarter of the refuge.

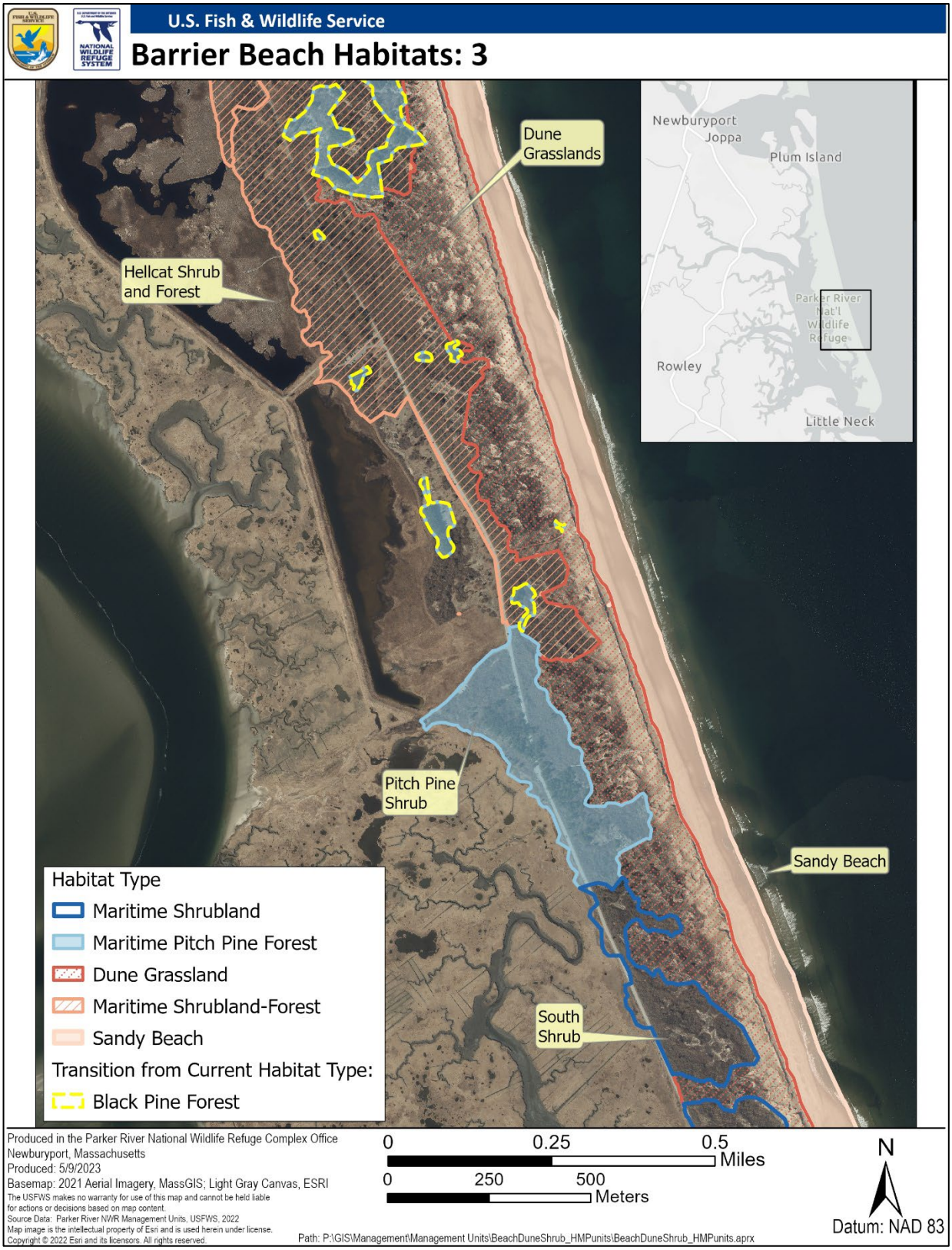

Figure 5-3 Parker River NWR Management Units for beach, dune, maritime shrubland, and maritime forest habitats. This map shows the south-central quarter of the refuge.

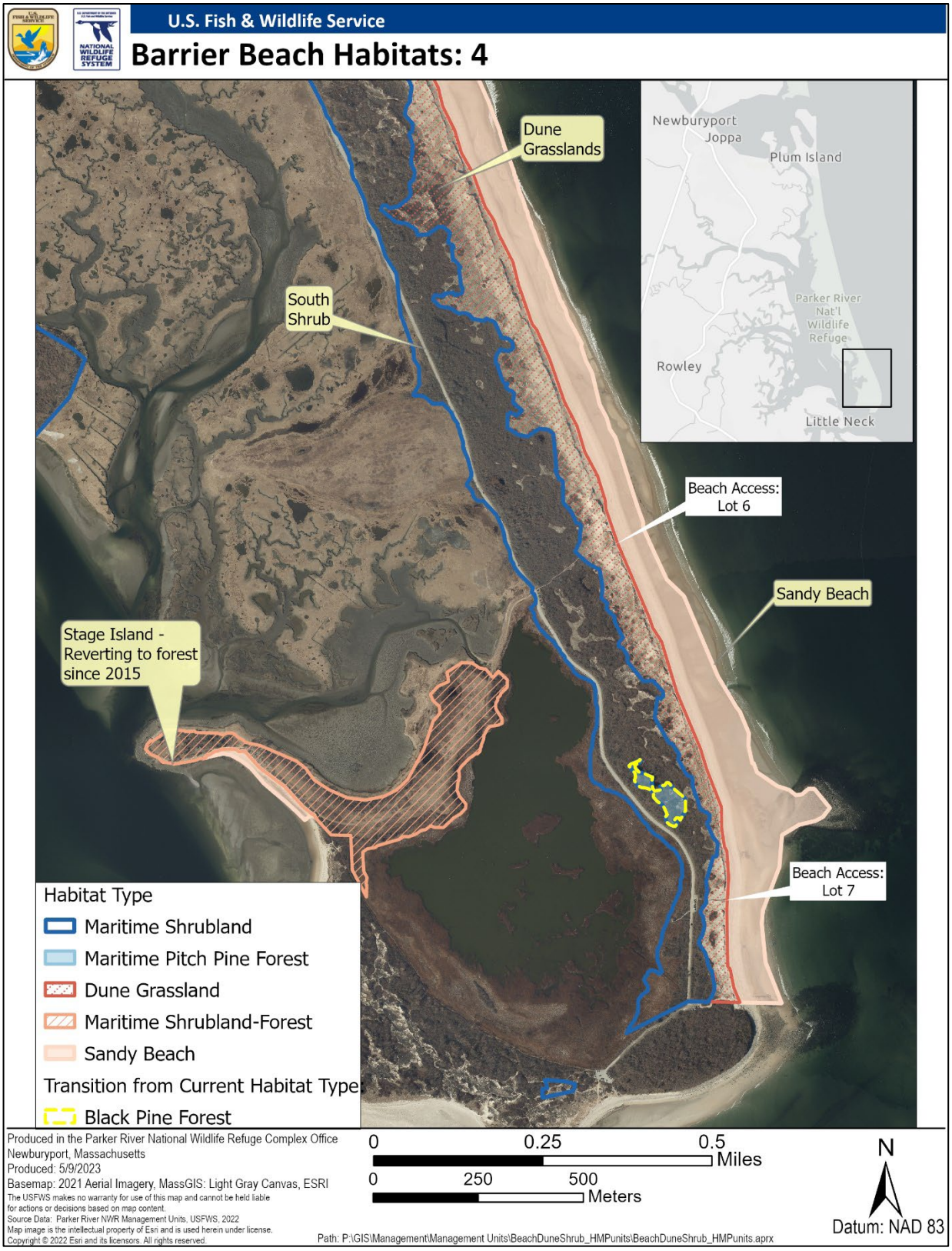

Figure 5-4 Parker River NWR management units for beach, dune, maritime shrubland, and maritime forest habitats. This map shows the southern quarter of the refuge.

1.2 Dune Grassland, Sandplain Grassland, Interdunal Swales

- Habitat Priority 2
- ROCs: Eastern Spadefoot Toad, rare Lepidoptera (e.g., Sandplain Euchlaena, Dune Noctuid Moth, Coastal Heathlands Cutworm)
- Other benefitting species: Ipswich Savannah Sparrow; migrating and wintering raptors (e.g., Northern Harrier, American Kestrel, Merlin, and Peregrine Falcon); rare beetles; breeding amphibians; rare plants (e.g., seabeach needlegrass)
- No planned change in acreage

Sandplain grasslands (24 acres) and interdunal swales (48 acres)

Sandplain grasslands and interdunal swales do not have their own management units because they are embedded within multiple other habitat types and management units. These rare natural communities primarily occur within maritime shrublands but can also be found within dune grasslands and maritime forests (Figure 5-5). While mainly located in maritime shrublands, these communities are biologically closely associated with dune grasslands as they all provide important resources to rare lepidopterans and the Eastern Spadefoot Toad. Although these habitats are included in many MUs, including North Shrub, Dune Grasslands, Hellcat Shrub and Forest, Pitch Pine Shrub, South Shrub, Black Pine Forest, and Bill Forward Shrub, the management strategies for sandplain grasslands and interdunal swales are listed here.

Dune Grasslands MU (444 acres)

The Dune Grasslands MU is a matrix of dune grasslands and interdunal swales with isolated patches of short, salt-tolerant maritime shrubs. There are 21 interdunal swales in this MU, some of which are cranberry bogs.

The dune grassland community occurs on windswept dunes within the salt spray zone, just behind the primary dunes. The salt spray and infrequent storms inhibit the growth of shrub species, so this habitat is dominated by grassland species such as beach grass, beach pea, seaside goldenrod, and beach heather. Populations of seabeach needlegrass (State threatened) are found in twelve different locations within this MU. While some of these populations remain relatively large (>10,000 individuals), all known seabeach needlegrass sites have decreased in size since 2004, and several subpopulations now contain less than 100 individual plants.

Sustain natural processes

- Allow the unrestricted and continual deposition and erosion of sand due to natural geological processes. The refuge will not inhibit such beach dynamics and will not construct infrastructure that may interfere with the shifting of the barrier beach and dunes but will repair existing infrastructure as necessary and appropriate.
- Reintroduce fire as a tool for creating disturbance and managing shrub encroachment within sandplain grasslands.

Support migratory birds, ROC, and T&E species

- Assess human disturbance levels associated with populations of sensitive species (e.g., seabeach needlegrass, Eastern Spadefoot Toad) and employ signage, trail closures or rerouting, as needed.

- Assess human disturbance associated with public use (e.g., cranberry picking, educational programs), and adjust use as needed through Compatibility Determinations.

Restore and maintain BIDEH

- Monitor rare plants (dragon's mouth orchid) and animal populations (Eastern Spadefoot Toad) and enhance or reintroduce if determined necessary.
- Selectively treat glossy buckthorn, black locust, Morrow's honeysuckle, and other invasive plants in the sandplain grasslands using mechanical, chemical, and fire strategies.
- Treat invasive plants in interdunal swales, including rusty willow, glossy buckthorn, *Phragmites*, and purple loosestrife using mechanical, chemical, and fire strategies.
- Eradicate beach rose on the refuge within 10 years using mechanical, chemical, and fire strategies. Educate the public on native and invasive roses.
- Treat spotted knapweed around Lot 1 using herbicide applications to prevent spread.
- Monitor to prevent and detect new infestations of invasive plant species.

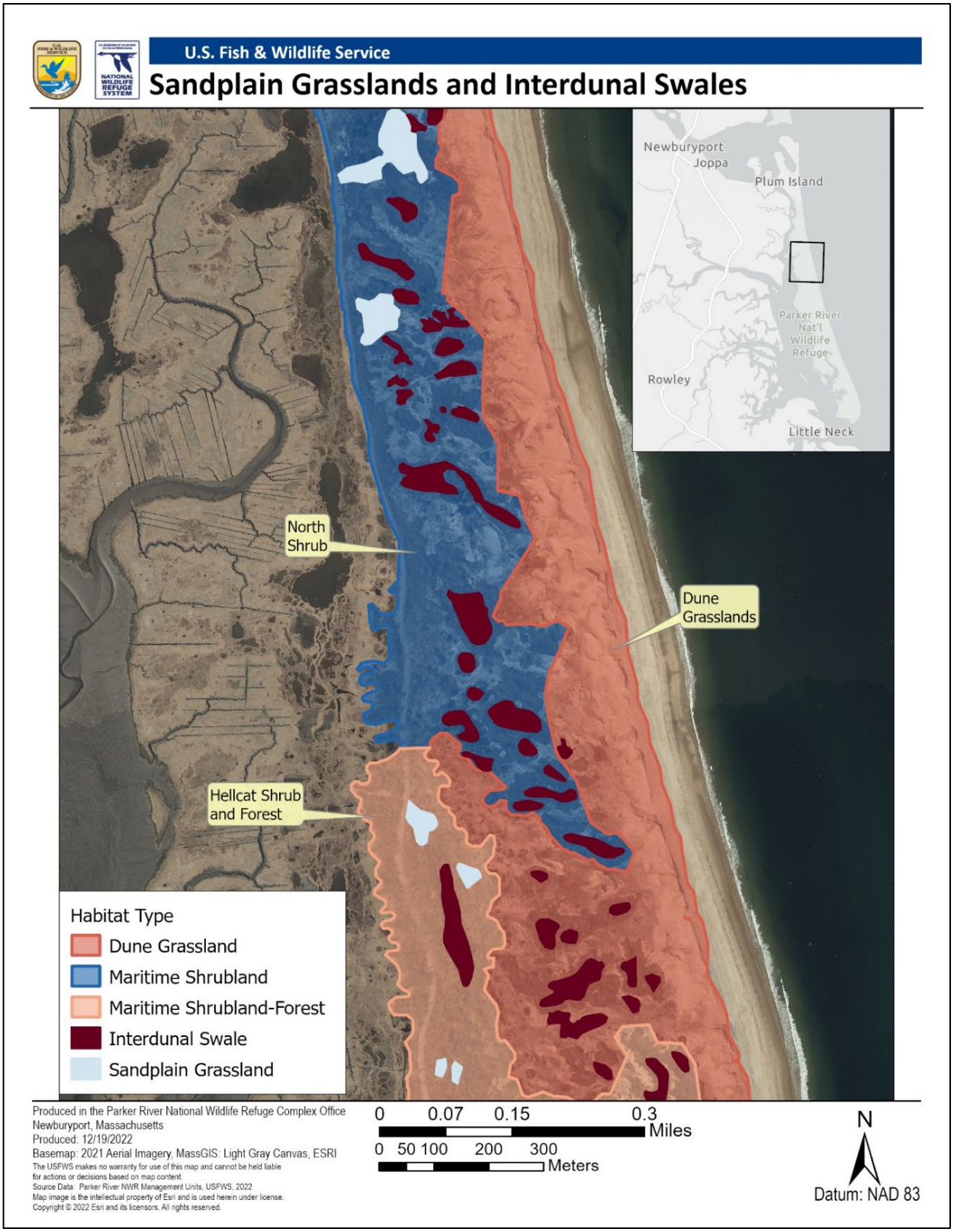

Figure 5-5 Example of how sandplain grasslands and interdunal swales intermingle with maritime shrubs and dune grasslands at Parker River NWR.

1.3 Maritime Shrubland, Maritime Forest

- Habitat Priority 2
- ROCs: Eastern Towhee, Brown Thrasher, Eastern Red Bat
- Other benefitting species: Eastern Kingbird; Baltimore Oriole; American Woodcock; migrating songbirds; New England Cottontail; migrating tree bats (e.g., Hoary, and Silver-haired Bats.
- No planned change in acreage (62 acres currently reverting from old field to Maritime Forest).

North Shrub MU (135 acres)

Maritime shrublands and forests, sandplain grasslands, interdunal swales

- The North Shrub Unit stretches from the northern boundary to the OMWM gate, an administrative entrance to the marsh located approximately 0.5 miles north of Sub-headquarters (Figures 5-3, 5-4, 5-7). It is located west of the dune grasslands and east of the salt marsh. The area is largely maritime shrublands intermixed with small amounts of dune pine forests, dune grasslands, sandplain grasslands and interdunal swales. Over time, the shrub density has increased within this MU. As of the last survey in 2017, this area had no invasive black pines. There are 44 cranberry bogs, including the largest, which is about one acre in size, and four sandplain grasslands in this MU.

Hellcat Shrub and Forest MU (170 acres)

Maritime shrublands and forests, sandplain grasslands, interdunal swales

The Hellcat Shrub and Forest unit stretches from the OMWM Gate (an administrative entrance to the marsh located approximately 0.5 miles north of Sub-headquarters) to the Lot 5 Pines Trail (Figures 5-1, 5-2, 5-5). It consists of maritime shrubland, and forest interspersed with 34 interdunal swales and four sandplain grasslands. The largest forest block on Plum Island lies within the heart of this MU, with mature tree species such as black gum, red maple, black cherry, and quaking aspen.

This unit surrounds the largest black pine forest, which is managed separately, and discussed below in Dune Pine Forest. A pilot project in 2009-2010 removed black pines from 1-acre area and planted pitch pine seedlings. Although successful, restoration is slow. Untreated, this stand of black pines provides the seed source for invasion of the adjacent dune grassland and maritime shrubs. This MU also hosts a long-term bird banding station, administered by Mass Audubon, which has operated since 1998.

South Shrub MU (106 acres)

The South Shrub Unit extends from the Pitch Pine Shrubs by Lot 5 to the southern boundary (Figures 5-3, 5-4). This MU is largely maritime shrubland punctuated by small patches of dune grasslands and interdunal swales. There is a small section of sandplain grasslands near the old Beach Buggy 2 access trail and two additional pockets bordering the Grape Island Marsh Unit. This unit has more mature trees than the North Shrub Unit, with more shrubs and forest patches and less open dune grasslands. There are 15 interdunal swales in this unit; they are small and spaced further apart, but some still support cranberry bogs.

Grape Island MU (23 acres)

Maritime shrublands and forests

Grape Island is a long, narrow strip of upland along the southwest edge of Plum Island (Figure 5-7). To the east, salt marsh separates Grape Island from other upland portions of Plum Island; to the west lies Plum Island Sound. A small farming settlement operated on the island beginning in the 1670s until the last resident passed away in 1984. All structures have since been removed, and the vegetation has succeeded to maritime forest and shrubland. Vegetation includes black pines, which refuge staff planted in 1980. Due to the difficulty in accessing the island (by boat or on foot through the salt marsh), no recent invasive mapping or treatment has been done.

Newbury Forest MU (21 acres)

Maritime shrublands and forests

The Newbury Forest consists of multiple small forest patches located along the western edge of the refuge (Figure 5-6). These patches are part of larger forest blocks that continue onto adjacent privately owned property. Four patches, including one 5-acre tract, are located adjacent to the Hunt Area A salt marsh. The largest patch (16 acres) is located within Hunt Area B. A small parking lot is located at the end of a private road in this unit, primarily to allow duck hunters to access the marsh. This MU receives little management due to its small size and access difficulties. There is potential for salt marsh migration within these forests as sea levels rise and salt water encroaches inland.

North Pool Shrub MU (33 acres)

Maritime shrublands and forests

In 2008, the refuge started restoration of the south portion of the North Pool Field (7 acres) to shrub habitat as part of a multi-refuge adaptive management project (Figures 5-2, 5-3). Restoration of the remaining 19 acres began in 2014. We treated invasive shrub species (e.g., glossy buckthorn and honeysuckle) in the southern portion in 2009 and in the full field in 2015-2017, and 2021. Monitoring indicates that the field has transitioned to the desired young shrub habitat with many berry-producing shrubs, including bayberry, winterberry holly, chokecherry, arrowwood, blueberry, and black cherry. Pervasive poison ivy in this unit currently makes invasive treatment very challenging.

Nelson Island MU (27 acres)

Maritime shrublands and forests

Nelson Island is a drumlin located on the western side of the refuge and is surrounded by salt marsh (Figure 5-6). A dirt road connects the drumlin to the nearest upland, crossing the salt marsh. Since the early 2000s, the frequency of road flooding has progressively increased, leaving some sections of the road permanently flooded. As a result, refuge management abandoned the road in 2013. Without a drivable access road, mowing ceased after 2012. Management shifted toward restoring Nelson Island to a maritime shrubland and forest. The distance from the drumlin to the nearest upland has reduced seed dispersal, leading to a slow recolonization of woody vegetation. Woody invasive plants like glossy buckthorn, honeysuckle, and multiflora rose were treated in 2015, 2016, and 2021 (Groves 2021).

Stage Island MU (25 acres)

Maritime shrublands and forests

Stage Island is a linear old field drumlin between the human-made Stage Island Pool and salt marsh, with Plum Island Sound along the western extent (Figures 5-4, 5-7). In 2014, the decision was made to restore this field to Maritime Shrub. The soil at this unit supports climax community dominated by oaks, hickory, red maple, sugar maple, birches, and white pine. As of 2020, this unit is comprised of a shrub/tree border around the edge of the drumlin, and dense patches of native species, such as bayberry and sumac, colonizing the field from the edges. The field is approximately 30% shrub cover, with black cherry and honeysuckle colonizing the middle, and an understory of Virginia rose, grape, poison ivy, bedstraw, vetch, and spurge. Woody invasive plants like glossy buckthorn, honeysuckle, multiflora rose, and Asiatic bittersweet were treated in 2015, 2016, and 2021. In 2016, the last privately-owned house on the refuge was removed from the western tip, allowing for the extension of the Stage Island Trail through the full MU to the point overlooking the Ipswich Bluffs. A small patch of tree-of-heaven was found by the bluffs and treated in 2017, but it persists.

Strategies for Maritime Shrubland and Forest

Sustain natural processes

- Reintroduce fire as a tool for creating disturbance and controlling invasive plants.
- Allow the North Pool Shrub MU, Stage Island MU, and Nelson Island MU to succeed to maritime forest.
- Assess potential for marsh migration within the Newbury Forest MU, including establishing marsh migration transect per Tiner et al. (2002).

Support migratory birds, ROC, and T&E species

- Continue to partner with Massachusetts Audubon Society to monitor landbird use during spring and fall migration via the banding program.
- Monitor berry-producing plants and abundance using established or new protocols to ensure high-quality foraging habitat for fall migrating songbirds.
- As part of modeling and final design for decommissioning of North Pool, explore vulnerability of Hellcat Forest to dieback with tidal restoration. Explore options to reduce impacts to Hellcat Forest both immediately post tidal restoration and under future SLR scenarios.
-

Restore and maintain BIDEH

- Treat invasive plants, such as bush honeysuckle, buckthorns, barberry, Asiatic bittersweet, rusty willow, multiflora rose, tree-of-heaven, and beach rose, using mechanical, chemical, and fire strategies, to restore native habitats, including pollinator plants.
- Map and remove invasive black pines using mixed approaches of cutting and spraying. Investigate additional methods of control.
- Monitor succession of North Pool Shrub MU, Stage Island MU, Nelson Island MU, to ensure recovery of native plant communities as described in Objectives. Monitoring should include the detection of new invasive species. If found, employ EDRR tactics to eradicate.

Figure 5-6 Parker River NWR management units: Newbury Forest and Nelson Island.

1.4 Dune Pine Forest

- Habitat Priority 2 (Figures 5-2 to 5-4)
- ROCs: Eastern Whip-poor-will
- Other benefitting species: Rare Lepidoptera
- No planned change in acreage

Pitch Pine Shrub MU (28 acres)

Dune pine forests, sandplain grasslands, interdunal swales

This unit is dominated by pitch pines, often with little or no shrub layer (Figure 5-3). The understory vegetation is composed of beach heather, bearberry, lichen, or Pennsylvania sedge with extensive amounts of invasive honeysuckle present. From the lack of fire in the unit, the duff layer is thick. This has resulted in the roots of the pitch pines to be shallow. It also prevents further seed germination. There is a small patch of sandplain grassland on the western edge and two interdunal swales on the southern end.

Black Pine Forest MU (48 acres)

Black pine forest, maritime shrubland and forest, dune grasslands, sandplain grasslands, interdunal swales

This unit encompasses the largest black pine infestations, with approximately 29 acres dominated by mature trees and an additional 6 acres of seedlings (Figures 5-2 to 5-4). The infestations are primarily within maritime shrublands and maritime forests but are also spreading into the dune grasslands. An area of sandplain grassland and seven interdunal swales are scattered throughout this management unit.

Strategies for Dune Pine Forest

Sustain natural processes

- Collaborate with fire program to develop strategy to reduce duff layer and shrub cover while preventing damage to the pitch pine root system.
- Monitor the response of invasives to a fire treatment.

Restore and maintain BIDEH

- Restore the pitch pine forest habitat using prescribed fire and control of invasive plants to create the desired open understory typical of this habitat.
- Transition black pine dominant forests to pitch pine forests by cutting and treating black pines with herbicide and planting pitch pines.
- Investigate additional control methods for black pines.
- Update black pine mapping to track black pine spread and treatment success.
- Reduce or eliminate non-native honeysuckles, buckthorn, and Asiatic bittersweet using mechanical, chemical, and fire strategies.
- Monitor for early detection of Southern Pine Beetle

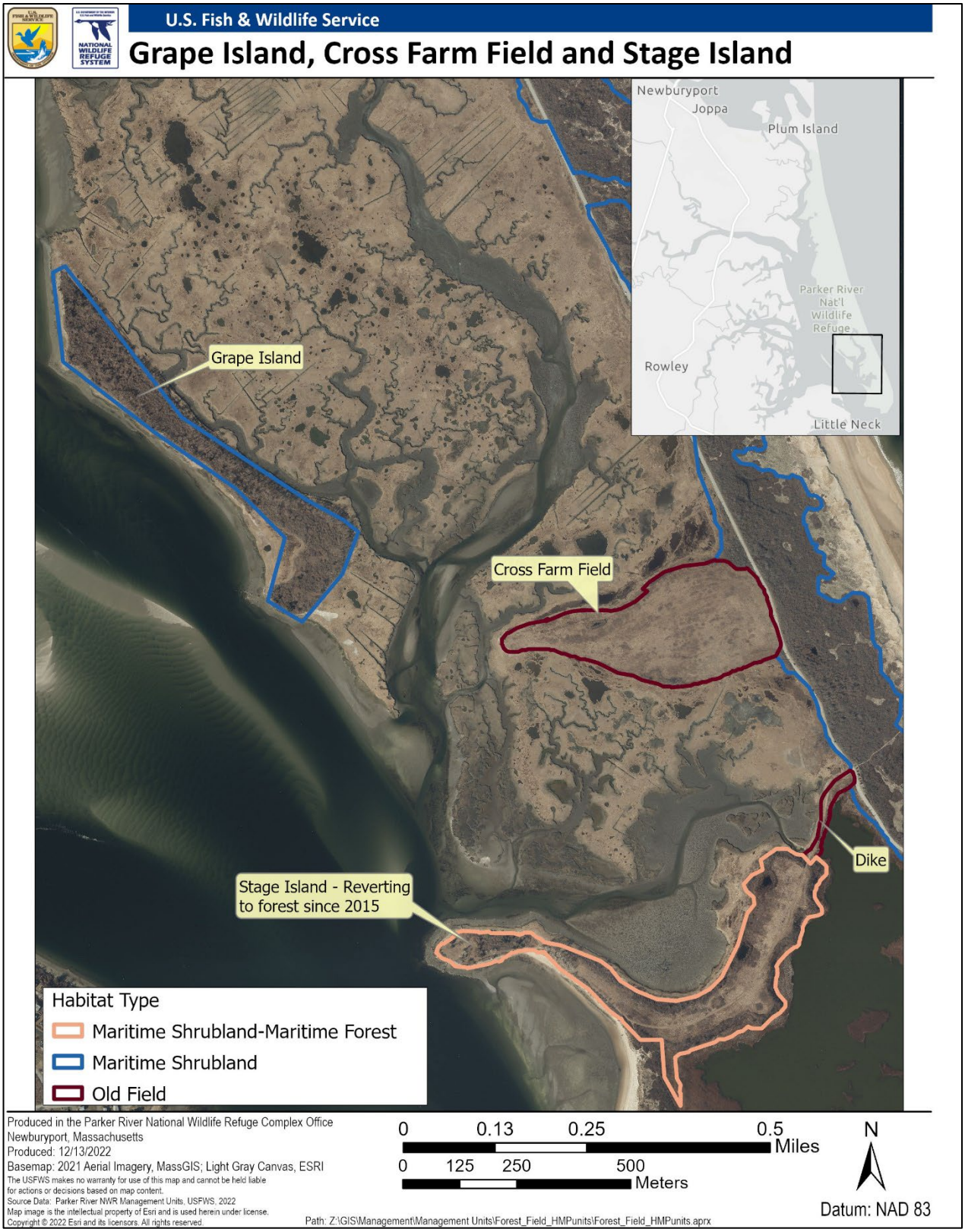

Figure 5-7 Parker River NWR management units: Grape Island, Cross Farm Field, and Stage Island.

2.1 Old Fields

- Habitat Priority 2 (Figures 5-7, 5-8)
- ROCs: Bobolink, pollinators (e.g., Monarch butterfly, native bees)
- Other benefitting species: American Woodcock, Northern Harrier, Short-eared Owl, Whimbrel, Savannah Sparrow
- No planned change in acreage

Cross Farm Field MU (24 acres)

Old field

Cross Farm Hill is a drumlin that was farmed prior to refuge ownership (Figure 5-7). Currently, it has virtually no native plants other than poison ivy, milkweed, and goldenrods. The upper part is covered with a mix of grass-leaved stitchwort and grasses, including quack grass, hard fescue, meadow fescue, common timothy, and Canada bluegrass. Interspersed among the mixed grasses are patches of common milkweed, Asiatic bittersweet, Canada thistle, wild garlic, and poison ivy. Several small patches of black swallowwort have been treated periodically with herbicide since 2010. In 2017, one invasive porcelain berry and seven rusty willows were found and treated. A patch of spotted knapweed was found in the southeast corner in 2011 but has not been treated.

According to Weare (1996), topsoil was removed from the top of this hill to build the road, which explains the shallow depth to the dense layer in the Windsor soil in this part of the field. This unit will likely succeed to coastal forest/woodland if unmanaged. Cross Farm Field has good potential to support grassland nesting birds due to its relatively large size and proximity to open habitat with the adjacent salt marsh. Refuge staff have confirmed breeding Savannah Sparrow and Bobolink as recently as 2021. Historically, this unit supported breeding Eastern Meadowlark.

A significant management consideration is to contain and eradicate black swallow-wort and porcelain berry to prevent spread of these invaders to other habitats and units. Both these species will invade shrub and forest habitats. Allowing a field to revert prior to eradicating these species may make control and eradication more difficult.

Bill Forward Field MU (11 acres)

Old field

The drier areas of the Bill Forward Field (near the road) grade into the shrub and grass mosaic north of the field (the Bill Forward Shrub MU) (Figure 5-8). They meet in a weedy area that harbors Canada bluegrass, drooping brome grass, English plantain, common king devil, rabbit-foot clover, common timothy, and Asiatic sweet clover. Wet areas support mainly non-native vegetation, with single species stands of curly dock, foxtail barley, and common plantain. Two native species are present in these wet areas: one-glumed spikesedge and sensitive fern. The northwest corner of the field closest to Bill Forward Pool was historically planted with a seed mixture of annuals and weedy perennials.

Sub-headquarters Field MU (12 acres)

Old field

The Sub-headquarters Field is dominated by Virginia rose, poison ivy, and Pennsylvania sedge, with patches of hair fescue, hairy hudsonia, and dune reindeer lichen (Figure 5-8). It is largely uninvaded and supports a dwindling population of seabeach needlegrass. Located ~150 ft east of the northernmost pond within the MU on a small, sandy dune area, this population now includes less than fifty individual plants - a significant reduction from a population size of 1,000 plants in 2004. The lower areas and pool edges support freshwater cordgrass and other native species as well as a large patch of climbing nightshade, an invasive plant. On the edge of this MU is the refuge's historic burn pile, where vegetation refuse was dumped and burned annually until 2010. The transported vegetation and soil disturbance may be responsible for nearby patches of invasive plants, including Morrow's honeysuckle, drooping brome grass, and leafy spurge. This unit is mowed annually to limit encroachment of woody vegetation.

North Pool/Bill Forward Dike MU (23 acres)

Old field

This unit includes the earthen berms that separate the human-made North and Bill Forward Pools from the salt marsh and each other (Figure 5-8). Annually mowed to prevent the growth of shrubs and trees, these long, narrow grassland units are characterized by a level top with a two-track path down the middle and sloping sides. Although the dike is narrow, it abuts the salt marsh and the impoundments, increasing its appeal for grassland nesting birds. Willet, Bobolink, and Savannah Sparrow nest along the dike. The dike is being invaded by spotted knapweed, leafy spurge, and Phragmites. No treatment has been applied thus far.

Bill Forward Shrub MU (15 acres)

Maritime shrubs, sandplain grasslands, old fields

This sandplain shrubland is a mosaic of sandplain grasslands and shrub islands (Figure 5-8). The area north of the Bill Forward Blind is approximately 50% shrubs. An additional 25% cover consists of small shrubs interspersed with graminoids, held in check by mowing every three to five years. Small patches of beach grass, Pennsylvania sedge, little bluestem, and other native grasses and forbs are interspersed in stands of shining sumac, beach plum, northern bayberry, and pasture rose. South of the blind there are fewer shrubs (20% cover) and more graminoids and forbs. Beach grass, poison ivy, Pennsylvania sedge, beach plum, beach heather, and little bluestem are more prevalent here than the north portion.

This unit is managed through mowing every three to five years to reduce encroachment by woody vegetation, allowing for the continuation of native grasses and forbs used by native pollinators. The patchy shrubland also provides habitat for American woodcock.

Stage Island Dike MU (1 acre)

Old field

While a majority of Stage Island has reverted to shrubland, the dike (Figure 5-7) continues to be mowed for dike maintenance and pedestrian safety. The most common species are Canada bluegrass, common timothy, Rhode Island bentgrass, red fescue, redtop, quack grass, and goldenrods. There are populations of invasive leafy spurge, spotted knapweed, Asiatic bittersweet, and drooping brome grass distributed in localized patches. Purple loosestrife and *Phragmites* are found in the wetter areas. A patch of perennial pepperweed at the toe of the dike was eradicated in 2019 and has been cleared since. Annual inspections are necessary to ensure no re-invasion as this marsh edge is across the way from large infestations in Ipswich.

Strategies for Old Fields

Support migratory birds, ROC, and T&E species

- Experiment with timing of mowing, grazing, fire, soil restoration, and native plants to restore plant communities more conducive to nesting grassland birds and pollinators.
- Mow Cross Farm Field, Bill Forward Field, Sub-Headquarters Field, and the North Pool/Bill Forward dike annually after August 15 to prevent shrub growth and encourage grasses. Leave patches of nectar and host plants (e.g., milkweed, asters, goldenrod) for Monarch and other pollinators.
- Evaluate the importance of Plum Island for migrating Monarchs and develop strategies for management.
- Mow the Bill Forward Shrub MU every 3-5 years to reduce shrub encroachment and create a habitat mosaic for species such as American Woodcock.

Restore and maintain BIDEH

- Treat invasive plants, such as bush honeysuckle, buckthorns, barberry, Asiatic bittersweet, multiflora rose, and beach rose, using mechanical, chemical, and fire strategies, to encourage native plant communities, including pollinator plants.
- Continue to use herbicide treatments for invasive black swallowwort and porcelain berry within Cross Farm Field and at Headquarters with the goal of eradication within the next 10 years.
- Monitor fields for new invasive species. If found, employ EDRR tactics to eradicate.
- Restore Cross Farm Field to more native and graminoid plant composition to support grassland nesting birds and to eradicate black swallow-wort and porcelain berry.
- If Cross Farm is not restored to more native grassland by 2030, consider letting this unit revert to maritime shrub and forest to support migratory birds and to reduce maintenance.

Figure 5-8 Parker River NWR management units: Sub HQ Field, Dikes, and Bill Forward Field.

2.2 Impoundments

- Habitat Priority 2 (Figures 5-11, 5-12)
- ROCs: Migrating shorebirds (e.g., Semipalmated Sandpiper, Red Knot, Black-bellied Plover), migrating waterfowl (e.g., American Black Duck, Northern Pintail, Green-winged Teal)
- Other benefitting species: Breeding waterfowl (e.g., Gadwall, Mallard, Canada Goose), secretive marsh birds (e.g., Virginia Rail, American Bittern, Least Bittern), Marsh Wren
- Reduce by 266 acres

North Pool MU (114 acres)

Impoundment

North Pool is a human-made impoundment created in 1948 by building an earthen dike through the salt marsh (Figure 5-11). North Pool is currently brackish to freshwater marsh habitat. Precipitation provides its sole source of fresh water, and water levels can be managed by adding or releasing water through a single water control structure along the dike. In the past, management was limited by an inability to adequately lower and raise water level. The impoundment is managed to support breeding marsh and wading birds, although marsh and wading breeding numbers have been declining. The static water level regime for marsh and wading birds has led to the development of undesirable monotypic plant communities, primarily invasive *Phragmites.* The aging dike will be subject to continued sea level rise and increased storm frequency, putting its long-term security in question. Hydrological and vegetative models predicted that restoration to a mix of high and low marsh is feasible (WHG 2018, 2019).

Interim strategies prior to breaching the dike

- Maintain high water levels (6-24" above marsh) through the breeding season (April – August), until decommissioning.
- Every five years, conduct a gradual drawdown beginning August 15 to allow for aerobic activity in benthic areas. Water levels during drawdown should be low enough to expose as much undecomposed organic matter as possible while still maintaining refugia (e.g., pools capable of supporting aquatic invertebrates, amphibians, reptiles, and fish). Water levels must be sufficient to allow relatively rapid recolonization of the impoundment when full water is restored.
- Drawdowns may occur sporadically for invasive *Phragmites* control and for other administrative or biological needs, such as overwintering *Galerucella* beetles that control purple loosestrife, and certain monitoring needs.
- In early October, flood as necessary to get water close to marsh surface, allowing precipitation to raise water level thereafter. Leave the pool full throughout the winter.
- Continue to collaborate with MassWildlife to improve habitat conditions to support marsh and wading bird breeding habitat in North Pool, seek funding to control *Phragmites*, and monitor breeding marsh and wading bird populations.
- Work with MassWildlife to conduct periodic water chemistry testing to track the effects of drawdowns on oxygen, salinity, phosphorous and nitrogen levels, and nutrient composition.
-

Bill Forward Pool MU (34 acres)

Impoundment

Bill Forward Pool is the smallest of the three impoundments at 34 acres (Figure 5-11). Bill Forward Pool and North Pool were created concurrently in 1948 and share the same main dike separating them from the salt marsh. A second shorter dike, perpendicular to the first, splits the area into the two pools. Bill Forward Pool currently has the most effective water management to benefit shorebirds and waterfowl due to its gradually sloping elevations. Sediment core samples (Fitzgerald et al. 2017) indicated that much of the substrate in this impoundment is sand and muddy sand, with very little organic peat matter. The refuge simultaneously manages for the competing needs of waterfowl (open water) and shorebirds (mudflats) in this impoundment. *Phragmites* has expanded into what were once mudflats, decreasing the amount of habitat available for shorebirds. This impoundment has subsided the most relative to the adjacent salt marsh, with an elevation difference of 69 cm. Climate change will also impact Bill Forward Pool in the future, as the aging dike will be subject to sea level rise and increased storm frequency.

Interim strategies prior to breaching the dike

- Create high water conditions in spring to suppress *Phragmites* and other robust perennial plants (fireweed, marsh fleabane, cattail, etc.)
- Alternate spring and fall drawdowns with Stage Island impoundment each year, such that optimal shorebird habitat (shallow water and mudflats with an abundance of invertebrates) is provided from May to September each year, and each impoundment is flooded during the growing season every other year to promote moist soil annual plants.
- Flood up in late August (Spring Drawdown) to October (Fall Drawdown) to provide habitat for fall waterfowl migration.
- Manage robust vegetation (cattail, *Phragmites*) to promote species favorable to feeding shorebirds and waterfowl.

Stage Island Pool MU (118 acres)

Impoundment

Stage Island Pool was created in 1957 at the southern end of the refuge, about four miles from the other two impoundments (Figure 5-12). Fifty-three acres of the impoundment can be managed as a moist soil unit due to its gradual sloping pool bottom elevations; the remainder of the impoundment (65 acres) is dominated with robust vegetation. Water level management for this unit is constrained by the need to avoid impacts to clamming in the tidal channel outside the water control structure. Typically, this restricts drawdowns to Sunday or when clam flats are closed due to weather events. Shorebird use in Stage Island has decreased in recent years compared to 2010 to 2011 numbers (USFWS 2012), potentially because of limitations on a drawdown schedule. The refuge plans to restore tidal flow to Stage Island Pool, which has subsided more than a foot relative to the adjacent marsh since impoundment (Fitzgerald et al. 2017). Restoration would convert Stage Island Pool to salt marsh, help control invasive plant species, and increase climate resilience in the future.

Interim strategies prior to breaching the dike

- Create high water conditions in the spring to suppress *Phragmites* and other robust perennial plants (fireweed, marsh fleabane, cattail, etc.).

- Alternating Spring or Fall drawdown with Bill Forward each year, such that optimal shorebird habitat (shallow water and mudflats with an abundance of invertebrates) is provided from May to September each year, and each impoundment is flooded during the growing season every other year to promote moist soil annual plants.
- Flood up in late August (Spring Drawdown) to October (Fall Drawdown) to provide habitat for fall waterfowl migration.
- Manage robust vegetation (cattail, *Phragmites*) to promote species favorable to feeding shorebirds and waterfowl.

Strategies for Impoundments

Mitigate or adapt to climate change

- Continue to monitor the relative elevation of impoundments in relation to adjacent salt marsh using established surface elevation tables.
- Add additional elevation transects using Real Time Kinetic GPS equipment.
- Develop monitoring protocols to understand uncertainties related to restoring to a salt marsh ecosystem for Stage Island Pool. Uncertainties include initial elevation loss with conversion from fresh to saline system, sediment accretion, natural restoration of geomorphological features with the new tidal regime, shifts in vegetation community after equilibrium has been reached and with continued sea level rise.
- Work with partners to plan and implement restoration of Stage Island to tidal flow by 2027.
- Every 3-5 years, update vulnerability assessment and timeframe for restoring tidal flow to North Pool and Bill Forward Pool t based on information learned from Stage Island Pool, condition monitoring, and the latest climate science.
- Explore alternatives (e.g., bridge, open bottom culverts) to provide continued access to Stage Island Trail post-restoration to support public use, habitat management, and maintenance.
- As part of modeling and final design for decommissioning of North Pool, explore vulnerability of Hellcat Forest to dieback with tidal restoration. Explore options to reduce impacts to Hellcat Forest both immediately post tidal restoration and under future SLR scenarios.
-

Restore and maintain BIDEH

- Using a combination of water level manipulation, herbicide application, mowing, and biological control, and fire to manage for desired vegetation and control of invasive plants.
- Monitor plant species composition and response to water level management using established vegetation plots.
- Continue to assess and implement strategies for *Phragmites* control.
- Monitor the populations of purple loosestrife.

2.3 Salt Marsh

- Habitat priority 1 (Figures 5-9 to 5-13)
- ROCs: Saltmarsh Sparrow, American Black Duck

- Other benefitting species: Nesting birds (e.g., Nelson's Sparrow, Seaside Sparrow, Black Rail, Clapper Rail, Willet); migrating shorebirds (e.g., Greater Yellowlegs, Short-billed Dowitcher, Least Sandpiper); foraging wading birds (e.g., Snowy Egret, Glossy Ibis); migrating and wintering raptors (e.g., Northern Harrier, Snowy and Short-eared Owl, Bald Eagle, Peregrine Falcon)
- Increase by 266 acres

Plum Island River Marsh MU (395 acres)

Salt marsh

The Plum Island River Marsh is located primarily on Plum Island, extending from the northern refuge boundary to Sub-headquarters (Figure 5-9). Several small marsh islands are located within the Plum Island River, which forms the unit's western boundary. To the east is the refuge road and associated upland. It contains one of the refuge's most notable features, the large salt pannes. This popular birding spot attracts a variety of shorebirds, wading birds, and dabbling ducks. The marsh surrounding the salt pannes is favored by the Saltmarsh Sparrow.

Due to its accessibility and high habitat value, the Plum Island River Marsh has been the primary focus of marsh restoration pilot projects, including ditch plug removal, runneling, and OMWM modification. A summary of these pilot projects can be found here (Pau et al. 2022). Historically, the area has received a host of human alterations, including the construction of agricultural embankments and ditches in the 1700s to 1800s and OMWM mosquito control treatment in the 2000s.

Area A Marsh MU (904 acres)

Salt marsh

The Area A Marsh Unit covers the area south of Little Pine Island Creek to the Parker River and is one of the three waterfowl hunt areas on the refuge (Figure 5-9). The area to the north is largely owned by Essex County Greenbelt. The refuge has no direct foot access to this unit, with most access occurring via boat, or via adjacent private land. Three large tidal creeks (Pine Island, Jericho, and Hason's Creeks) meander through this unit. This unit has a high density of breeding Saltmarsh Sparrow and Marsh Wren populations. The marsh north of Pine Island Road has higher occurrences of invasive *Phragmites* and perennial pepperweed. The initial runnel project was piloted in this unit from 2015-2017 (Burdick 2017).

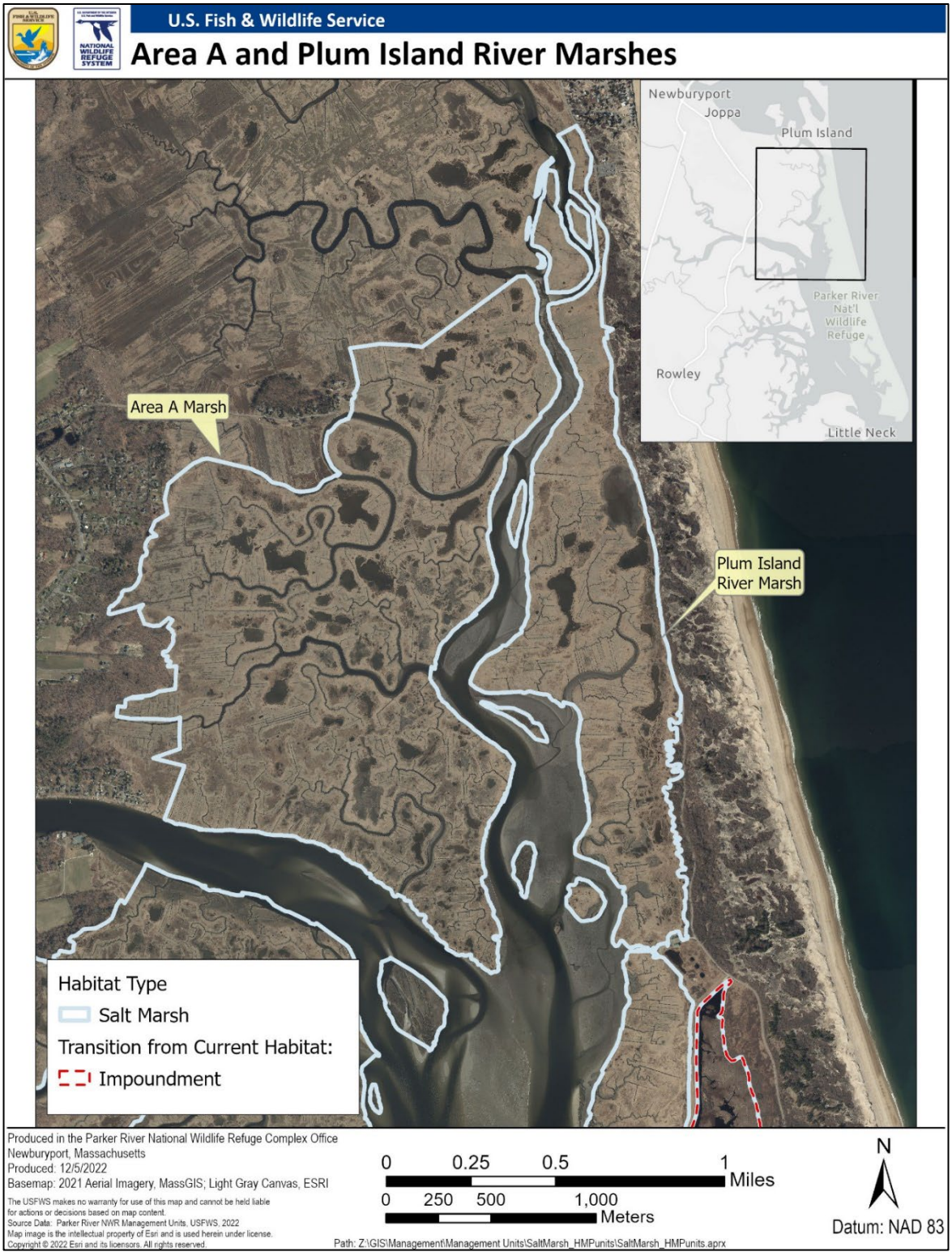

Figure 5-9 Parker River NWR management units: Area A and Plum Island River Marshes.

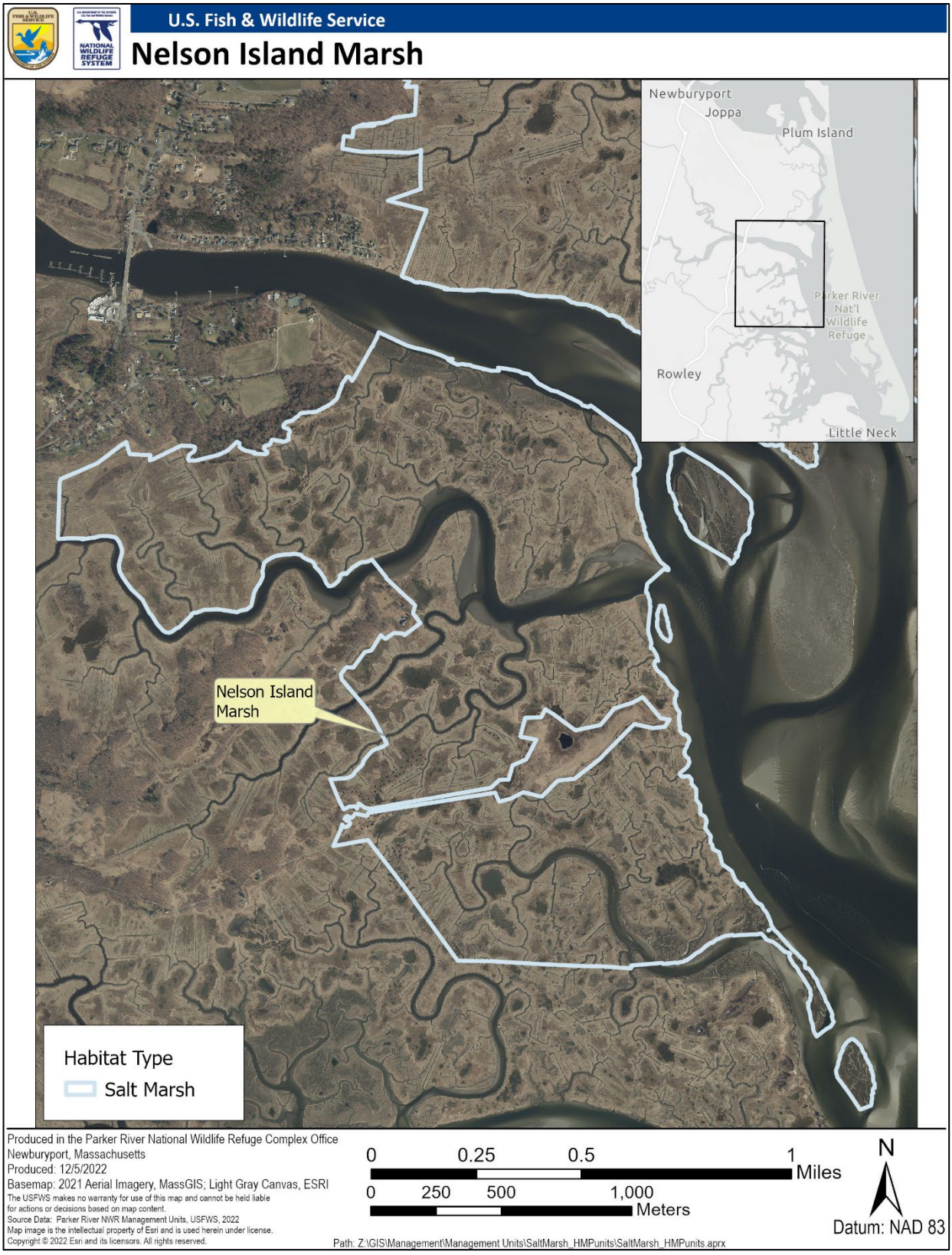

Figure 5-10 Parker River NWR management unit: Nelson Island Marsh

Figure 5-11 Parker River NWR management units: Impoundment Marsh, North Pool, Bill Forward Pool.

Nelson Island Marsh MU (798 acres)

Salt marsh

Nelson Island Marsh is bordered by the Parker River to the north, Plum Island Sound to the east, and the outlet of Nelson Island Creek to the south (Figure 5-10). Much of the abutting land to the west is owned by Essex County Greenbelt or Massachusetts Audubon Society. The Unit includes both Waterfowl Hunt Area B (located in the town of Newbury) and C (Nelson Island, located in the town of Rowley). Access to the northern portion of this unit (Hunt Area B) is via boat or on foot from a small parking area in the Newbury Forest MU located off Marsh Avenue. The marsh surrounding the Nelson Island Shrub Unit can be accessed on foot from the end of Stackyard Road. Mud Creek, a large tidal creek, separates Hunt Areas B and C.

A pilot ditch remediation project was implemented in this unit from 2014 through 2016. This secondary pilot project is testing the spatial distribution of ditches to be kept open for proper draining and flooding. These remediation sites have experienced extensive revegetation and sediment trapping, indicating the successful healing of treated ditches. Continued monitoring will determine marsh-wide impacts of remediation. Success criteria include formation of single channel hydrology that does not clog over time, increase in ground water table and elevation gain in the marsh platform as the ditches heal. Boston University also piloted an eelgrass transplant pilot from 2017 to 2019 as part of an effort to restore eelgrass to Plum Island Sound. Success has been mixed with winter damage and green crab herbivory in some years.

Impoundment Marsh MU (230 acres)

Salt marsh

The Impoundment Marsh lies between the Bill Forward and North Pools to the east and Plum Island Sound to the west (Figure 5-11). From north to south, it stretches from Sub-headquarters to the south end of Bill Forward Pool. This is the narrowest stretch of salt marsh on the refuge, ranging between 625 ft and 1,425 ft wide. The narrowness combined with its proximity to Plum Island Sound makes this marsh highly vulnerable to erosion and marsh degradation. The impoundment dike compounds the problems, preventing flood waters from expanding eastward and causing more impounding within this marsh as compared to other marshes.

To date, little restoration activity has taken place within this unit. It was, however, the pilot site for an early ditch remediation project in 2010. The project demonstrated the proof of concept that we can re-create peat in ditches by placing cut grass in them. The peat in these ditches has not recovered to the same elevation as the adjacent marsh, but *Spartina* is growing in most remediated ditches. A large sediment deposition event caused by a Nor'easter occurred in January 2018, with this site receiving extensive sediment deposits totaling 40 acres. Rough calculations estimated 10-years' worth of elevation gain within this one event. Despite the thickness of the deposit (25.6 $\pm$ 2.9 mm), the entire site was vegetated by August. Subsequent monitoring in 2022 indicated that the vegetation community has transitioned to a diverse mix representative of high marsh and the peat has developed porosity and an extensive root network like other marsh sites.

Photo 5-1 Sediment deposited by Nor'easter Grayson at Parker River NWR, January 2018. Credit: Greg Moore.

Grape Island and Stage Island Marsh MU (543 acres)

Salt marsh

The Grape Island and Stage Island Marsh lie between the southern end of Bill Forward Pool and surrounds Stage Island drumlin (Figure 5-12). Plum Island Sound forms the western boundary, while the Refuge Road and associated upland forms the eastern boundary. Middle Ground, a 37-acre sandbar/marsh island within Plum Island Sound, is also part of this unit. Pine Creek, a large tidal creek, runs through the unit. Access to the marsh west of Pine Creek is challenging and is largely by boat. The north end of this unit abuts the Knobbs sand spit, and the south end of this unit surrounds the Stage Island drumlin. Both these areas are higher in elevation and support nesting Saltmarsh Sparrows.

Figure 5-12 Parker River NWR management units: Grape Island and Stage Island Marshes.

McCue Marsh MU (56 acres)

Salt marsh

Also known as Waterfowl Hunt Area D, this marsh is located just south of the Rowley River in the Town of Ipswich (Figure 5-13). Large areas of this unit are low marsh that are flooded daily and dominated by tall form *Spartina alterniflora*. Access to this parcel is via boat only.

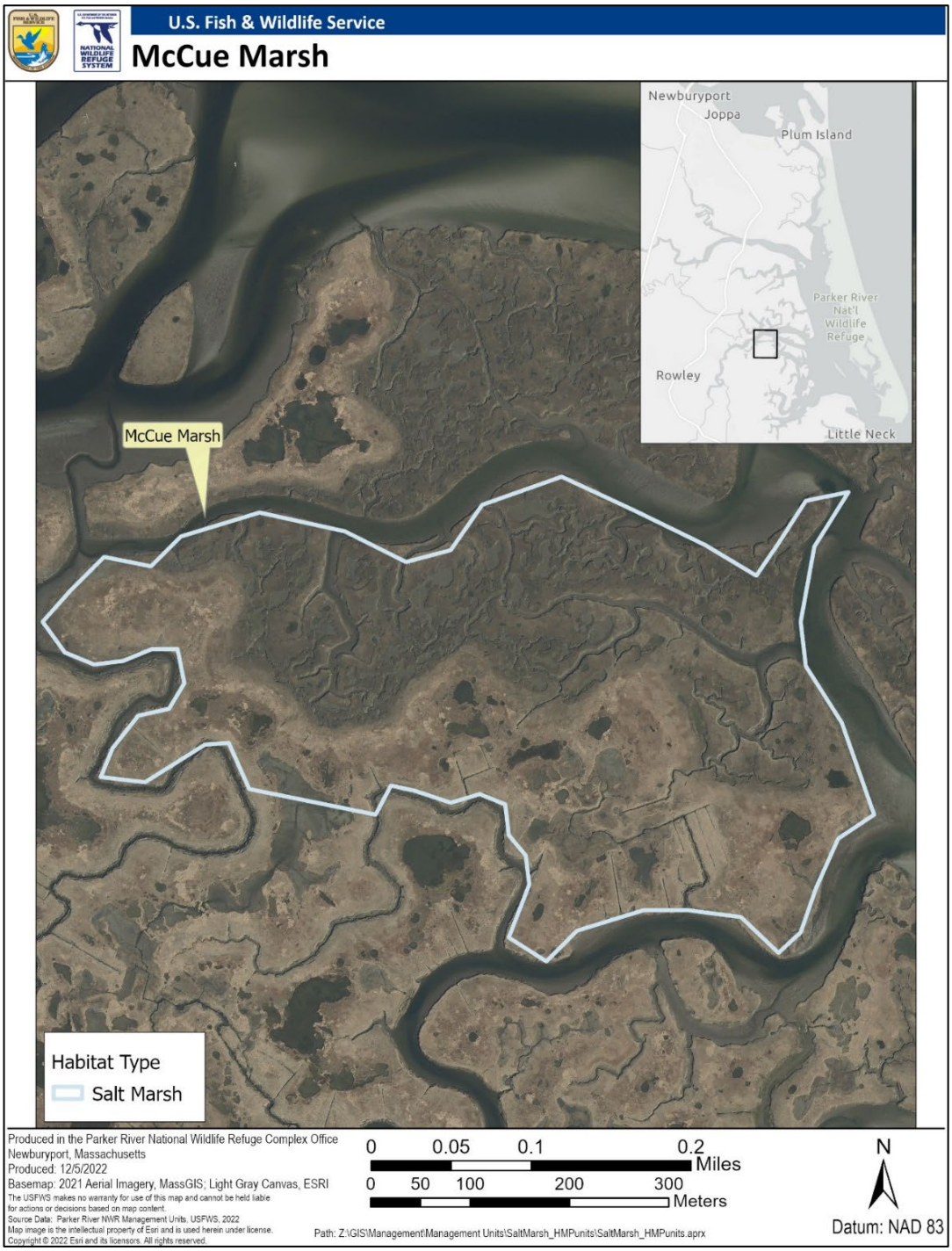

Figure 5-13 Parker River NWR management unit: McCue Marsh.

Strategies for Salt Marsh

Sustain natural processes

- Restore 8,000 acres of salt marsh in the Great Marsh, including 2,500 acres on the refuge, using hydrological restoration techniques piloted by refuge staff and Salt Marsh Restoration Team (SMARTeam).
- Monitor the restoration site, natural pool breaches, natural ditch remediation, and sediment deposition sites to understand how the marsh is responding to climate change with and without restoration intervention.
- Continue to fine tune restoration techniques, including determining the appropriate width and depth of runneling, identifying the best restoration techniques for different sites, and selecting the sites that need intervention.
- Restore impoundments to salt marsh (See Objective 2.2 Impoundments above).
- Work with engineers and transportation experts to allow for movement of water and sediment across the refuge road to accommodate eastward marsh migration.
- Assess potential for marsh migration on west side of the refuge, including establishing marsh migration transect per Tiner et al. (2014).
- Assess the potential for thin layer deposition as a strategy to increase accretion rates by continuing to monitor and evaluate natural deposition events.
- By 2030, work with US Army Corp of Engineers, regulators, and partners to pilot a thin layer deposition project to benefit salt marsh habitat and nesting species such as Saltmarsh Sparrows and Common Terns.
- Work with Regional Fire staff to understand role of fire in salt marsh, including benefits of fire and impacts to accretion rates and ability to capture sediment.
- Work with Parker-Ipswich-Essex Rivers Partnership, local towns, and conservation groups to protect and restore the Parker River Watershed and Plum Island Sound.
- Continue to read sediment elevation tables (SET) and feldspar horizon markers on a rotating basis. Analyze SET data to assess marsh accretion rates relative to sea level rise and impacts of plant species on accretion.
- Monitor extent, sediment elevation, sediment thickness, and revegetation of the natural 2018 sediment deposition event at the Impoundment Marsh MU by partnering with the University of New Hampshire. Monitor impacts of any similar events in the future.
- Use aerial imagery and LIDAR to document the timing, frequency, and pattern of pool breaches and sedimentation events.
- Support (e.g., access permission, funding, labor, etc.) partners implementing eelgrass restoration in Plum Island Sound and areas adjacent to the refuge.

Support migratory birds, ROC, and T&E species

Sustain bird populations

- Annually conduct point count surveys with an emphasis on Saltmarsh Sparrows; support similar surveys conducted by the Saltmarsh Habitat and Avian Research Program (SHARP 2023).
- Conduct Saltmarsh Sparrow rapid demographic surveys in accordance with SHARP protocols, contributing to regional monitoring and modeling efforts.

- Coordinate with SHARP and other regional partners regarding development of new Saltmarsh Sparrow restoration techniques.
- Continue to annually monitor Common Tern nesting colonies in Plum Island Sound as part of the State's annual colonial nesting bird survey.
- Redesign and implement a volunteer bird survey protocol to quantitatively assess waterbird and shorebird use, specifically at the salt pannes.

Minimize human disturbance

- Continue to review requests for public access to and use of the salt marsh and associated mudflats (e.g., clamming, research, aquaculture) to minimize potential human impact.
- Continue to collaborate with the Northeast Mosquito Control District to implement the minimum, least environmentally damaging strategies for nuisance mosquito control.

Restore and maintain BIDEH

- Partner with Mass Audubon and other partners to treat using hand-pulling and herbicides perennial pepperweed within the 28,000-acre Great Marsh, aiming for increased eradication from more marsh areas.
- Control *Phragmites* using herbicides to reduce expansion, while working to pilot innovative treatment that focuses on hydrology restoration as a long-term control method.
- Monitor erosion near the road immediately south of Lot 1 (Plum Island River Marsh MU).
- Continue to monitor and treat Japanese knotweed using chemical and mechanical means near Headquarters.

MANAGEMENT STRATEGIES – THATCHER ISLAND NWR

3.1 Rocky Intertidal Shore

- Habitat priority 2
- ROCs: Roseate Tern, American Oystercatcher
- Other benefitting species: Common and Arctic Terns; Common Eider
- No planned change in acreage
- One management unit: Rocky Shore MU (12 acres, Priority Tier 2, Figure 4-2)

Support migratory birds, ROC, and T&E species

- If deemed a regional priority, reestablish Common Tern colony on Thacher Island and adjacent Milk Island (owned by MassWildlife), in collaboration with MassWildlife and Mass Audubon.
- Continue to monitor nesting American Oystercatchers and Common Eiders.

3.2 Maritime Shrubland

- Habitat priority 2
- ROCs: New England Cottontail
- Other benefitting species: Willow Flycatcher; Eastern Kingbird; migrating songbirds
- No planned change in acreage
- One management unit: Maritime Shrubland MU (10 acres, Priority Tier 2, Figure 4-2)

Support migratory birds, ROC, and T&E species

- Work with New England Cottontail Working Group to assess Thacher Island as an island breeding colony.
- If deemed a priority, develop a reintroduction plan, including veterinarian care, disease protocols, and genetic diversity management plan. Reintroduce New England Cottontail from wild populations or from zoo-born rabbits.
- Work with Thacher Island Association to minimize trails that fragment Maritime shrub habitat. For needed trails, aim to have canopy cover over trails to reduce aerial predation of cottontails.

Restore and maintain BIDEH

- Conduct a biotic inventory of plants, insects, and birds.
- Map and assess need to treat invasive plants such as bush honeysuckle, rusty willow, glossy buckthorn, common barberry, purple loosestrife, and *Phragmites*.

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APPENDIX A. FIRE MANAGEMENT PLAN

Parker River and Thacher Island National Wildlife Refuges

Final Fire Management Plan

February 2024

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations.

Cover Page Photo: Prescribed burn in pitch pine forest in Concord, NH. NHFG photo

Signature Page

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Scott Kahan, Regional Chief NWRS Date

Table of Contents

1.0 INTRODUCTION, POLICY, AND LAND MANAGEMENT PLANNING

Parker River and Thacher Island National Wildlife Refuges (NWRs, Refuges) are located along the coast of northern Massachusetts, approximately 30 miles north of Boston. The 4,735-acre Parker River NWR is located within the City of Newburyport and the Towns of Newbury, Rowley, and Ipswich in Essex County. The main portion of the refuge occupies the southern three-fourths of Plum Island, a 9-mile-long barrier island that supports a rich diversity of coastal habitats such as salt marshes, sandy beach and dune grasslands, maritime shrubland and forest, interdunal swales, sandplain grasslands, pitch pine woodlands, tidal estuary, and rocky shores. Thacher Island NWR is located at the northern end of Thacher Island, a 50-acre island located one mile off the coast of Rockport. The refuge encompasses 22 acres of rocky intertidal shore and maritime shrubland ecosystems. The Town of Rockport owns the remaining 28 acres of the island, which is managed by the Thacher Island Town Committee and the Thacher Island Association as a historic site and tourist destination.

This Fire Management Plan (FMP) is written as a strategic plan for managing the wildland fire and prescribed fire programs of the refuges. This plan is written to meet U.S. Department of the Interior and U.S. Fish and Wildlife Service (Service) requirements that every area with burnable vegetation must have an approved FMP (620 DM 1.5). The goal of wildland fire management is to plan and make decisions that help accomplish the mission of the National Wildlife Refuge System, which 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 for the benefit of present and future generations of Americans (601 FW 1). This FMP follows and complies with national wildland fire management policy, including the US Fish and Wildlife Service (USFWS) wildland fire management policy found in the Fire Management Handbook, the Interagency Standards for Fire and Aviation (Red Book), as well as the National Cohesive Wildland Fire Management Strategy.

The Parker River and Thacher Island NWR Fire Management Plan provides for firefighter and public safety and includes strategies for managing wildland fire. This FMP integrates all wildland fire management and related activities within the context of an approved Habitat Management Plan (HMP). It defines a program to manage wildland fires, and to assure that wildland fire management goals and components are coordinated, and is consistent with Parker River and Thacher Island NWR resource management objectives and environmental laws and regulations such as the National Environmental Policy Act, the National and State Historic Preservation Acts, the Clean Air Act, etc. Included within this plan is all refuge lands except those surrounding Headquarters and Old Headquarters at Parker River NWR. As these locations are primarily developed and lie within urban settings, any fires originating on or near these properties will be handled through normal municipal extinguishing activities undertaken by the local fire departments. Prescribed Fire Plans will be written to provide details associated with that habitat management strategy.

1.1 Program Organization

While USFWS Region 5 (Northeast) has a smaller fire program compared to other regions due to dense development and less fire-adapted ecosystems, it still has a robust Fire Management Program that

assists with fire prevention and habitat management within the region while also supplying trained personnel to assist with fire suppression in other regions. Regional Fire Management staff, including the Fire Management Coordinator, work from the Regional Office, located in Hadley, Massachusetts. Parker River and Thacher Island NWRs are in the New England Fire Management Zone. The organizational structure includes a Zone Fire Management Officer (ZFMO), prescribed fire specialist, engine captain, and seasonal fire fighters located at Rachel Carson NWR. Currently, the Zone Fire Management Officer (ZFMO) position is vacant, but efforts are underway to fill this vacancy. The ZFMO is delegated the responsibility from the Complex Project Leader/Agency Administrator for management of all wildland fire and fire related aviation operations on refuges and National Fish Hatcheries within the zone. There are no fire management-funded staff at either refuge in this plan.

Partners

Parker River and Thacher Island NWRs participate in multiple partnerships related to fire management with local and regional federal, state, and local agencies and departments. These municipalities are the primary responders for wildland fires occurring on the refuges and their cooperation is vital to ensuring successful implementation of this FMP and protection of resources on the refuges. Upon completion of this FMP, fire and refuge staff will renew relationship with local fire departments and establish procedures and agreement for both wildfires and prescribed fires. The fire zone has agreements with all the states within region 5, the Northeastern Interagency Coordination Center, and is also a member of The Northeast Forrest Fire Protection Compact (NFFPC). These agreements allow for and facilitate the exchange and response of resources across all New England states as well as some Canadian Providences. These agreements are currently facilitated by regional fire management staff.

1.2 Environmental Compliance

This Fire Management Plan complies with the National Environmental Policy Act (NEPA) as it is incorporated into the Habitat Management Plan and Environmental Assessment (EA) of Alternatives for Parker River and Thacher Island NWRs. This FMP provides specific details of the fire program that meet fire management direction for the planning period, including organization, facilities, equipment, activities, timing, locations, training, and related costs. The plan will be reviewed annually. Adjustments will be made when appropriate, reflecting changes in the planning process.

This FMP implements the guiding principles of the “Redbook,” the Interagency Standards for Fire and Fire Aviation Operations, meets the direction in the National Strategy, The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy, adheres to DOI policy as stated in 620 DM 1, and fully applies procedures and guidelines in both the Service Fire Management Handbook (Handbook) and USFWS fire policy (621 FW 1).

Threatened and Endangered Species Compliance

This FMP will take appropriate action to identify, and protect from adverse effects, any rare, threatened, or endangered species. When addressing issues that affect or may affect endangered species, consultation on specific projects will be conducted prior to implementation to avoid any adverse impacts to these species and their habitat. An intra-Service review under Section 7 of the Endangered

Species Act is required. Effects to candidate species have been considered and are described in the HMP/Environmental Assessment.

Federally listed and proposed species known to occur on Parker River NWR include:

- Piping Plover (*Charadrius melodus*) – Threatened
- Red Knot (*Calidris canutus*) – Threatened
- Roseate Tern (*Sterna dougallii*) – Endangered
- Northern Long-eared Bat (*Myotis septentrionalis*) – Endangered
- Tricolored Bat (*Perimyotis subflavus*) – Proposed for Listing (Endangered)
- Monarch Butterfly (*Danaus plexippus*) – Candidate Species
- Salt Marsh Sparrow (*Ammospiza caudacuta*) – Under Review

There have been no listed species documented on Thacher Island NWR; although bats and Monarch butterflies likely use the Refuge, and Roseate Terns likely forage off-shore and may nest on the island in the future, if a tern colony is restored. Thacher Island is being considered for reintroduction of New England cottontail (NEC), a former Candidate species, as a captive rearing facility. If Thacher Island becomes a captive rearing facility for NEC, close coordination with the Captive Rearing working group will ensure no impact to rabbits from prescribed fire. There are also numerous species listed by National Marine Fisheries Service that inhabit the waters surrounding the refuges, but fire would not impact any of these species.

Cultural Resources Compliance
All FMP actions/decisions comply with Section 106 of the National Historic Preservation Act (NHPA), per the terms of the working agreement between the refuge and the State Historic Preservation Office. NHPA compliance will be conducted as needed on a case-by-case basis through submittal of a Request for Cultural Resource Compliance form to the Regional Archaeologist in Hadley, Massachusetts.

Tribal Consultation
Consultation with local tribes will be conducted on a project-by-project basis. Areas sensitive to the tribes are known, and during wildfire events, notification to the tribes will be made early if these areas are anticipated to be impacted.

Clean Air Act Compliance
Activities which discharge pollutants, including ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, and lead, are subject to, and must comply with, all applicable Federal, State, and local air pollution control requirements as specified in Section 118 of the Clean Air Act, as amended. Air quality for the area covered by this FMP is regulated by the State of Massachusetts Department of Environmental Protection. Please see Section 3.4 for more information regarding smoke management.

Clean Water Act Compliance
All FMP actions/decisions comply with regulations within the Clean Water Act. Erosion from wildland fires is considered a non-point source form of pollution by the federal Environmental Protection Agency. Recently burned areas can erode when heavy precipitation occurs. Additionally, fire retardant chemicals

and foams that may be used in wildland fire activities may pose a threat to water resources. This FMP will follow guidelines for use of fire retardants and foam identified in the Guidelines for Aerial Delivery of Retardant or Foam near Waterways, found at Policy for Aerial Delivery of Wildland Fire.

1.3 Resource Management Planning

This FMP is a step down of the (HMP), where overarching resource management strategies and objectives are delineated. The HMP specifies that prescribed fire will be used to achieve habitat objectives on several habitat types within the refuges, including maritime shrubland/forest, pitch pine forests, old fields, dune grasslands, sandplain grasslands, interdunal swales, impoundments, salt marshes, sandy beach, and rocky shore. The FMP will help to meet the goals and objectives detailed in the HMP. See Section 2.0 for a detailed listed of goals and objectives related to fire management.

Prior to application of prescribed fire, a prescribed fire plan is required. The FWS utilizes the NWCG Standards for Prescribed Fire Planning and Implementation guide (PMS 484), and subsequent NWCG Prescribed Fire Plan Template (PMS 484-1). A prescribed fire plan will detail planned fire for 5 years.

1.4 Collaborative Planning

The Wildland Fire Leadership Council (WFLC) adopted the following vision for the next century:

> *To extinguish fire safely and effectively, when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire.*

This FMP meets the direction in the National Strategy, The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy because it emphasizes the following primary goals identified as necessary to achieving the vision.

- **Restore and maintain landscapes:** Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.
- **Fire-adapted communities:** Human populations and infrastructure can withstand a wildfire without loss of life and property.
- **Wildfire response:** All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

Parker River and Thacher Island NWRs participate in multiple external partnerships related to fire management with adjacent federal, state, and local agencies and departments. See Section 3.1.2 (Coordination and Dispatching) for a list of refuge agreements, dispatch plans, and preparedness plans.

1.5 Communication and Education

The outreach goal is to enhance knowledge and understanding of wildfire management policies and fire effects through internal and external communication and education. Information about fire ecology, and the differences between prescribed fire and wildfire, will be incorporated into outreach programs and informal contacts, this includes with the local fire departments. Information and education are critical to increasing support for prescribed fires on the refuges.

2.0 Fire Management Goals and Objectives

The overall goal for fire management on Parker River and Thacher Island NWRs is to promote a program that provides for firefighter and public safety, reduces the occurrence of unplanned human-caused fires, and ensures appropriate suppression response capability to meet expected wildland fire complexity. All wildfires occurring on Thacher Island NWR will receive a full suppression response. Wildfires occurring on Parker River NWR will receive a management decision that incorporates a range of tactical responses or strategies ranging from monitoring (very limited actions) to full suppression, with a goal of minimizing resource damage, at least cost, but ensuring safety as the highest of all priorities. Whenever safely feasible, wildfires may not receive immediate suppression if they can be properly contained, and the continued burn will meet habitat management objectives detailed in the 2023 HMP. In addition, the use of prescribed fire as a tool for habitat management will be incorporated into planned activities at both refuges.

See the Fire Management Unit (2.3) section for a complete list of operational guidance, strategies, and constraints for all FMUs.

2.1 Goals

This FMP is a strategic plan that implements the goals and objectives identified within the Habitat Management Plan (HMP). Management goals included within the Parker River and Thacher Island NWR HMP are:

- **Goal 1. Front Barrier Ecosystems** – Protect, enhance, and restore the biological integrity, diversity, and environmental health of Parker River NWR's front barrier beach habitats to support native wildlife and plant communities, including species of conservation concern.
- **Goal 2. Back Barrier Ecosystems** – Protect, enhance, and restore the biological integrity, diversity, and environmental health of Parker River NWR's back barrier habitats to support native wildlife and plant communities, including species of conservation concern.
- **Goal 3. Rocky Shore and Shrubland** – Perpetuate the biological integrity and diversity of coastal habitat on Thacher Island to sustain native wildlife and plant communities, including species of conservation concern.

2.2 Objectives

All wildfires will receive a management decision that incorporates a range of tactical responses or strategies ranging from monitoring (very limited actions) to full suppression. Ensuring fire fighter and human safety is the highest priority in any fire response, with secondary goals of minimizing resource damage and operational costs. The use of prescribed fire and mechanical treatment as management tools to reduce hazardous fuels and to accomplish habitat management goals is explicitly listed in the HMP for Parker River and Thacher Island NWRs.

Specific fire management objectives are to:

- Promote a fire management program that incorporates the use of prescribed fire and mechanical treatment as management tools to reduce hazardous fuels and to accomplish habitat management goals.
- Protect life, property, and resources from wildland fires at costs commensurate with resource values at risk. This includes all administrative facilities, residences, buildings, equipment storage areas, and Refuge signs. Private lands adjacent to the refuge will be protected from fires originating on the refuge.
- Use appropriate suppression tactics and strategies that minimize long-term impacts of suppression actions.

Specific resource management objectives related to fire management include:

- Use prescribed fire to reintroduce historical fire regimes for fire dependent ecosystems to increase the system's health and resiliency.
- Use prescribed fire to manage invasive plant species, where applicable and appropriate.
- Incorporate prescribed fire as a tool for managing desired vegetation and habitat conditions.

2.3 Fire Management Units

Fire Management Units (FMU) at Parker River NWR have been delineated based on habitat type, like the objectives detailed in the 2023 HMP. Thacher Island NWR has a single FMU encompassing the full refuge. Prescribed fire units will be aligned to the Management Units (MUs) delineated within the 2023 HMP, with additional details provided within the Prescribed Fire Plans. FMUs includes:

1. FMU 1 – Parker River NWR Dune Grasslands
2. FMU 2 – Parker River NWR Maritime Forest/Shrubland and Pine Forests
3. FMU 3 – Parker River NWR Old Fields
4. FMU 4 – Parker River NWR Impoundments
5. FMU 5 – Parker River NWR Salt Marsh
6. FMU 6 – Thacher Island NWR

2.3.1 General FMU Considerations

2.3.1.1 Safety Considerations Across All FMUs

Primary safety considerations include employee accountability/evacuation, public safety/evacuation, and protection of onsite hazardous materials and sensitive facilities. The access and egress to the Plum Island portion of Parker River NWR is one way in and out and may be compromised, while access to Thacher Island NWR is by boat at a single, specialized boat launch or via helicopter at a designated helicopter pad. The following conditions help mitigate safety concerns:

- On-site safety zones, where there is no burnable vegetation, will be identified and communicated to employees.

- Natural features that may pose a safety concern will be identified and communicated to local responders.
    - Poison ivy is ubiquitous across both refuges and may pose a safety hazard to firefighters if touched or if the smoke from burning plants is inhaled.
    - Ticks are prevalent throughout both refuges.
    - Wetland habitat contains many ditches and uneven surfaces that make navigation difficult.
- Hazardous materials stored onsite will be properly signed and communicated to local responders and added to the operation maps annually when the Station Hazard Plan is updated.
- Annual safety reviews will be conducted with all refuge personnel to ensure emergency protocols are understood.

2.3.1.2 Strategies Across All FMUs

The following strategies will be employed:

- Aggressive suppression in the Wildland Urban Interface. Protect structures and other public values at risk immediately adjacent to the refuge.
- Suppression tactics will consider cost effectiveness, with the least effort when feasible, but safety is always the highest priority.
- A full range of initial suppression actions may be considered, including:
    - Control – Aggressive actions to fully suppress fire spread and put it out.
    - Contain – Moderate actions to establish a sound perimeter.
    - Confine – Use of natural barriers to limit fire spread to an area when there are no resource values at risk.
    - Monitor – Observation, limited suppression actions taken, if any. Take advantage of favorable weather conditions (rain events) to suppress fire and limit costs.
- Prescribed fire will be undertaken in accordance with annual work plans that include application of fire under carefully controlled conditions following the direction, environmental prescription, and limitations within an approved Prescribed Burn Plan to achieve management objectives.

2.3.1.3 Operational Constraints and Requirements Across All FMUs

The following operational constraints are required for the protection of sensitive resources:

- Mechanical control of fire will be allowed only along refuge boundaries and on established roadways, unless otherwise specified by the Refuge Manager. Mechanical control is defined as construction of a fire line using a bulldozer or other heavy equipment.
- Minimum Impact Suppression Tactics (MIST) will be used to the greatest extent practicable.
- No vehicular traffic or mechanical equipment is permitted in refuge tidal marshes, freshwater marshes (including interdunal swales), or mudflats. Use is permitted on the established sand trails and the refuge beach from September through March at Parker River NWR. All other off-road use will require approval from the Refuge Manager or designee for each incident and will be monitored to minimize potential adverse impacts to sensitive areas.

- Manual control of fire is allowed in all refuge areas and will be accomplished with methods such as standard hand tools (shovel, flapper, Pulaski, etc.), backpack water sprayers, engine hose lays, and chainsaws.
- Aerial ignition by drone and suppression efforts by helicopter, fixed wing aircraft, or drones may be utilized on the refuges. Water drops will be allowed in all refuge areas.
- In sensitive areas such as wetlands habitats, fire chemicals will be cautiously and conservatively used to protect structures and to reinforce fire lines within 20 feet from road edges. Fire-trol® retardant will not be used on refuge lands due to its cyanide component and toxicity to aquatic organisms. Silv-ex® and Phos-check® wildland fire foams will not be used on refuge lands since they are more toxic to aquatic organisms than other types of fire foams. Other foam suppressant chemicals may be used judiciously on refuge lands, primarily within the vicinity of Sub-Headquarters and the Visitor Contact Station/Gatehouse.
- Retardant use is prohibited within 300 feet of any water resource, including interdunal swales. There are very few places where retardant could be used on the refuges due to the ubiquitous surface water.
- Unburned snags will not be felled along fire lines, except where necessary to protect human life and property. When possible, the use of water or fire chemicals should be used to protect snags from burning.
- Prevent oil and fuel contamination by using spill pads and/or containment units.

The following operational constraints are required for the protection of cultural resources:

- MIST will be used whenever possible.
- Resource Advisors will inform fire suppression personnel of any areas with cultural resources. The Resource Advisor should contact the Regional Archaeologist for more detailed information.
- Foam use will be minimized in areas known to harbor surface artifacts.
- Mechanized equipment should not be used in areas of known cultural significance.
- The location of any “new” sites discovered as the result of fire management activities will be reported to the Regional Archaeologist.
- Rehabilitation plans will address cultural resources impacts and will be submitted to the Regional Archaeologist.

2.3.1.3 Fuels Management Across All FMUs

While wildland fires are uncommon within the Northeast, they do occur, and fuels management should always be a consideration to protect sensitive resources and structures. Hazard fuel management is not a necessary annual activity at Parker River and Thacher Island NWR, but should be monitored and undertaken, if necessary, especially considering changing climate conditions.

The objectives of hazard fuel reduction activities are:

- Reduce hazard risk to refuge structures and facilities from an approaching wildland fire.
- Reduce the risk of a fire spreading to the wildland from a fire originating in a refuge owned structure or facility.

- Reduce the risk of fire spreading to privately owned lands from refuge lands.
- Provide defensible space and safety to personnel at those facilities during a wildland fire.

2.3.2 FMU 1 Parker River NWR Dune Grassland

FMU 1 is 370 acres, primarily consisting of dune grasslands with isolated patches of short, salt-tolerant maritime shrubs and interdunal swales. The dune grassland community occurs on windswept dunes within the salt spray zone, just behind the primary dunes along the full length of the refuge. The salt spray and infrequent storms inhibit the growth of shrub species, so this habitat is dominated by grassland species such as beach grass, beach pea, seaside goldenrod, and beach heather. Populations of seabeach needlegrass (State threatened) are found in twelve different locations within this FMU.

Infrastructure within or adjacent to this FMU includes:

- Visitor Contact Station at Parking Lot 1.
- Gatehouse at the refuge entrance.
- Seven boardwalks located at each parking lot. Of these, viewing platforms are present at Lots 1, 4 (Hellcat), 5, and 7.

This infrastructure should be protected during all fire incidents. Heavy public use of this infrastructure and the adjacent beach should be noted and taken into consideration during all fire events.

2.3.2.1 Operational Strategies, Constraints, and Requirements

Operational strategies, constraints, and requirements for FMU 1 Parker River NWR Dune Grassland include:

- The substrate in this unit is primarily soft sand, thus off-road use of vehicles is limited to established sand trails to prevent negative impacts to the habitat and for firefighter safety. These trails are located at Parking Lot 1, Parking Lot 2, and the north lot at Sandy Point State Reservation. Each of these access points are gated and require a key to open.
- Off-road use on the beach is limited to September through March unless permission is granted by the Refuge Manager or designee.
- No mechanical control (fire line construction by bulldozer) is permitted within FMU 1 due to the sensitive nature of the habitat and cultural resource concerns.
- Retardant use is prohibited within 300 feet of any interdunal swales.
- Numerous historical and cultural resource locations are known throughout this unit and should be avoided to the greatest extent possible. No ground disturbance is permitted within the vicinity of these known resources.

2.3.3 FMU 2 Parker River NWR Forest and Shrubland

FMU 2 is 477 acres of maritime shrubland/forest of various successional stages as well as pitch pine/black pine forests. These forests and shrublands are dispersed throughout the refuge, although the main portion runs along either side of the main refuge road within the center of Plum Island. The dune grasslands lie to the east and the salt marsh lies to the west. There is also maritime shrubland/forest located on several drumlins including Stage Island (southern end of Plum Island), Grape Island (also on

the southern end of Plum Island and surrounded by salt marsh and Plum Island Sound), and Nelson Island (located within the western portion of the refuge, off Plum Island). Stage Island and Nelson Island have been reverting to maritime forest since 2014 and 2013, respectively. Small patches of forest are also present along the refuge's western boundary, adjacent to residential areas. Densities and heights vary, with short shrubs to the east where salt spray and sandy soil limits growth to more mature forests within the protected areas in the center of Plum Island or along the western boundary. There are also three old fields that are in varying levels of succession. Typical species within the maritime shrubland include bayberry, beach plum, black cherry, serviceberry, chokeberries, winterberry, arrowwood, eastern red cedar, and staghorn sumac. The maritime forest includes the addition of black oak, quaking aspen, sassafras, red maple, and black gum.

Within the forest/shrubland complex are pockets of native pitch pine and non-native Japanese black pine. These can range from the presence of scattered individuals within the surrounding shrublands to larger patches of an acre or more. The non-native black pines were planted on numerous occasions to stabilize the dunes following fires. Some patches have since spread and the species is now considered invasive with efforts being undertaken to control the species. Also intermingled within this FMU are pockets of interdunal swales and sandplain grasslands. The latter has historically benefited from natural fires that setback succession and allow the herbaceous plant communities to thrive.

Most of the infrastructure on the Refuge lies within or adjacent to this FMU. These include:

- Visitor Contact Station at Parking Lot 1.
- Gatehouse at the refuge entrance.
- Sub-headquarters containing two large maintenance/storage garages that contain heavy equipment, boats, fuel cans in flammable cabinets, along with various smaller maintenance equipment, tools, and biological equipment.
- Compostable toilet bathrooms at Sub-headquarters and Parking Lot 4 (Hellcat).
- Audubon Banding shed and refuge "boneyard" (lean-to storage of materials) across the road (east) from Sub-headquarters.
- Bill Forward bird blind.
- Pines Trail viewing platform.
- Viewing platform and observation tower at Stage Island.
- Five linear boardwalks that connect Parking Lots 1, 2, 3, 6, and 7 to the beach. Parking Lot 5 contains a linear boardwalk that ends in an observation platform overlooking the beach.
- The 0.61 miles of boardwalk within the Hellcat Area, primarily on the west side of the road, but with boardwalk and an observation platform on the east side of the road.

This infrastructure should be protected during all fire incidents. Heavy public use of this infrastructure should be noted and taken into consideration during all fire events.

2.3.3.1 Operational Strategies, Constraints, and Requirements

Operational strategies, constraints, and requirements for FMU 2 Parker River NWR Forest and Shrubland include:

- Vehicular use should remain on the main refuge road as much as possible. Use of other established trails is also permitted, including the North Pool/Bill Forward/Cross Dikes, Stage Island Trail, short access trails at the boneyard/banding station and the "Mosquito Gate" (approximately 0.4 miles north of Sub-HQ). Stage Island, the boneyard/banding station, and the Mosquito Gate are all gated and require a key to open.
- The established sand trails on the east side of the road allow for vehicular use but require special consideration due to the soft sand. These trails are located at Parking Lot 1, Parking Lot 2, and the north lot at Sandy Point State Reservation. Each of these access points are gated and require a key to open.
- Although the road to the Nelson Island drumlin has been abandoned, it may be utilized under emergency circumstances with permission from the Refuge Manager or designee. This road is gated and requires a key to open.
- All other off-road vehicular use is prohibited unless permission is granted by the Refuge Manager or designee.
- Retardant use is prohibited within 300 feet of any waterways, including interdunal swales.
- Aggressive suppression tactics should be taken along the western Refuge boundary within the Wildland Urban Interface to prevent spread to adjacent residential areas.
- Numerous historical and cultural resource locations are known throughout this unit and should be avoided to the greatest extent possible. No ground disturbance is permitted within the vicinity of these known resources.

2.3.4 FMU 3 Parker River NWR Old Fields

FMU 3 is 69 acres of old fields divided into five separate fields (Sub-HQ Field, Bill Forward Field, Cross Farm Field, North Pool/Bill Forward Dike, Stage Island Dike) along the Plum Island portion of the refuge. Many of these fields were heavily managed early in the refuge's history, but in recent decades management has been limited to annual mowing and some invasive plant control. Vegetation is a mix of grass and forbs with some woody stems, including poison ivy.

While infrastructure is limited in the vicinity of this FMU, the largest and most important infrastructure on the refuge (Sub-headquarters) is located adjacent to the Sub-headquarters Fields. All infrastructure within or adjacent to this FMU includes:

- Sub-headquarters containing two large maintenance/storage garages that contain heavy equipment, boats, fuel cans in flammable cabinets, along with various smaller maintenance equipment, outbuildings, tools, and biological equipment.
- Compostable toilet bathrooms at Sub-headquarters.
- Observation tower on the dike between North Pool and Bill Forward Pool.

This infrastructure should be protected during all fire incidents.

2.3.4.1 Operational Strategies, Constraints, and Requirements

Operational strategies, constraints, and requirements for FMU 3 Parker River NWR Old Fields include:

- Vehicular use is permitted along the North Pool/Bill Forward/Cross Dike and Stage Island Dike. The Stage Island Dike is gated and required a key to open.
- Use of vehicles within Sub-HQ, Bill Forward, and Cross Farm Fields requires Refuge Manager or Designee permission. The access to Cross Farm Field is gated but is not locked.
- Retardant use is prohibited within 300 feet of any waterways, including interdunal swales and the salt marsh.

2.3.5 FMU 4 Parker River NWR Impoundments

FMU 4 is 266 acres of human-made impoundments divided into three separate impoundments on the Plum Island portion of the Refuge: North Pool (114 acres), Bill Forward Pool (34 acres), Stage Island Pool (118 acres). Vegetation varies due to differing management regimes, with North Pool being primarily composed of dense cattail and *Phragmites* with substantial open water areas. Bill Forward and Stage Island also have dense areas of cattail and *Phragmites* along their upland edges, with their centers either consisting of open water or various short, herbaceous vegetation and/or mudflats during drawn down conditions. The water within the impoundments is brackish, with North Pool having lower salinity levels than the other two. As detailed in the HMP, restoration of these impoundments to salt marsh will be undertaken within the near future.

The only infrastructure present within the FMU, besides a water control structure for each impoundment, is a boardwalk with a viewing platform within the North Pool.

Infrastructure adjacent to this FMU includes:

- Bill Forward Bird Blind.
- Observation towers on the dike between North Pool and Bill Forward Pool and at Stage Island Pool.

This infrastructure should be protected during all fire incidents.

2.3.5.1 Operational Strategies, Constraints, and Requirements

Operational strategies, constraints, and requirements for FMU 4, Parker River NWR Impoundments, include:

- Vehicular use is permitted along the North Pool/Bill Forward/Cross Dike and Stage Island Dike. The Stage Island Dike is gated and requires a key to open.
- Tracked vehicles are permitted within the impoundments with Refuge Manager permission.
- Retardant use is prohibited within this unit.
- Utilization of the wetland habitat should be used to contain the fire to the greatest extent possible, minimizing ground disturbance as much as possible.

2.3.6 FMU 5 Parker River NWR Salt Marsh

FMU 5 includes the approximately 2,735 acres of salt marsh that comprises the majority of Parker River NWR. Although not all contiguous due to various rivers and creeks, it is the primary habitat found within the western side of the Refuge, both on and off Plum Island. It also includes a small (~ 9 acres) area of marsh located along Plum Island Turnpike, adjacent to the "Pink House". The Parker River NWR salt marsh is a mix of high marsh and low marsh with open pools and tidal creeks. Vegetation is dominated by halophytic grasses and forbs with marsh elder shrubs along the upland edges. No fire is proposed for salt marsh units due to concerns about loss of marsh elevation and releasing sequestered carbon. For fire to be considered in the units in the future, section 2.2.6.1 will guide fire operations.

There is no infrastructure within this FMU. Infrastructure adjacent to this FMU includes:

- The Pink House along Plum Island Turnpike.
- Sub-headquarters containing two large maintenance/storage garages that contain heavy equipment, boats, fuel cans in flammable cabinets, along with various smaller maintenance equipment, outbuildings, tools, and biological equipment.
- Pines Trail viewing platform.

These infrastructures should be protected during all fire incidents.

2.3.6.1 Operational Strategies, Constraints, and Requirements

Operational strategies, constraints, and requirements for FMU 5 Parker River NWR Salt Marsh include:

- Use of vehicles and retardant is prohibited within this unit. No ground disturbance is permitted.
- Vehicular use is permitted around the perimeter on existing roads and trails, including the Refuge Road and North Pool/Bill Forward/Stage Island dikes on Plum Island. Off Plum Island, vehicular use is permitted on public roads including Plum Island Turnpike, Pine Island Road, Old Pine Island Road, Cottage Road, Marsh Ave, Patmos Road, and Stackyard Road.
- Boat use is permitted within this unit. Be alerted to tides as many tidal creeks are only passable within 2 hours of high tide. Boat launches are within the following locations:
    - North end of the refuge, across from Parking Lot 1.
    - Town of Newbury: Route 1A, launching into the Parker River.
    - City of Newburyport: Cashman Park, launching into the Merrimack River
    - City of Newburyport: Joppa Park on Water Street, launching into the Merrimack River (ramp not paved below mean high tide).
    - Town of Ipswich: Eagle Hill Landing on Eagle Hill Road, launching into the Eagle Hill River (gravel ramp).
    - Town of Ipswich: Ipswich Town Landing on East Street, launching into the Ipswich River.

2.3.7 FMU 6 Thacher Island

FMU 6 covers the full 22 acres of Thacher Island NWR. The interior 10 acres are maritime shrubland consisting of winterberry, arrowwood, bayberry, staghorn sumac, black cherry, and other shrubs and

small trees. The outer 12 acres are rocky intertidal shore that consist of areas of bare rock with patches of various algae to sparsely vegetated rock covered by short, herbaceous plants.

Most of the infrastructure on Thacher Island lies off the Refuge, although the Refuge does contain one of the historic stone lighthouses in addition to a small wooden entryway structure. Adjacent to this FMU, on the town-owned portion of the island, there is substantial infrastructure. In 2001, Thacher Island and its structures were designated a National Historic Landmark. The structures covering the entire island include:

- Two, 123-ft granite lighthouses with associated wooden entryway structures and wooden boardwalks. The south tower also contains adjacent free-standing solar panels.
- Two historic lightkeeper's houses.
- The "whistle house" with associated wooden boardwalk.
- Maintenance barn in the center of the island.
- Boat house and boat ramp and nearby storage shed.
- Wooden helicopter pad.
- Picnic pavilion with adjacent large bank of solar panels
- Historic wooden rail system that connects the boat house to the keeper's houses and the maintenance barn.

This infrastructure should be protected during all fire incidents.

2.3.7.1 Operational Strategies, Constraints, and Requirements

Operational strategies, constraints, and requirements for FMU 6 Thacher Island NWR include:

- Access to Thacher Island is via boat only. The boat ramp is specially designed to winch up a flat bottom boat. The Thacher Island Association (TIA) maintains and operates two of these boats out of Rockport Harbor.
- TIA has UTVs on the island that can be utilized, but their access around the island is limited due to dense shrubs and the rocky shoreline.
- Both lighthouses have a walkway platform that can be used as look-out points.
- TIA shuttles small groups of public visitors on Wednesdays and Saturdays from June through August, along with volunteer work crews. Public visitors are also permitted via kayak any day of the week. A small number of volunteers live on the Island during the summer months.
- Retardant use is prohibited within 300 feet of any waterways.
- Aggressive suppression tactics should be taken within the vicinity of any infrastructure on the island.
- Numerous historical and cultural resource locations are known throughout this unit and should be avoided to the greatest extent possible. No ground disturbance is permitted within the vicinity of these known resources.

3.0 Wildland Fire Operation Guidance

3.1 Preparedness

Fire preparedness is the state of being ready to provide an appropriate response to wildland fires based on identified objectives. Preparedness is the result of activities that are planned and implemented prior to fire ignitions. Preparedness requires a continuous process of developing and maintaining firefighting infrastructure, predicting fire activity, implementing prevention activities, identifying values to be protected, hiring, training, equipping, pre-positioning, and deploying firefighters and equipment, evaluating performance, correcting deficiencies, and improving operations. All preparedness activities should be focused on developing fire operations capabilities and on performing successful fire operations. Preparedness should include interagency partner collaboration to address actions identified above. Preparedness can be referenced in detail in Chapter 10 of the Red Book and Chapter 10 of the USFWS Fire Management Handbook.

3.1.1 Qualifications and Training

USFWS personnel utilized in wildfire suppression activities must meet either:

- The fitness, training, and qualifications identified in the most recent version of NWCG Wildland Fire Qualifications System Guide PMS 310-1;
- The fitness, training, and qualifications identified in the most recent version of Federal Wildland Fire Qualifications Supplement to NWCG PMS 310-1; and
- Agency-specific qualifications found in the FWS Fire Management Handbook.

There may be occasions when unqualified USFWS personnel discover a wildfire. If a USFWS employee, volunteer, or contractor discovers a wildfire, the individual must report it to the appropriate authority. They must not try to suppress the fire unless they hold a current Incident Qualification Card. If the fire poses an imminent threat to human life, the employee may take action to protect life, but he/she may not engage in any other fire control activities (FWS Manual 621 FW1 1.14 B).

3.1.2 Coordination and Dispatching

Parker River and Thacher Island NWRs are dedicated to working cooperatively with neighboring units and agencies. While there are no formal agreements between the local fire departments and the refuges, the refuges maintain a cooperative relationship with these departments. The informal understanding is that if a wildfire were to occur on either of the refuges, the local fire departments would be the first units to respond without needing to gain permission from USFWS staff first. They have been asked to notify the refuge Law Enforcement Officer and/or Project Leader as soon as possible if they do respond to any incidents on the refuges. All local fire and police departments have the necessary entry codes and keys to access refuge facilities in the event of an emergency.

3.2 Management of Wildfires

All wildfires occurring on Thacher Island NWR will receive a full suppression response. Wildfires occurring on Parker River NWR will receive a management decision that incorporates a range of tactical responses or strategies ranging from monitoring (very limited actions) to full suppression. Ensuring fire

fighter and human safety is the highest of all priorities, with secondary goals of minimizing resource damage and operational costs. Whenever safely feasible, wildfires may not receive immediate suppression if they can be properly contained, and the continued burn will meet habitat management objectives detailed in the 2023 HMP. When immediate control is necessary, the Incident Commander (IC) will consider a full range of suppression tactics when responding to wildfires. There may be occasions when direct attack on high intensity, rapidly spreading wildfire could jeopardize firefighter safety and be inappropriate. In these cases, indirect attack will be accomplished by utilizing natural and human-made barriers to halt the fire spread and keep soil disturbance to a minimum. Typical barriers include roads, water, and bare sand.

Suppression Actions include:

- Whenever possible, suppression activities will be limited to existing roads, including administrative trails, to minimize environmental damage and the spread of noxious and invasive plants.
- Maximize the use of wet lines to create fire breaks and minimize ground disturbance.
- To the extent possible, ground disturbed by suppression activities will be repaired to pre-incident condition.
- Limit off-road vehicle travel and wash undercarriages of vehicles that access off-road areas to limit spread of noxious weeds.
- The use of retardant, dozer or plow lines will not be permitted on USFWS lands except to protect life or improvements such as buildings or bridges, and only with the approval of the Project Leader or his/her acting.

3.3 Post Fire Response- BAER/ES/BAR

Repairing the impacts of suppression activities (such as repairing cut fences, rehabilitating containment lines, damage due to suppression operation, etc.) is the responsibility of the Incident Commander (IC) and funded by the wildfire account. This work should be completed by the incident management team prior to the final demobilization of the suppression forces whenever practical. However, it may be more cost-effective and practical to delay some repairs to improve the chance of success. It is the responsibility of the Agency Administrator to ensure suppression activity damage repair.

The IC will be responsible for mop-up and rehabilitation actions on FWS fires. Rehabilitation of suppression actions will take place prior to firefighters being released from the fire. Tasks to complete include:

- All trash will be removed.
- Fire lines will be restored to pre-suppression condition as soon as possible to preserve the living root stock and soil biome.

The USFWS is required to initiate Burned Area Emergency Response (BAER) that includes both Emergency Stabilization (ES) and Burned Area Rehabilitation (BAR) actions after a wildfire occurs, if deemed necessary by agency personnel, and planned actions are within ES and BAR policy. When

natural recovery post-fire is not likely, ES treatments may be needed to prevent and/or reduce: 1) further degradation of cultural and natural resources in the burned area; 2) downstream impacts from erosion, and 3) invasion of undesirable species. BAER uses emergency appropriations and activities must be completed within one year from the date of fire containment. As delegated by the Agency Administrator, an IC may initiate BAER actions before the fire is demobilized. BAR actions are rehabilitation treatments that can occur up to three years post-fire. For a better description of this policy, please see the Interagency Burned Area Emergency Response and Interagency Burned Area Rehabilitation guidebooks, as well as the Departmental Manual 620 DM 3. Supplemental policy can be found in the Service Manual 095 FW 3.9 with Service-specific policy guidance and programmatic procedures provided in the USFWS Fire Management Handbook - Chapter 11.

3.4 Air Quality/Smoke Management

Refuges must comply with National and State regulations concerning air pollution. To do this, they must take aggressive action to manage smoke from both prescribed burns and wildfires to minimize impacts and maintain air quality. Smoke management is especially important at Parker River NWR because of the proximity of homes on the northern and western boundaries. As much as possible, prescribed fires will be set at times when winds will carry smoke out to sea.

Specific guidance pertaining to smoke management is addressed in detail within each prescribed fire plan.

Federal Smoke Regulations

The most important Federal regulations concerning smoke management on refuges is the Clean Air Act (42 USC (USO) 7401). The specific areas of concern to fire managers are Non-Attainment Areas (NAA) and Class 1 Areas. There are no NAA or Class 1 areas within Essex County, Massachusetts nor nearby Rockingham County, New Hampshire.

State Smoke Management Requirements

Combustion of fuels during prescribed fire operations may temporarily impact air quality, but the impacts are mitigated by small burn unit size and distance from population centers. Refuge and fire staff will work with neighboring agencies and in consultation with State air quality personnel to address smoke issues that require additional mitigation. The Massachusetts Department of Environmental Protection (MassDEP) requires a permit for all prescribed burns which incorporates air quality regulations as a condition of the permit.

3.5 Data Sources, Reports and Systems

The following reporting systems are used for Parker River NWR's Fire Management Program:

- Fire Reports: The USFWS' Guide to Using the Fire Management Information System (FMIS) provides policy and guidance on completing the Individual Fire Report into the Service-owned FMIS, for both unplanned ignitions, as well as any other fire management activity, including prescribed fire, hazardous fuels, and other habitat restoration treatments. The Individual Fire

Report is required to be completed and entered within FMIS within 15 days of a fire being declared out.

- Wildfire Decision Documentation: The USFWS requires documentation of wildfire decisions. Systems and/or methods for this documentation are outlined in the annual updated Interagency Standards for Fire and Fire Aviation Operations (Red Book).
- GIS Data Standards: Location and timing of fire activities will be recorded in Refuge GIS databases, as well as Regional Monitoring and Management layer. The Refuge and the Regional fire program will coordinate with the National Wildfire Coordinating Group Data Standards and Terminology Subcommittee, which develops, approves, and maintains data standards for interagency wildland fire management activities (found in PMS 910).
- ES/BAR Project Planning: Direction for USFWS ES/BAR project planning, budgeting, and accomplishment reporting is provided by the Regional Fire Ecologist, based out of Hadley, Massachusetts.
- Monitoring: All prescribed fire should have explicit monitoring metrics to determine if habitat objectives are met and for any impacts. The Refuge will coordinate with regional fire program to make sure these are in place prior to implementing any prescribed fire (ideally at the development of the Prescribed Fire Plan).

4.0 Monitoring and Evaluation

4.1 Fire Management Plan Revisions, and Monitoring

Fire management plans (FMPs) are intended to be dynamic and reflect current situations and policies. Therefore, to maintain currency, U.S. Fish and Wildlife Service (USFWS) FMPs must be reviewed annually using the nationally established review process which applies the officially approved fire management review checklist. Any substantial update will require transitioning the FMP to the most recent template and obtaining new signatures on the front page of the FMP. The front page of the FMP should only be updated with new signatures and a new approval date when a full FMP update is completed; FMP maintenance does not require new signatures on the front page.

The prescribed burn plan is a step-down plan developed under the Fire Management Plan that lays out planned fires to meet goals and objectives described in the Habitat Management Plan. Prescribed fire plans are typically written for 5 years and reviewed annually to ensure compliance with current policy and management direction. In addition to documenting the location and timing of any fires on the Refuge as described in Section 3.5 above, we will monitor habitat response to determine if: (1) fire had desired effect as anticipated in the Habitat Management Plan; (2) have any negative impacts to ecosystem. These monitoring protocols will be developed as part of the Refuge Inventory and Monitoring Program prior to initiating any prescribed fire.

4.2 Science, Climate Change

This FMP is directly associated with a NEPA-based Habitat Management Plan. Climate Change is centrally featured in the Parker River Habitat Management Plan, and management strategies, including the decision to restore fire to the landscape, are included to increase climate resiliency. See Chapter 2,

Climate and Climate Change for baseline conditions and how the Refuge intends to address Climate Change. See Chapter 4, for how Climate Change affects each habitat type on the Refuge.

The Northeast Region's Division of Wildland Fire will follow National and Regional Service guidance on climate change and continue to base fire management decisions on guidance provided in Refuge Comprehensive Conservation Plans and associated step-down plans. Adaptive management will increasingly be more important to assess climate change effects on management activity outcomes. The refuge fire programs will continue to conduct fire effects monitoring and share information across jurisdictional boundaries. For more information on projected climate change on Parker River NWR, see the Habitat Management Plan, Chapter 2.

FINDING OF NO SIGNIFICANT IMPACT

ENVIRONMENTAL ASSESSMENT

for the

PARKER RIVER AND THACHER ISLAND NATIONAL WILDLIFE REFUGES
HABITAT MANAGEMENT PLAN
NEWBURYPORT, MASSACHUSETTS

The U.S. Fish and Wildlife Service (Service) is implementing the Habitat Management Plan (HMP) for Parker River and Thacher Island National Wildlife Refuges (NWR or refuge). The Service prepared the HMP, which includes an Environmental Assessment (EA) and a Fire Management Plan (FMP) as appendices, to strategically guide the next 15 years of habitat management activities planned for the 4,727-acre Parker River and 22-acre Thacher Island refuges. The HMP provides a long-term vision and specific guidance for refuge staff on managing priority species, habitats, and ecosystems at the two refuges.

SELECTED ACTION

Alternative B: Restoration, Ecosystem Health, and Climate Resilience

Under this alternative, the Service will implement the HMP to protect migratory birds and other resources of concern by restoring the barrier beach ecosystems and natural processes, coastal habitats, and associated native wildlife and plant communities on the Parker River and Thacher Island refuges. For migratory birds, we align our objectives with flyway scale regional strategies developed in collaboration with diverse partners. Collectively, we will implement strategic, adaptive landscape approaches that address the habitat needs of federally endangered or threatened species, as well as species of conservation concern due to small distributions, high threats, or declining populations. Conserving biological integrity, biodiversity and environmental health on the refuges builds resiliency and the capacity of wildlife (from common to rare) to adapt to climate changes and other stressors.

We incorporate prescribed fire as a tool for reintroducing natural disturbance regimes that have been largely eliminated in Northeast United States. Prescribed fire will be prioritized in fire-adapted habitats: pitch pine forests, sandplain grasslands, managed fields, maritime shrubs, and forests, and may be used in other habitats, as guided by the latest research and the 2023 FMP. When feasible, wildfires may not receive the most aggressive suppression actions if they can be more safely contained using natural breaks and existing trails and road.

Numerous environmental conditions have changed on these refuges since the last HMP was written in 2007. We have greater scientific knowledge of the impacts of these changes on our management priorities. Rising ambient and ocean temperatures, rising sea levels, increased frequency and intensity of storm surges, and other climate changes affect the adaptive capacity of coastal ecosystems (see discussion in Chapter 2 of the 2023 HMP). We are faced with the increasing challenge of managing the

three impoundments to meet biological objectives and a greater risk of catastrophic failure of the dikes during storm surges. Unprecedented acceleration of marsh conversion and marsh loss is occurring in the Great Marsh, including on Parker River NWR. Maintaining biological integrity, diversity, and environmental health on the refuges requires increased focus on restoring ecological function and managing invasive plants to ensure successful regeneration of native plant communities that support present and future wildlife. Uncertain future conditions require us to use the full range of management tools including prescribed fire and accepting and directing transformation of natural processes.

The HMP incorporates the Service's Resist, Accept, Direct Framework for addressing Climate Change. We largely 'accept' the transformation of ecosystem composition and structure as necessary for a sustainable, functioning ecosystem. In certain situations, we 'direct' the transformation of less sustainable habitats (grasslands, coastal impoundments) to more functioning coastal shrub and estuarine habitats. We 'resist' species extinction by prioritizing strategies that will increase populations of rare and vulnerable species, such as the piping plover and the saltmarsh sparrow.

OTHER ALTERNATIVES CONSIDERED AND ANALYZED

Continuing Current Management (No Action)

The No Action Alternative represents a continuation of existing management, guided by the 2007 HMP. For Parker River NWR, the highlights of the 2007 HMP included the maintenance of the three impoundments as brackish/freshwater habitats to support migrating shorebirds, breeding waterbirds, and migrating and breeding waterfowl; an emphasis on seasonal closures, predator control, and public education to protect breeding birds and sensitive areas; restoring salt marsh health through invasive plant control; and management units organized around habitat types. Prescribed fire was not a management tool in the 2007 HMP. For Thacher Island, the 2007 HMP focused on restoring a colony of Common and Roseate Terns.

This Alternative restores salt marshes at the existing scale of 10 to 100 acres every few years and maintains the three impoundments with the following management regimes, benefits, and consequences. At the current pace of restoration, it would take 25 to 40 years to complete restoration of all marshes needing restoration. We expect significant loss of marsh platform during that timeframe as the impaired hydrology causes inundation, vegetation die-back, and loss of marsh elevation. Such marsh degradation may require more expensive and intrusive restoration techniques, such as sediment placement, which would have greater impacts on all wetland functions and values. In addition, we added risk of catastrophic failure of the impoundment dikes based on the best available science.

The 'No Action' alternative was not selected because it would not address the rapid ecosystem transformation of the two refuges in response to climate change. As described under the Selected Action, environmental conditions have changed substantially since the 2007 HMP, and managing for static conditions or trying to retore historic conditions is not a sustainable strategy. The Selected Action builds on the 2007 HMP baseline conditions and strategies.

SUMMARY OF THE EFFECTS OF THE SELECTED ACTION

The Environmental Assessment compares the impacts of the two alternatives. Here, we highlight the major effects of the Selected Action (Restoration, Ecosystem Health, Climate Resilience):

Impoundment Decommissioning and Saltmarsh Restoration

A major difference between the 2007 HMP (current management) and the 2023 HMP (selected action) is our decision to decommission the three impoundments and restore them to salt marsh. The impoundments are not sustainable over time. Persistent problems in managing the impoundments include aging water control structures, eutrophication, silting of channels and ditches, subsidence, poor water quality, lack of fresh water, and invasive plants, which prevent us from achieving desired wildlife objectives. These issues are detailed in the 2007 HMP and in the North Pool Restoration Feasibility Study report (Louis Berger Group 2004), Chapter 4 in the 2023 HMP, and in the Environmental Assessment -- Affected Environment for Impoundment and Salt Marsh.

The risk of (unplanned) catastrophic failure of dikes during storm surges, ongoing maintenance issues, and our focus on restoring healthy and resilient habitats to address climate change prompted us to pursue restoring impounded areas back to the salt marshes they once were. Only the portion of the dike needed to restore tidal flow will be removed; removal of the remainder of the dike is not currently planned. As documented in the HMP and EA, studies begun in the early 2000s that assessed existing conditions and vegetation and the creation of hydrological models, deemed restoration of salt marsh in the breached impoundments to be feasible. A second model developed in 2018 provided additional details incorporating sea level rise.

The timing of our restoration aims to balance the benefits to bird use and wildlife observation opportunities with long-term sustainability and health of the ecosystem. We will update our restoration predictions and timeframe for North and Bill Forward Pools based on information learned from the Stage Island restoration as well as the latest climate science. We propose the restoration of the Stage Island impoundment from the current 1.5-meter opening to a 40-meter opening by 2027. By 2035, we propose restoration of the North Pool and Bill Forward Pools from their current 1.5-meter openings to 16 meters and 6 meters, respectively; although the exact timing may shift based on monitoring results of the tidal restoration at Stage Island and changing tidal and storm conditions. Transitioning the impoundments to healthy estuaries will restore ecological function, improve water quality, and improve the ability of the habitat to keep pace with sea level rise and adapt to future changes; thus, ensuring long term sustainability of these units. Most of the management issues associated with maintaining the water control structures, dikes, and vegetation management within the pools will be eliminated. The Service will actively pursue options (e.g., bridge, open bottom culverts) and funding to provide continued access to the Stage Island Trail post-restoration to salt marsh to support public use, habitat management, and maintenance.

Salt marsh restoration was not a significant component of the 2007 HMP; however, its importance has been identified since 2012. From 2012 to 2023, refuge staff have been working with partners to test nature-based restoration techniques to address historical hydrological alterations in the salt marsh, and

to restore the ability of the marsh to adapt to changing conditions. Success from these pilot projects has led to planning large-scale hydrological restoration throughout the Great Marsh.

Under the Selected Action, we will work with partners to restore 8,000 acres of salt marsh in the Great Marsh, including 2,500 acres on the refuge, using hydrological restoration techniques piloted by refuge staff and partners. By maintaining natural processes (e.g., total marsh extent, vegetation communities, vegetated and non-vegetated marsh, elevation relative to sea level rise, and migration) over time, we will support migratory birds (e.g., Saltmarsh Sparrow and American Black Duck), and maintain native biological diversity and ecological integrity of the back barrier ecosystem.

The Great Marsh is designated as a regionally important site for shorebirds in the Western Hampshire Shorebird Reserve Network, largely due to the extensive salt marsh, related estuarine habitat and its geographic location. Shorebirds will continue to stop in the Great Marsh including the refuge during migration, attracted by the diversity of healthy estuarine habitats, and the high density of invertebrates supported by tidal flooding. After breaching of the impoundment dikes, the tidal flats will receive regular flooding and ebbing on a daily and monthly cycle, bringing in nutrients that support robust invertebrate populations, a primary shorebird food source. As these flats transition to salt marsh over time, shorebirds will concentrate in flats adjacent to tidal creeks and salt pannes and pools that form in the marsh.

Other Refuge Habitats

Much of the other habitats on the Refuge (beach, dunes, maritime shrubs, sandplain grasslands) have maintained the natural processes that sustain them, allowing them to adapt to changing climatic conditions. Managing these habitats primarily includes allowing dynamic shifts in habitat conditions, reducing negative impacts from invasive plants, and monitoring to ensure continued resiliency.

For habitats that were historically modified by human use (grasslands, black pine forests), we are working to restore habitat composition, structure, and integrity as funding and staffing allows. The refuge will maintain 69 acres of grasslands to benefit nesting and migratory birds as well as pollinators. The Service allowed some previously maintained fields to revert to maritime shrubs where the soils were more suited to shrubby habitat and thus benefiting fruit-eating migratory birds.

We introduce prescribed fire as a tool to allow staff to better manage invasive plants, deter encroachment of other woody growth, and promote the regeneration of native plants in many of the refuge habitats including interdunal swales, sandplain grasslands, dune grasslands, and maritime shrublands and forests.

Threatened and Endangered Species and Species of Concern

The recovery goal for Piping Plover in the Selected Action is, over a 5-year period, an average of 30 nesting pairs producing an average of 40 fledglings annually. The refuge will rely on dynamic, natural processes of erosion and deposition to maintain habitat conditions for plovers and Least Terns. Nesting plovers are protected through predator control and by preventing human disturbance through seasonal closures, public education, and monitoring. A diversity of habitats (salt marsh, tidal flats, beach,

impoundments prior to tidal restoration) will continue to support migratory shorebirds, while the restoration proposed under salt marshes will expand quality foraging habitat for shorebirds. We will expand efforts to reduce human disturbance during migration through value-based messaging, particularly along the Refuge beach.

Removal of the impoundments will eliminate the freshwater/brackish wetlands and mudflats used by shorebirds, wading, and water birds; however, as documented in the EA, we anticipate that many shorebird and waterfowl species will continue to use the refuge's salt marshes, beaches, mudflats, and tidal creeks. Black Rails and American Bitterns use salt marshes, but other marsh and wading birds would likely seek other areas. King Rails have been documented breeding in salt marshes, but they are more closely associated with freshwater marshes. Accelerated marsh restoration on the refuge will contribute significantly to the Saltmarsh Sparrow population.

We seek to add Thacher Island as a captive rearing facility for New England Cottontails for augmenting the wild population on the mainland. Plans to reintroduce a tern nesting colony on Thacher Island will be deferred while we work on other priority objectives.

Visitor Use and Experiences and Local Community Benefits

Seasonal closures and other public access restrictions continue to be used to protect priority species, and sensitive habitats at Parker River NWR. Off-road vehicle use on the beach was discontinued in 2022. Refuge staff have been piloting value-based messaging to reduce wildlife disturbance, and we will likely expand those as well as consider additional access restrictions to ensure we meet recovery goals and to protect rare species.

Transitioning 266 acres from fresh to brackish marsh to salt marsh with the decommissioning of the three impoundments will change the birding experience at those sites. Currently they are popular locations for viewing waterfowl, wading birds, and shorebirds. Many of the same species will utilize the new salt marsh habitat, and the refuge will continue to provide viewing opportunities of these areas, however, visibility may decline over time as healthy salt marsh vegetation replaces mudflats and shallow water of impoundments. Current viewing infrastructure, including the observation towers and blinds, the marsh spur in North Pool, and the publicly accessible portions of the dikes, will provide good opportunities to view and interpret the habitat and wildlife transition.

While the shift from impoundment to salt marsh may shift some bird use in the impoundments, we do not anticipate a major changes in birdwatching opportunities. The transition of the impounded areas to tidal flow and salt marsh will provide unique opportunities to witness an ecosystem transition that will draw many different types of birds to the area over a period of 10 to 20 years. We anticipate that visitation will remain high or increase for the other popular activities, including beach-going, hiking, fishing, and participation in interpretive programs. Currently, visitation often exceeds parking capacity, resulting in many closures during the summer months. We expect this demand to increase in future years.

The accelerated marsh restoration and breaching of the impoundments to restore tidal flow will directly protect both marsh size and extent of the salt marsh system. Benefits to surrounding communities include: (1) Increased flood protection against storms by restoring resiliency to the marsh, (2) Increased carbon sequestration value of salt marsh as salt marshes are twice as effective as forests in sequestering carbon, (3) Increased socioeconomic health of communities and local tourism tied to fishing (striped bass), shell fishing (softshell and razor clams), recreation (birding, hiking, kayaking, beach use), and tourism industries, and (4) Increased resilience of several critical infrastructure components identified by local towns in the Great Marsh Coastal Adaptation Plan. The economic value of salt marshes has been estimated at $5 million per square kilometer.

CONSULTATION WITH PARTNERS

As part of the Comprehensive Conservation Planning started in 2010, we consulted with Massachusetts Department of Fish and Wildlife (MassWildlife) and Massachusetts Department of Conservation and Recreation (DCR), and representatives of those agencies served on the core planning team. When we shifted to completing the HMP, we continued to consult with MassWildlife on issues of concern to them. Specifically, we met several times on our plans for the management of the refuge's three impoundments, and the strategies and objectives in the Proposed Alternative reflect discussions with MassWildlife. Many of the biological management goals, objectives and strategies are developed in collaboration with other conservation organizations, stepping down from national and regional conservation strategies.

PUBLIC OUTREACH, REVIEW, AND COMMENTS

The HMP and EA were released for public review for 30 days (September 28 to October 28); advertised in the local paper, on our website, and in multiple Facebook postings. Copies of the HMP were made available through multiple venues, including online, hard copies at the Refuge, Town offices, and local libraries. We hosted two in-person information sessions on October 11, 2023, and at the request of some visitors, hosted a third virtual info session via Zoom on October 25, 2023. Fifteen people attended the two in-person sessions, 125 people joined the Zoom session, and 145 people submitted comments in writing.

In reviewing the written comments, 107 submittals were strongly opposed to breaching the impoundments. Thirteen people expressed support for the HMP, including the proposed actions on the impoundments, but some of these people were sorry that this decision had to be made. Most of the opposition to the impoundment proposal is due to the anticipated impacts it will have on existing bird use as well as associated birding opportunities.

A summary of the public comments and the Service responses are included here as an Appendix. In response to the overwhelming request to reconsider breaching the impoundments, staff consulted experts and literature again and considered the pros and cons of not restoring tidal flow in the impoundments. After careful analysis, we still believe the proactive transition of the impoundments to a functioning estuarine habitat is the best way to ensure sustainable, functioning habitat for the wildlife.

We have changed the term “restoring impoundments” to “restoring tidal flow” or “decommissioning the impoundments” to describe the planned restoration more clearly.

As many commenters noted, for many decades after the impoundments were created, the pools hosted large concentrations of birds that were easy to view and survey during this period; but it is increasingly more difficult to manage the impoundment water levels to achieve biological goals, and we have observed a decline in peak bird use over the years. More urgently, the increasing subsidence of the impoundments relative to the adjacent salt marsh and increasing storm activity presented significant risk of system failure if we continue with the status quo.

MITIGATION MEASURES

Measures to mitigate and/or minimize adverse effects have been incorporated into the selected action.

These are described below:

- We are actively pursuing funding for a foot bridge to enable continued pedestrian access to the Stage Island Trail post-restoration to support public use.

- The HMP proposes to phase decommissioning of the 3 impoundments, largely in consideration of the strong opinion previously expressed by the birding community about the value of the impoundment and loss of viewing opportunities. Phasing the restoration will allow us to understand bird and other wildlife response and the timeline for the transition of a freshwater impoundment to functioning salt marsh and allow the birding community to enjoy the current wildlife use in the other two impoundments longer. The timeframe for restoring the other impoundments is a placeholder and will be adjusted based on monitoring of the transition of Stage Island to estuarine habitat as well as the risk of breaching for the other two impoundments.

- We recognize that decommissioning the impoundment is difficult for many long-time Refuge visitors. The staff will share major milestones for the planning and implementation of restoring tidal flow to Stage Island with visitors; and will work with birders to document the shift in bird use during the habitat transition.

- Depending on the location of a prescribed fire, a portion of the refuge may be temporarily closed to public use for safety reasons. Refuge staff and the regional fire crews will work to minimize impacts to visitors as much as possible, but safety will take a higher priority over recreation.

DETERMINATION

Based upon a review and evaluation of the information contained in the Environmental Assessment as well as other documents and actions of record affiliated with this proposal, the Service has determined that the proposal to implement the Parker River and Thacher Island NWRs Habitat Management Plan will not have a significant effect on the quality of the human environment under the meaning of section 102 (2) (c) of the National Environmental Policy Act of 1969 (as amended). As such, an environmental impact statement is not required. The EA has been prepared in support of this finding and is available upon request to Parker River NWR.

The Service has decided to select the proposed action as described in the EA and implement the Parker River and Thacher Island NWR HMP and FMP effective immediately after the public is notified of this final determination. This action is consistent with applicable laws and policies.

SCOTT KAHAN

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Regional Chief
National Wildlife Refuge System

Date

Final Environmental Assessment
Parker River and Thacher Island NWRs
Habitat Management Plan

February 2024

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations.

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INTRODUCTION

This Final Environmental Assessment (EA) evaluates the effects associated with this Proposed Action and complies with the National Environmental Policy Act (NEPA) in accordance with Council on Environmental Quality regulations (40 CFR 1500-1509) and Department of the Interior (43 CFR 46; 516 DM 8) and Service (550 FW 3) regulations and policies. NEPA requires examination of the effects of a proposed action on the natural and human environment.

PROPOSED ACTION

The U.S. Fish and Wildlife Service (Service, USFWS) is proposing to implement a Habitat Management Plan (HMP) that protects migratory birds and other resources of concern by restoring the barrier beach ecosystems and natural processes, coastal habitats, and associated native wildlife and plant communities on Parker River and Thacher Island National Wildlife Refuges (Refuges or NWRs). The HMP includes prescribed fire as a management tool to achieve biological and ecological objectives. The fire prescriptions will be incorporated into a Fire Management Plan (FMP) for Parker River and Thacher Island Refuges.

The draft Proposed Action may be modified depending on the comments received from the public and other agencies and organizations. The Service's Northeast Region Refuge Chief will decide which alternative will be implemented.

The analysis in this EA will inform the decision of whether a Finding of No Significant Impact (FONSI) can be reached. The FONSI will identify the alternative selected for implementation and the rationale behind the decision. If a FONSI cannot be reached, an Environmental Impact Statement (EIS) will be prepared.

BACKGROUND

National wildlife refuges are guided by the mission and goals of the National Wildlife Refuge System (NWRS), the purposes of an individual refuge, Service policy, and laws and international treaties. Relevant guidance includes the NWRS Administration Act of 1966, as amended by the NWRS Improvement Act of 1997 (Improvement Act), Refuge Recreation Act of 1962, and selected portions of the Code of Federal Regulations and Fish and Wildlife Service Manual.

Parker River NWR was established in 1942, under the authority of the Migratory Bird Conservation Act, "*… for use as an inviolate sanctuary, or for any other management purpose, for migratory birds*" (MBCA; 16 U.S.C. 715). In 1948, Presidential Proclamation 2817 closed 1,753 acres of tidal waters surrounding the refuge to pursuing, hunting, taking, capture, or killing of migratory birds, or attempting to take, capture, or kill migratory birds. In 1962, the Refuge Recreation Act expanded the purposes of Parker River NWR to include: "*…(1) incidental fish and wildlife-oriented recreation development, (2) the protection of natural resources, (3) the conservation of endangered species and threatened species…*" (16 U.S.C. 460k–460k-4).

Thacher Island NWR was established in 1972, when title to the northern 22 acres of the island was transferred from the U.S. Coast Guard to the Service for the area's "*…particular value in carrying out the National Migratory Bird Management Program*" (16 U.S.C. 667b-667d).

The mission of the NWRS, as outlined by the NWRS Improvement Act (16 U.S.C. 668dd et seq.), is: *"... to administer a national network of lands and waters for the conservation, management and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."*

We derive our statutory authority to conduct habitat management planning from the Improvement Act, 16 U.S.C. 668dd - 668ee. Section 4(a)(3) of the Improvement Act states: "*With respect to the System, it is the policy of the United States that -- (A) each refuge shall be managed, as a network of lands and waters, to fulfill the mission of the System, as well as the specific purposes for which that refuge was established ...*" Section 4 further states: "*In administering the System, the Secretary shall (B)* ensure that the biological integrity, diversity, and environmental health of the System are maintained for the benefit of present and future generations of Americans"; and –*"(N) monitor the status and trends of fish, wildlife, and plants in each refuge.*" The Improvement Act provides the Service with the authority to establish policies, regulations, and guidelines governing habitat management planning within the System. Habitat management planning is guided by Service policy, primarily 620 FW 1.

The US Fish and Wildlife Service is the primary Federal agency responsible to conserving wildlife species for present and future generations of Americans. For migratory birds, we largely achieve our mission by working with diverse partners on a flyway scale, to meet the breeding, migratory, and wintering habitat needs of all birds throughout their life cycle. Through the Joint Ventures programs, the Service works with partners to develop and implement strategic, adaptive, collaborative approaches that address habitat requirements of birds at landscape scales to keep common birds common. We address the needs of species that are federally listed as endangered or threatened, as well as species that are of conservation concern due to small distributions, high threats, or declining populations through the Resources of Concern identified in Chapter 3 of HMP. Conserving biological integrity, biodiversity and environmental health builds resiliency and the capacity of wildlife to adapt to climate changes and other stressors.

Purpose and Need for the Proposed Action

The purpose of the Proposed Action is to implement the 2023 HMP, which provides a long-term vision and specific guidance on managing priority species and their habitats, and ecosystems at the 4,737-acre Parker River and 22-acre Thacher Island National Wildlife Refuges. The Service is proposing to use prescribed fire as a management tool as well as continue to manage unplanned wildfires, both of which are addressed in the 2023 FMP, which is an update to the 2005 FMP.

The need for the Proposed Action is to fulfill the refuge purposes of managing a sanctuary for migratory birds, to maintain the biological integrity, diversity, and environmental health (BIDEH) of the Refuge System, and to meet other Service priorities and mandates. The 2007 HMP for Parker River and Thacher Island Refuges provided the baseline of information and initial sets of broad goals, specific objectives, and prescriptive strategies for protecting resources, managing habitats, maintaining BIDEH, and identifying conflicting habitat management needs on these two refuges (USFWS 2007).

For Parker River NWR, the highlights of the 2007 HMP included the maintenance of the three impoundments as brackish/freshwater habitats to support migrating shorebirds, breeding waterbirds, and migrating and breeding waterfowl; an emphasis on seasonal closures, predator control, and public education to protect breeding birds and sensitive areas; restoring salt marsh health through invasive plant control; and management units organized around habitat types. Prescribed fire was not a management tool in the 2007 HMP. For Thacher Island, the 2007 HMP focused on restoring a colony of Common and Roseate Terns.

Numerous environmental conditions have changed on these refuges since 2007, and we have greater scientific knowledge of the impacts of these changes on our management priorities. Rising ambient and ocean temperatures, rising sea levels, increased frequency and intensity of storm surges, and other climate changes affect the adaptive capacity of coastal ecosystems (see discussion in Chapter 2 of the 2023 HMP). We are faced with the increasing challenge of managing the three impoundments to meet biological objectives and a greater risk of catastrophic failure of the dikes during storm surges. Unprecedented acceleration of marsh conversion and marsh loss is occurring in the Great Marsh, including on Parker River NWR. Maintaining biological integrity, diversity, and environmental health on the refuges requires increased focus on restoring ecological function and managing invasive plants to ensure successful regeneration of native plant communities that support present and future wildlife. Uncertain future conditions require us to use the full range of management tools including prescribed fire and natural processes. The goals, objectives, and strategies in the 2023 HMP reflect these conditions.

ALTERNATIVES

This EA evaluates two alternatives:

- Alternative A: No Action Alternative—Continue Current Management
- Alternative B: Proposed Action Alternative—Restoration, Ecosystem Health, Climate Resilience

ALTERNATIVE A: CONTINUE CURRENT MANAGEMENT (NO ACTION)

The No Action Alternative is carried forward in this EA in accordance with 40 CFR 1502.14(d) to represent the environmental baseline against which to compare the impacts of the Proposed Action. The No Action Alternative represents a continuation of existing management. Current wildlife and habitat management programs focus on Piping Plovers; Saltmarsh Sparrows and other salt marsh nesting birds; management and restoration of salt marsh and maritime shrub habitat; managing and maintaining impoundments for waterfowl, shorebirds, and marsh and wading birds; and limited habitat restoration. Prescribed fire is not used as a habitat management tool. In the event of wildfires, fire suppression occurs with the help of local fire crews. Native vegetation is promoted through the control of invasive plants using a range of mechanical, biological, and chemical methods.

As stated in the 2007 HMP, the primary purpose of the Parker River NWR is to preserve and manage habitat for a diversity of species, particularly migratory birds and wintering American black ducks. The management focus on Thacher Island is on tern restoration, specifically to restore a colony of Common and Roseate Terns by creating gull-free zones on the refuge portion of the Island, removing predators, and providing optimal breeding habitat in an area not susceptible to storm surges. The refuge has

conducted some gull control efforts and bird surveys, but no tern restoration efforts yet due to staffing constraints.

Under this Alternative, the refuge would continue to manage according to the objectives and strategies as described in the 2007 HMP, under the following three broad goals:

GOAL 1. Perpetuate the biological integrity and diversity of coastal habitats to sustain native wildlife and plant communities, including species of conservation concern.

GOAL 2. Manage the refuge's modified habitats to mimic natural functions and support native wildlife and communities, including species of conservation concern. Where appropriate, restore the biological integrity and diversity of these habitats.

GOAL 3. Perpetuate the biological integrity and diversity of coastal habitat on Thacher Island to sustain native wildlife and plant communities, including species of conservation concern.

ALTERNATIVE B: RESTORATION, ECOSYSTEM HEALTH, CLIMATE RESILIENCE (PROPOSED ACTION ALTERNATIVE)

Under the Proposed Action, Service staff will work to achieve the objectives and implement the strategies in the 2023 HMP and 2023 FMP. This Proposed Action builds on the 2007 HMP baseline conditions and strategies and incorporates additional climate resiliency strategies as well as prescribed fire as a management tool.

The priorities for migratory birds and other wildlife are stepped down from national and regional planning efforts completed by the Service and partner organizations. Chapter 3 of the HMP outlines this prioritization process. The 2023 HMP is informed by several recent or ongoing refuge research and monitoring projects including ongoing inventory and monitoring of wildlife populations and habitats, native shrub restoration; regional bird and bat migration studies that highlight how Parker River fits into the larger conservation landscape; salt marsh restoration pilot studies; monitoring of how refuge habitats are adapting to climate change (beach erosion, storm surges, and marsh assessments); hydrodynamic modeling of refuge impoundments, salt marsh, and barrier beach habitats; and studies on how mercury and climate change is affecting Saltmarsh Sparrow populations, both locally and globally. These studies are described in more detail in Chapter 1 of the 2023 HMP.

In this Proposed Action, we emphasize maintaining the health of barrier ecosystems, restoring natural process where they have been altered (i.e. restoring hydrology to most salt marsh units and decommissioning the three impoundments), and protecting rare and endangered species. Collectively, these suites of strategies will enhance habitat for migratory birds throughout the Parker River and Thacher Island Refuges by allowing natural habitat to be resilient and adapt to future climate stressors. We consider and protect a broad suite of native plants and animals, as well as the habitats, ecosystems, and natural processes and functions that sustain them, with knowledge of the potential impacts of rising ambient and ocean temperatures, rising sea levels, more storm surges, and other climate changes. Eradicating and containing invasive plants is a strategy across all habitat types and is essential to maintaining BIDEH.

We will incorporate prescribed fire as a tool for reintroducing natural disturbance regimes that have been largely eliminated in Northeast US. Prescribed fire will be prioritized in fire-adapted habitats: pitch pine forests, sandplain grasslands, managed fields, maritime shrubs, and forests, and may be used in

other habitats, as guided by the latest research and the 2023 FMP. When safely feasible, wildfires may not receive immediate suppression if they can be properly contained, and the continued burn will meet habitat management objectives detailed in the 2023 HMP.

This Proposed Action will help the Service achieve the purpose and need described earlier.

Habitat Transition Under Proposed Action Alternative

To meet the Objectives described in Chapter 4 of the 2023 HMP, some habitats at Parker River NWR will transition to different habitat types over 15 years due to sea level rise, forest and shrubland succession, or planned management actions.

Table 1 highlights the changes in habitat condition from 2007 to 2023, and what's proposed in the 2023 HMP. The habitat acres are derived from Geographic Information System (GIS) calculations of the habitat map. Table 1 shows the acres used in the 2007 HMP with the correct acreage in parentheses, as some of the acreage was incorrect in the 2007 HMP. The refuge acquired 75 acres of salt marsh in 2011, increasing the total Parker River Refuge from 4,662 acres to 4,737 acres.

Table 1 Current and desired habitat types for Parker River and Thacher Island NWRS in the proposed action.

Objective	*Habitat Type*	*2007 HMP Acres*	*Current Acres (2023)*	*Desired Acres (2038)*	*Note on Change in Acres*
1.1	Sandy Beach, Rocky Shore	182	182	182	No change
1.2	Dune Grassland	540 (444)	444	444	No change
1.2	Sandplain Grassland	24	24	24	No change
1.2	Interdunal Swale	48	48	48	No change
1.3	Maritime Shrubland and Forest	333 (372)	440 (Gain of 68 acres)	440	Fields (see below) left to naturally succeed to shrubland
1.4	Dune Pine Forest	37	37	37	No change
2.1	Old Fields	130 (137)	69 (Loss of 68 acres)	69	Allowed North Pool (2008), Stage Island and Nelson Island (2012) fields to revert to shrub
2.2	Impoundments	266	266	0	Decommission all 3 impoundments
2.3	Salt Marsh	2,660	2,735	3,001	Acquired 75 acres in 2011. Gain 266 acres from decommissioning impoundments
NA	Tidal Flats	492	492	492	Areas above Mean low tide are included in refuge acres. Expect to shift over time.
NA	Total Parker River Acreage	4662	4737	4737	Acquired 75 acres in 2011
3.1	Thacher Island Rocky Intertidal Shore	12	12	12	No change
3.2	Thacher Island Maritime Shrubland	10	10	10	No change

Under the Proposed Action, the refuge staff would manage according to the goals, objectives, and strategies as described in the 2023 HMP, with key strategies that differ from the 2007 HMP summarized below:

Goal 1 – Parker River NWR Front Barrier Ecosystems: Protect, enhance, and restore the biological integrity, diversity, and environmental health of Parker River NWR's front barrier habitats to support native wildlife and plant communities, including species of conservation concern.

Sandy Beach and Rocky Shore

- Maintain over a 5-year period, an average of 30 nesting pairs of Piping Plovers producing an average of 40 fledglings annually.
- Maintain natural processes, such as natural erosion and deposition, and maintain specific habitat characteristics of the upper beach, wrack line, and primary dune to benefit nesting and migratory birds.
- Consider habitat enhancement strategies, such as reducing dune vegetation or creating blow out areas, only if necessary to meet plover recovery goals.
- Beach closures: No persons or dogs along 6 miles of plover and tern breeding habitat from April 1st until nesting is complete; no dogs and minimal foot traffic (<1 per hour) on 3.5 miles of refuge beach from early July to November 15th to protect migrating shorebirds. No use of public over-sand vehicles year-round and minimal use of refuge vehicles as needed for management purposes.
- Sandy Point State Reservation and local Towns conduct their own efforts to protect nesting plovers and terns.

Dune Grassland, Sandplain Grassland, and Interdunal Swales

- Recognize that sandplain grasslands and interdunal swales are embedded within maritime shrublands but are biologically closely associated with dune grasslands.
- Rely on natural or managed processes (storm surges, salt spray, wind, fire) over time to maintain ecological integrity and support rare species: Eastern Spadefoot Toad, rare Lepidoptera (Coastal Heathlands Cutworm, Sandplain Eucheana, Frosted Elfin), and rare plants.
- Reintroduce fire as a tool for creating disturbance and managing shrub encroachment in sandplain and dune grasslands.
- Assess human disturbance on rare plant populations.

Maritime Shrubland and Forest

- Maintain a minimum of 221 acres of maritime shrubland with >70% cover of fruit-bearing native shrubs with <25% tree canopy.
- Maintain a minimum of 218 acres of maritime forest with >70% native species composition.
- Rely on maritime processes (such as salt spray, winds, shifting sands, and fire) to sustain the habitat conditions. Where feasible and effective, prescribed fire will be used to enhance habitat.
- Priority species: Brown Thrasher, Eastern Towhee, Eastern Red Bat, migratory songbirds.

Dune Pine Forest

- Use natural and managed (prescribed fire) disturbances to maintain dune pine forest, with <70% canopy and mid-canopy closure and a native plant understory.
- Manage habitat to support breeding Eastern Whip-poor-will, rare Lepidoptera, and roost sites for Northern Long-eared Bat.

Goal 2 – Parker River NWR Back Barrier Ecosystems: Protect, enhance, and restore the biological integrity, diversity, and environmental health of Parker River NWR's back barrier habitats to support native wildlife and plant communities, including species of conservation concern.

Old Fields

- Manage 69 acres as old field (described as "grasslands" in the 2007 HMP): 60-80% dominated by grasses and forbs, 5-15% dominated by native shrubs, less than 5% dominated by native trees.
- Disturbances (mowing, prescribed fire) occur at least once a year to sustain habitat conditions.
- Priority species: breeding Bobolink and Savannah Sparrow, pollinators including Monarch butterflies and native bees.

Impoundments

A major difference between the 2007 HMP and the 2023 HMP is the Proposed Action to decommission the three impoundments and restore them to salt marsh. The impoundments are not sustainable over time. Persistent problems in managing the impoundments include aging water control structures, eutrophication, silting of channels and ditches, subsidence, poor water quality, lack of fresh water, and invasive plants, preventing us from achieving desired wildlife objectives. These issues are detailed in the 2007 HMP and in the North Pool Restoration Feasibility Study report (Louis Berger Group 2004), Chapter 4 in the 2023 HMP, and Affected Environment for Impoundment and Salt Marsh (below). The risk of catastrophic (unplanned) failure of dikes during storm surges, ongoing maintenance issues, and the focus on restoring healthy and resilient habitat to address climate threats has prompted the Service to pursue the decommission of the impoundments and restore them to salt marsh. In all proposals, only the portion of the dike needed to restore tidal flow would be removed. The removal of the remainder of the dike is not currently planned. Studies begun in the early 2000s that assessed existing conditions and vegetation and the creation of hydrological models, deemed restoration feasible (Louis Berger Group 2004; Konisky 2004; USFWS 2007). A second hydrodynamic study, considering climate impacts, increased flooding, and ecosystem adaptation was conducted from 2015 to 2019 (Fitzgerald et al. 2017; Woods Hole Group 2018, 2019).

The timing of restoration aims to balance the benefits to bird use and wildlife observation opportunities with long-term sustainability and health of the ecosystem.

- Prior to breaching the dike of each impoundment, continue to manage as specified in Chapter 5 (management prescriptions) in the 2023 HMP.
- By 2027, restore Stage Island Pool to tidal estuary marsh by removing the existing water control structure, and restoring the historical tidal flow by restoring original creek dimensions (40 meters wide and original creek bottom elevation) as detailed in hydrodynamic section and

Proposed Action Alternative below. Implement monitoring protocols to gauge the response that may include initial elevation loss with conversion from fresh to saline system; sediment accretion; natural restoration of geomorphological features with the new tidal regime; and shifts in vegetation community after equilibrium has been reached and with continued sea level rise.

- By 2035, restore Bill Forward Pool to tidal estuary marsh by removing the existing water control structure, and restoring the historical tidal flow by restoring creek dimensions (6 meters wide and original creek bottom elevation) as detailed in hydrodynamic section and Proposed Action Alternative below
- By 2035, restore North Pool to tidal estuary marsh by removing the existing water control structure, and restoring the historical tidal flow by restoring original creek dimensions (16 meters wide and original creek bottom elevation) as detailed in hydrodynamic section and Proposed Action Alternative below.
- Update restoration predictions and timeframe for North and Bill Forward Pools based on information learned from Stage Island restoration as well as the latest climate science.
- Explore alternatives (e.g., bridge, open bottom culverts) to provide continued access to Stage Island Trail post-restoration to support public use, habitat management, and maintenance.

Salt Marsh

- Manage 2,735 acres of salt marsh (plus 266 acres to be restored after impoundment decommissioning) by maintaining natural processes (e.g., total marsh extent, vegetation communities, vegetated and non-vegetated marsh, elevation relative to sea level rise, and migration) over time, to support migratory birds (e.g., Saltmarsh Sparrow and American Black Duck), and to maintain native biological diversity and ecological integrity.
- Maintain at least 1,000 acres of suitable breeding habitat for Saltmarsh Sparrow, with at least 775 adults (median 5-year refuge-level abundance), with at least 45% annual nest success (i.e., at least one chick present before expected fledge date).
- Work with partners to restore 8,000 acres of salt marsh in the Great Marsh, including 2,500 acres on the refuge, using hydrological restoration techniques piloted by refuge staff and partners. Continue to adapt restoration techniques based on monitoring data on marsh response.

Goal 3 – Thacher Island NWR Rocky Shore and Shrubland: Perpetuate the biological integrity and diversity of coastal habitat on Thacher Island to sustain native wildlife and plant communities, including species of conservation concern.

Rocky Intertidal Shore and Maritime Shrubland

- By 2027, re-evaluate FWS resources and regional priority for reestablishing a Common Tern colony on Thacher Island.
- Work with Regional Captive Rearing Working Group and Thacher Island Association to reintroduce New England Cottontail to Thacher Island, if deemed suitable.
- Evaluate feasibility of prescribed fire to manage and maintain habitat conditions.

ALTERNATIVES CONSIDERED BUT DISMISSED FROM FURTHER CONSIDERATION

The following alternatives were considered but dismissed from further consideration.

- ***Keeping Impoundments in Perpetuity:*** The Service has been evaluating the pros and cons of maintaining or breaching the impoundments on the Parker River Refuge since 2000, and how to enhance the ecological health of the impoundments since the 1980s. As part of our comprehensive planning process and in response to resiliency planning for climate change, we considered the consequences of both keeping the impoundments and restoring them to tidal flow and salt marsh, addressed uncertainties through research and modeling, and consulted with Massachusetts Division of Fisheries and Wildlife (MassWildlife) on these issues related to the impoundments. The details of these assessments are further discussed under Environmental Consequences. The Service concluded that proactive restoration of these impoundments to tidal flow prior to catastrophic failure of the dikes is a responsible and prudent action, and thus keeping the impoundments in perpetuity was dismissed as an alternative. We expect many migratory birds currently using the impoundments will continue to use the site post tidal restoration, or will shift to refuge habitats including saltmarsh, mudflats, beach, and open water after decommissioning of the impoundments. Details are provided in Environmental Consequences for Wildlife Species.
- ***Maintaining all grasslands in 2007 HMP:*** The grassland units at Parker River were originally maintained for goose browse in the early days of refuge management. Most are small (11 to 26 acres) and do not support grassland nesting birds that require larger acres. Even with annual mowing, these grassland units contain degraded breeding conditions for Bobolinks and Savannah Sparrows, and the fields are increasingly dominated by shrub species and invasive plants. An assessment conducted in 2006 (Hoy 2006) found that the soils, hydrology, and plant assemblages in many of the Parker River Refuge's managed grasslands favor a restoration to maritime shrublands (a globally imperiled habitat that provides critical foraging habitat for forest and shrub birds during migration). An adaptive management study from 2008 to 2012 (Pau et al. 2012) found that restoring fields to maritime shrubland with native plant assemblages and ecological function for birds is feasible with less staff needed to maintain the habitat as maritime shrubland. With federal carbon-neutral targets and declining budgets, we decided to maintain three fields to provide wildlife viewing opportunities for the visiting public, while restoring the rest to Maritime Shrublands and Forests to reduce the need for management and chemical use. Stage Island, Nelson Island, and North Pool fields have transitioned to shrubland habitat since the 2007 HMP.
- ***Restore or Allow Natural Processes in All Natural Habitats***: Under this alternative, the Service would manage the refuge with an emphasis on restoring ecological processes and increasing resiliency to climate change. It reduces single-species management, instead managing habitats and ecosystems for suites of species, while assessing how the refuge contributes to regional and national priorities. With the uncertainty of climate predictions, restoring natural processes is an important strategy for managing the refuge; however, this alternative would restore all managed habitats (restore all grasslands to shrublands and immediately restore impoundments to salt marsh). It would de-emphasize managing listed species including Piping Plover, and imperiled species such as the Saltmarsh Sparrow. In future transition of salt marsh due to

climate change, techniques such as thin-layer deposition would be de-emphasized. This alternative does not allow us to meet our mandate to protect listed species, would hamper our ability to manage for wildlife observation, and may constrain our management strategies to meet future climate stressors.

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

Parker River and Thacher Island NWRs are located along the coast of northern Massachusetts, approximately 30 miles apart and approximately 40 miles north of Boston, MA. The 4,737-acre Parker River Refuge, located in the towns of Newbury, Rowley, Ipswich, and the city of Newburyport, occupies the southern three-fourths of Plum Island, a 9-mile-long barrier island, and hosts salt marshes, maritime dunes, maritime shrublands and forests, interdunal swales, sandplain grasslands, pitch pine woodlands, tidal estuary, beaches, rocky shores, and mudflats. Three impoundments and several old fields and grasslands are also present.

Thacher Island Refuge is located at the northern end of Thacher Island, a 50-acre island located one mile off the coast of the mainland portion of Rockport, Massachusetts. The refuge encompasses 22 acres of rocky intertidal shore and maritime shrubland ecosystems.

The Parker River and Thacher Island NWRs 2007 and 2023 HMPs (USFWS 2007, 2023) provide a comprehensive description of the landscape and geographic setting of Parker River and Thacher Island Refuges.

The following section analyzes the affected environment and environmental consequences of the two alternative actions on each affected resource, including direct and indirect effects.

IMPOUNDMENTS AND SALT MARSH

Impoundments and Salt Marsh–Affected Environment

Salt Marsh

Parker River NWR is within the 25,500-acre Great Marsh, a state-designated Area of Critical Environmental Concern (ACEC) (CZM 2000) and the largest contiguous salt marsh north of New Jersey. Salt marsh is the largest and most significant habitat type on the refuge, currently at 2,735 acres. The salt marsh and associated tidal flats are an important nursery for many fish species, providing prey fish for commercially important species. Parker River Refuge supports a relatively large population of Saltmarsh Sparrows, an obligate tidal marsh specialist and candidate species for federal listing, providing essential habitat for this species that has declined more than 87% since 1998 across its range (Hartley & Weldon 2020).

Salt marshes protect shorelines from erosion caused by strong wave dynamics and storm surges, provide areas for flood storage, filter water pollutants, and serve as nursery habitat for terrestrial and marine organisms (Greenberg et al. 2006). Flooding tides bring inorganic sediment to and promote vegetation growth in salt marshes (Langston et al. 2020; Morris et al. 2002); both critical for vertical marsh accretion. This ability of salt marshes to maintain dynamic equilibrium with sea level rise has maintained this ecosystem for the past 4,000 years.

The salt marshes and tidal flats of Plum Island Sound are experiencing increased inundation associated with sea level rise, storm-driven tides, and legacy alterations (see Historic Influences in Chapter 2, 2023 HMP). Evidence of agricultural alterations have been found on many salt marshes on the East Coast (Adamowicz et al. 2020; Smith 2023), and almost all marsh units at Parker River Refuge need restoration to be resilient to climate impacts. Details on historical alterations can be found in the HMP, under the following sections: Chapter 2, Affected Environment, Hydrology, Sea Level Rise & Storm Surge, and Chapter 4, Rationale for Objective 2.3 Salt Marsh.

Salt marsh restoration was not a significant component of the 2007 HMP; however, its importance has been identified since 2012. From 2012 to 2023, refuge staff have been working with partners to test nature-based restoration techniques to address historical hydrological alterations in the salt marsh, and to restore the ability of the marsh to adapt to changing conditions (Burdick et al. 2020; Pau et al. 2022). Success from these pilot projects has led to planning large-scale hydrological restoration throughout the Great Marsh. On Parker River Refuge we implemented the 100-acre marsh project in 2021 and 2022, using all the piloted restoration techniques to restore flood/ebb hydrology to the entire marsh (Pau 2021a).

For the purposes of the environmental consequences analysis, we are including all work from 2007 to 2022 under Current Management and future restorations under Proposed Action.

Impoundments

Three impoundments--North, Bill Forward, and Stage Island Pools--were constructed by refuge staff in the salt marsh in the 1940s and 1950s, by installing berms to provide waterfowl breeding habitat, especially for American Black Duck and Canada Goose. The impoundments were intensely managed for many years to benefit breeding waterfowl, with prescriptions including discing, plowing, mowing, flooding, seeding, planting, burning, herbicide application, and drawdown. Nationally, the focus for nesting waterfowl habitat has shifted to the prairie pothole regions of the U.S. and Canada; the Atlantic flyway, including refuge salt marsh and other estuarine habitats, continues to provide important migration and wintering habitat for waterfowl.

Accordingly, refuge impoundment objectives have shifted to managing for migratory shorebirds and waterfowl since the 1990s. In the late-2000s, we started managing North Pool for breeding marsh and wading birds due to its importance to the State of Massachusetts (USFWS 2007).

Persistent problems in managing the impoundments including aging water control structures, eutrophication, silting of channels and ditches, subsidence, poor water quality, lack of fresh water, and invasive plants, have prevented the refuge from achieving desired wildlife objectives.

In 2000, at the advice of the Great Marsh Restoration Team and a wetland management expert, Leigh Frederickson, the refuge initiated a study to explore tidal flow and salt marsh restoration alternatives for the North Pool. Through a partnership with the State's Wetland Restoration Program, Normandeau Associates was contracted to collect baseline ecological data, including elevation, tidal prism, salinity regime, vegetation, and wildlife use. Louis Berger Group Inc. (2004) were contracted to explore various restoration alternatives and to develop hydrological models to predict both tidal flow restoration feasibility and potential impacts to the adjacent Hellcat swamp. Finally, Konisky (2004) used the hydrological models, existing vegetative composition, and interspecific competition to predict the response of marsh vegetation to various restoration scenarios (USFWS 2007).

The restoration study found that the North Pool had subsided a foot since being impounded, and the existing water control structure allows little tidal exchange between the pool and surrounding marsh. The hydrological and vegetative models predicted that restoration is feasible. However, local birdwatchers and the MassWildlife Natural Heritage Program expressed opposition to restoration due to North Pool's importance to breeding marsh and wading birds. Ultimately, the Service put further restoration planning on hold until the Comprehensive Conservation Planning (CCP) process was completed.

When CCP planning started in 2010 (but was paused indefinitely), climate-related concerns, such as continued subsidence and a catastrophic breach of the dike, prompted the refuge to evaluate the long-term viability of all three impoundments. For more details, see the Impoundment Modeling and Restoration Reports (Woods Hole Group 2018, 2019).

Subsidence

All three impoundments have subsided significantly since the dikes were constructed: From 1950 to 2015, North Pool subsided 42 cm, Stage Island 49 cm, and Bill Forward 69 cm below the level of the salt marsh outside the pools (Fitzgerald et al. 2017; Normandeau Associates 2003) (Table 2). Subsidence in the impoundments is caused by the dike cutting off tidal flooding that brings sediment and flooding waters to build elevation and by the decomposition of existing peat associated with impoundment water level management (Portnoy & Giblin 1997). The relative subsidence of the impoundments is approximately 1 cm per year and is much higher than the marsh accretion rate of 0.28 cm per year, indicating that much of this subsidence can be attributed to compaction and decomposition associated with impoundment management.

Table 2 Comparison of impoundment and adjacent salt marsh elevations at Parker River NWR.

Impoundment	Average impoundment elevation	Range in impoundment elevation	Adjacent salt marsh elevation	Difference between impoundment and salt marsh elevation
North Pool	0.90 m	0.85-1.29 m	1.32 m	0.42 m
Bill Forward Pool	0.79 m	0.60-1.21 m	1.48 m	0.69 m
Stage Island Pool	0.63 m	0.33-1.24 m	1.12 m	0.49 m

Note: Based on RTK data collected in 2015 (FitzGerald et al. 2017).

Three Surface Elevation Tables (SETs) were installed within each impoundment in 2016, and have since been monitored annually, allowing us to collect detailed data on changes in elevation. Data from 2016 to 2020 indicate that elevation is being lost at a rate of 0.5 mm/year in Bill Forward Pool and 1 mm/year in Stage Island Pool (N. Pau, refuge files). While elevation in North Pool has increased over the past five years due to the high density of cattail growth, marker horizon data indicates that sub-surface subsidence is occurring at a rate of 1.88 mm/year (these rates are 6.04 mm/year and 7.29 mm/year in Bill Forward Pool and Stage Island Pool, respectively). These results indicate that the subsidence process is still ongoing in all three pools and will continue if the tidal hydrology remains restricted.

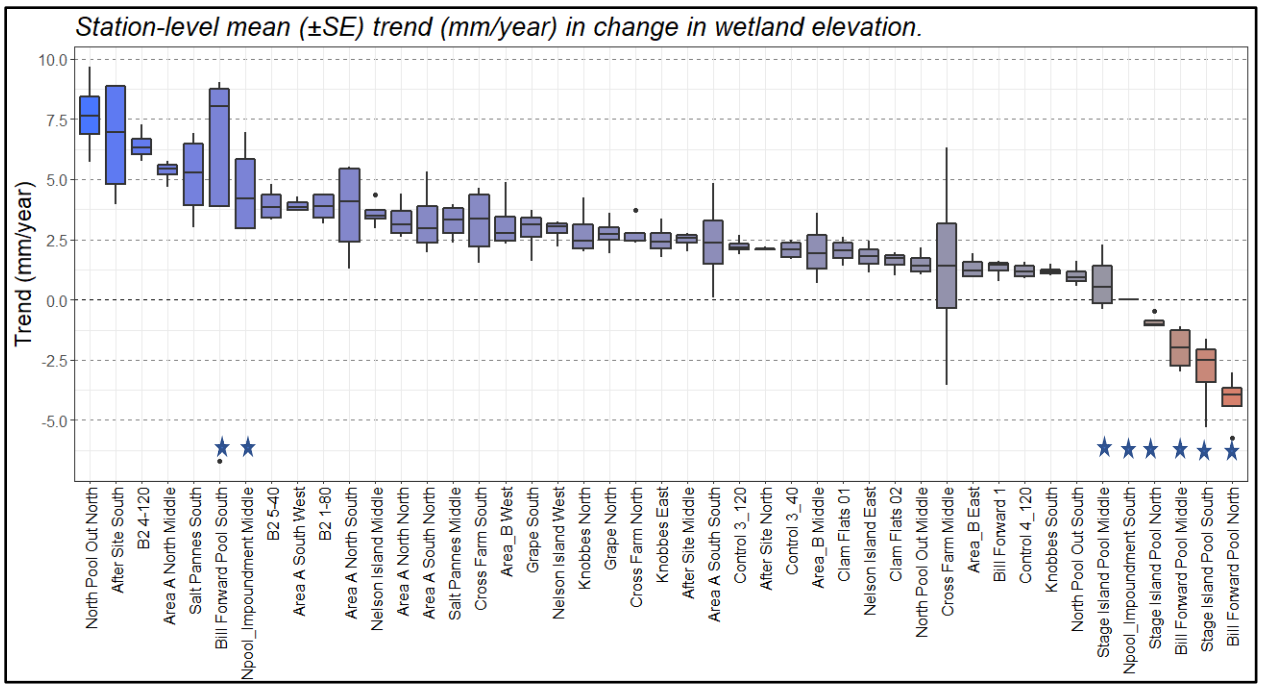

Figure 1 Elevation change data from 47 Sediment Elevation Tables at Parker River NWR indicate that the impoundments (indicated by stars) are subsiding at a rapid rate compared to salt marsh habitats (Stuntz, L. 2021, refuge files).

**Note: SETS in impoundments are denoted with stars. Notice that many of them are losing elevation compared to salt marsh sites.*

This elevation difference will likely increase in the next 15 years, as the accretion rate in the salt marsh accelerates in response to increasing sea level rise. As sea level accelerates and the impoundment marsh elevation subsides, there will be an increasing deficit in elevation, hindering the ability of the refuge to flood and draw down the impoundments to provide specific prescriptions for waterfowl and shorebirds.

This differential elevation rate in the impoundments, the outside marsh, and the tidal prism also affects the ability of the refuge to effectively manage impoundments in the future. Current water level management is tied to bathymetry surveys conducted in 2007 (Wurster & Hunt 2015). In the last five years, refuge staff have noticed that these prescriptions based on water gauges are no longer accurate due to increased tidal fluctuations and likely further subsidence. Instead, monitoring of water levels over mudflats, vegetation, and bird use are needed on a weekly basis to accurately provide optimal habitat for shorebirds and waterfowl. In Stage Island Pool, despite efforts to provide various mudflat and shallow water habitat, shorebird use has decreased greatly in the last decade, whereas similar declines are not observed in Bill Forward Impoundment, salt marsh, or on the beach. With continued subsidence of impoundment marsh platform and increasingly unpredictable tides, current management prescriptions, particularly drawdowns to provide for shallow water and mudflats, may become infeasible in future years.

Invasive species

Our inability to effectively manage water levels in the North Pool impoundment over the past 50 years resulted in a static water level regime for many years that led to the growth of monotypic, undesirable

plant communities, primarily invasive *Phragmites* and purple loosestrife. Despite various efforts to control invasive plants (e.g., mowing, burning, discing, flooding, chemical spraying, planting of desirable plants, and release of biological control agents for purple loosestrife) these plants remain abundant and are expanding. Both the USFWS and the State of Massachusetts are concerned over the increasing prevalence of *Phragmites* and the decrease in breeding marsh and wading bird use.

In response to concerns of habitat degradation in North Pool, the refuge investigated alternative management options in the 1990s, including securing a source of freshwater for water level management, installing a water control structure to Plum Island Sound for brackish marsh management, creating ditches to improve water circulation, and creating sub-impoundments within the North Pool. Most of these alternatives were found infeasible (USFWS 2007). A water control structure and circulation ditches were created to increase water circulation in the impoundment in the 1980s and 1990s; however, neither strategy significantly improved management capabilities nor anaerobic conditions in the impoundment.

Risk of catastrophic failure

With the increase in episodic weather events, the likelihood of catastrophic failure of the impoundment dikes also increases. We have observed more of these episodic events in the last decade, including Hurricanes Sandy and Irene, stronger Nor'easters, and unprecedented back barrier flooding and sediment transport. In January 2018, Nor'easter Grayson coincided with extreme high and low tides and freezing weather, resulting in flooding of refuge buildings and depositions of 15 years' worth of sediment on the marsh surface (Moore et al. 2019; Fitzgerald et al. 2020). The event caused tides to flood the top of the dike, depositing an ice chunk over 3 meters across on top of the dike and snail shells along the side of the dike (Pau 2018, pers. observation).

Temmerman and Kirwan (2015) found that engineered infrastructure — such as a dike — leads to long term increased erosion risk. An engineered dike does not provide protection to the impoundment, rather the salt marsh in front of the dike is protecting both the dike and the impoundment (Fagherazzi, pers. comm.), (USFWS 2019). Salt marshes greatly attenuate wave energy and storms, dissipating eroding forces that may reach the dikes (Shepard et al. 2011). The size and width of the salt marsh directly correlates to the vulnerability of an impoundment (Donatelli et al. 2020; USFWS 2019). Marsh erosion and size are in a positive feedback loop, wherein the marsh traps less sediment as its area decreases, resulting in insufficient accretion and further marsh loss (Donatelli et al. 2020).

Sergio Fagherazzi, professor of coastal geology and research with Plum Island Ecosystems LTER, predicts a high likelihood of breach for the North Pool dike if the bordering salt marsh (currently ranging between 200 and 450 meters) erodes to less than 50 meters in width (USFWS 2019). In assessing the marshes adjacent to North Pool and Bill Forward Pool dikes, he expressed alarm at the narrowness of the existing marsh and signs of bank erosion along the creeks that are extending to the dike. He observed that the flood waters during Winter Storm Grayson overtopped the dikes, as indicated by ice rafts and snail deposits. Such overtopping can lead to rapid dike failure. In the event of a dike breach, we anticipate extensive marsh plant dieback and rapid marsh peat decomposition and subsidence, as occurred at Prime Hook National Wildlife Refuge in Delaware (USFWS 2015). Such unplanned and extensive marsh loss would result in rapid elevation loss, leaving the refuge road vulnerable to storm forces.

Hydrodynamics modeling; alternatives and feasibility

Hydrodynamic models were developed to provide a range of alternatives for restoring tidal flow to the three impoundments (Fitzgerald et al. 2017; Woods Hole Group 2018, 2019). The models simulated replacing the water control structures with open channels to restore tidal hydrology and sedimentation. The simulations also assessed restored impoundment under sea level rise scenarios and modeled restoring immediately and waiting until 2050 to restore.

When the existing 1.5 meter water control structure is open at North Pool, the tidal range within the impoundment is only 19.5% of the range in Plum Island Sound (Woods Hole Group 2019). To increase tidal flow, WHG assessed four alternatives:

(1) removing the berm, using the material to fill part of the pool channel, and replacing the water control structure with a 10-meter-wide open channel

(2) removing the berm, using the material to fill part of the pool channel, and replacing the water control structure with a 25-meter-wide open channel

(3) replacing the water control structure with a 16-meter-wide open channel (comparable to the historic channel)

(4) replacing the water control structure with a 25-meter-wide open channel.

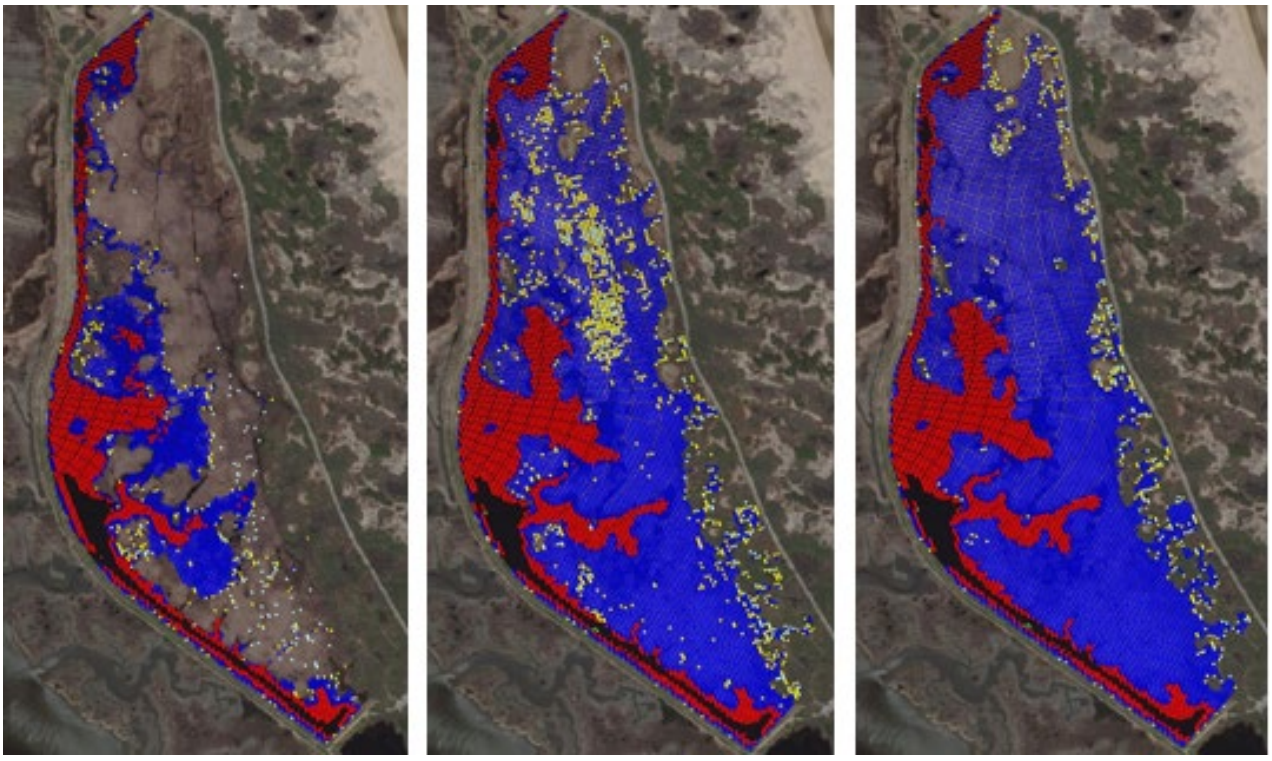

Figure 2 Three modelled images of North Pool showing 2050 vegetation under different restoration scenarios: current 1.5 m opening (left), restored immediately with 16 m opening (center), restored with 16 m opening in 2050 (right).

Note: Restored with a 16 m opening and assuming a 0.49 m sea level rise. Red indicates intertidal, blue indicates low marsh, and yellow indicates high marsh. This model indicates that restoring sooner would result in more high marsh habitat [hydrodynamic models by WHG (2018, 2019)].

While the model indicated that a 10 meter channel would still slightly restrict tides, the 16 meter opening showed negligible tidal restriction, and the 25 meter opening showed no significant improvement (Woods Hole Group 2019). Removing the berm did not change the tidal inundation. North Pool is much more likely to retain high marsh if restored immediately compared to restoration initiated in 2050 (Woods Hole Group 2019)(Figure 2).

The tidal range within Bill Forward Pool is only 10.1% of the range in Plum Island Sound when the existing 1.5-meter water control structure is open (Woods Hole Group 2019). Woods Hole Group considered two alternatives for Bill Forward Pool: replacing the water control structure with a 6-meter or 12-meter-wide open channel. WHG also considered a 6-meter opening with a lowered berm and an 18-meter opening but found these options offered no additional restoration benefits (Woods Hole Group 2019). The model indicated negligible tidal restriction with a 12-meter channel but slight restriction with a 6-meter channel (Woods Hole Group 2019). Bill Forward Pool will primarily become low marsh if restored (Woods Hole Group 2019),(Figure 5-7).

Stage Island Pool has only 12.5% of the tidal range in Plum Island Sound when the existing 1.5-meter water control structure is open (Woods Hole Group 2018). WHG assessed two alternatives for Stage Island Pool: converting the water control structure to a 5-meter-wide open channel and reinstating a 40-meter-wide channel in the location it historically existed (Woods Hole Group 2018). According to the model, only the 40-meter channel will restore full tidal hydrology to the impoundment. The 5-meter opening causes additional impounding of water as flood waters are not able to drain fully prior to the turning of the tide (Woods Hole Group 2018). Stage Island will be comprised mostly of low marsh with fringing high marsh if restored.

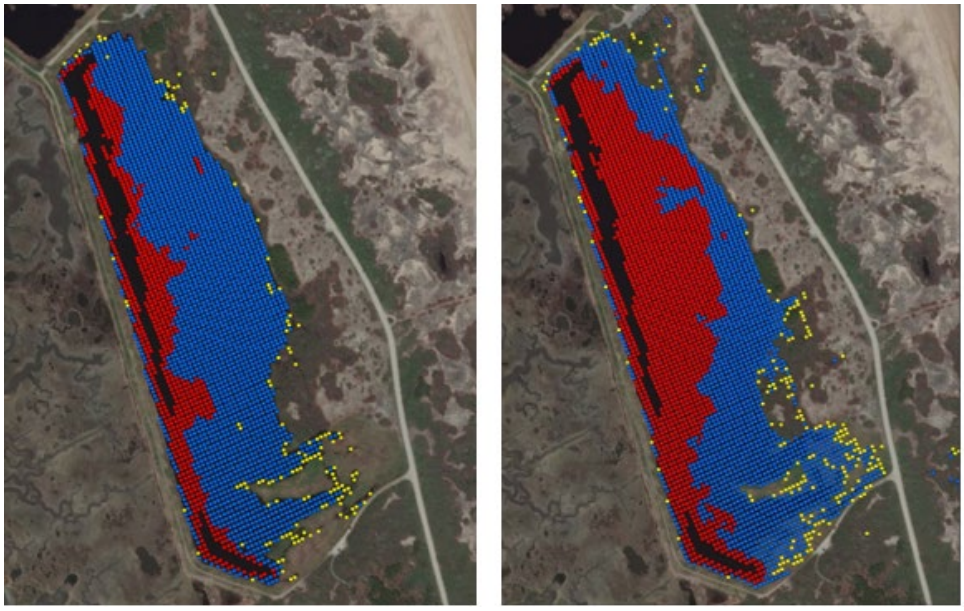

Figure 3 Two modelled images of Bill Forward restored with 6 m opening: restored immediately (left), restored in 2050 (right).

Note: Restored with a 6 m opening and assuming a 0.49 m sea level rise. Red indicates intertidal, blue indicates low marsh, and yellow indicates high marsh (hydrodynamic models by WHG).

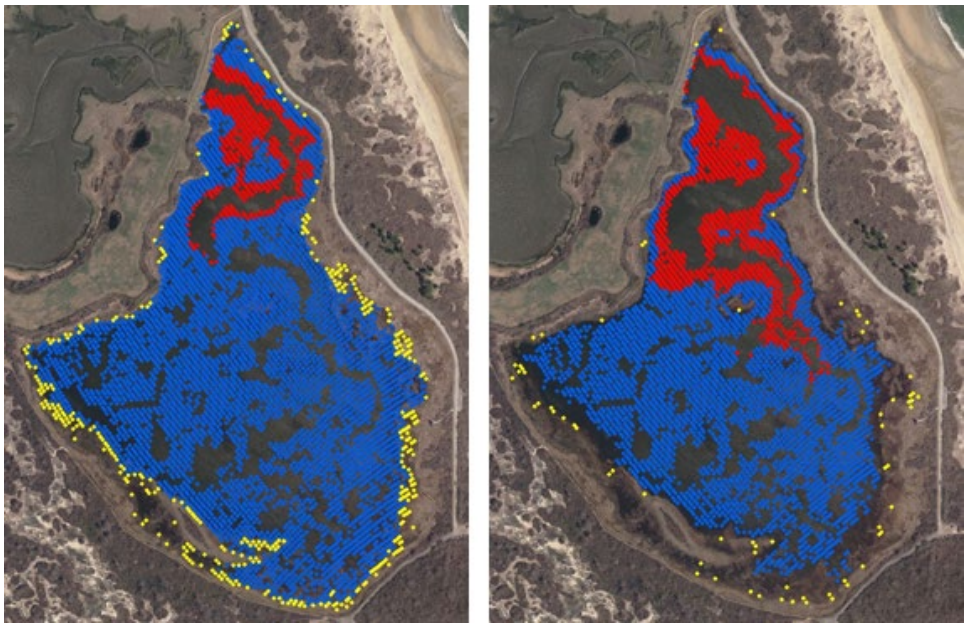

Figure 4 Two modelled image of Stage Island Pool with a 40 m opening if restored immediately (left) and in 2050 (right) with 0.49 meters of sea level rise. (hydrodynamic models developed by WHG).

Note: Restored with a 40 m opening and assuming a 0.49 m sea level rise. Red indicates intertidal, blue indicates low marsh, and yellow indicates high marsh (hydrodynamic models by WHG).

Impoundments and Salt Marsh--Environmental Consequences

1. No Action Alternative

This Alternative restores salt marshes at the existing scale of 10 to 100 acres every few years and maintains the three impoundments with the following management regimes, benefits, and consequences.

At the current pace of restoration, it would take 25 to 40 years to complete restoration of all marshes needing restoration. We expect significant loss of marsh platform during that timeframe as the impaired hydrology causes inundation, vegetation die-back, and loss of marsh elevation. This interim marsh degradation may require more expensive and intrusive restoration techniques, such as sediment placement, which would have greater impacts on all wetland functions and values.

Bill Forward and Stage Island Pools are managed for migrating shorebirds (e.g., Short-billed Dowitcher, Semipalmated Sandpiper, Greater Yellowlegs), to provide a mix of shallow water (<10 inches water depth), mudflat with sparse vegetation (<15% cover) and mudflats with no vegetation, at time of peak migration (spring: late May, and fall: early August), and by controlling invasive species.

Bill Forward and Stage Island Pools are managed for fall migrating waterfowl (e.g., American Black Duck, American Wigeon, Gadwall) to provide shallow flooded (<12 inches) annual vegetation composed primarily of sedges, barnyard grass, knotweed, beggar-ticks, and other seed producing moist soil vegetation at time of peak migration (late October to early November), and by controlling invasive species.

North Pool is managed for breeding marsh and water birds (e.g., Clapper Rail, American Bittern, Least Bittern, Marsh Wren) and waterfowl (e.g., Gadwall) by maintaining water levels and controlling invasive species.

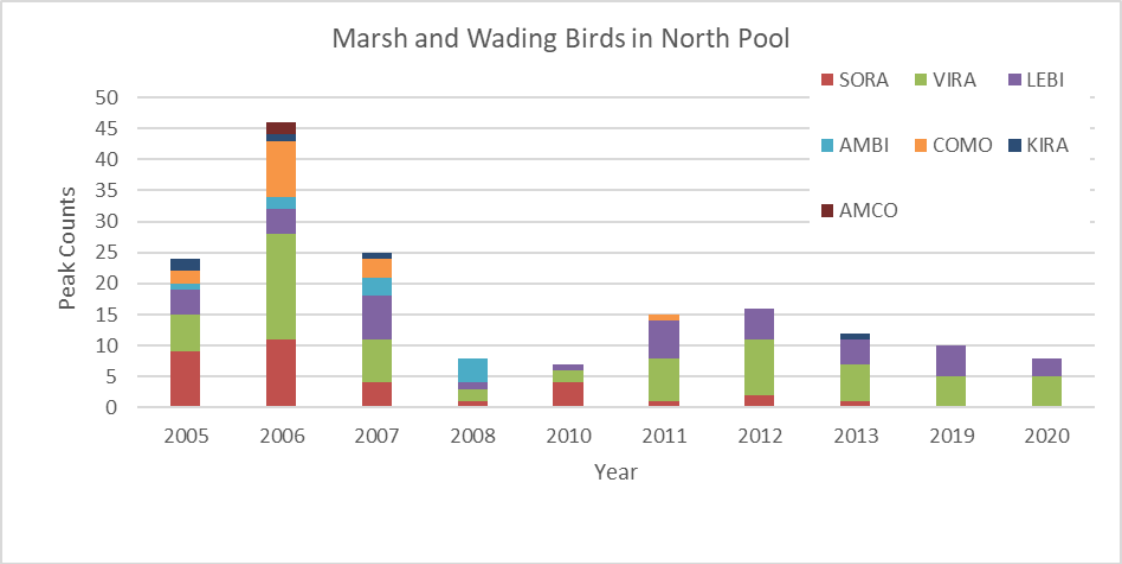

Figure 5. Secretive marsh birds detected (peak counts) during call back surveys from 2005-2020 at ten surveys points in the North Pool impoundments.

Persistent problems in managing the impoundments include aging water control structures, eutrophication, silting of channels and ditches, subsidence, anaerobic water conditions, and continued expansion of invasive *Phragmites* and Asian Carp. The marsh and wading bird populations in the North Pool have declined since a peak in 2006. In 2006, seven species--Sora rails, Virginia Rail, Least Bittern, American Bittern, Common Moorhen, King Rail, and American Coot --were confirmed during breeding season in the North Pool. Species richness declined since 2010. In 2019 and 2020, only Least Bittern and Virginia Rails were detected in 2019 and 2020.

With continued subsidence of impoundment marsh platform and increasingly variable tide levels, achieving water level prescriptions is becoming increasingly difficult. This is particularly challenging as staff capacity dedicated to biological management continues to decline (from 3.5 in 2000 to 1 to 2023) at Parker River Refuge due to national budget cuts and shifts in management priorities. Drawdowns required to provide habitat for waterfowl and marsh and wading birds will accelerate the loss of marsh elevation, furthering the subsidence rate. As demonstrated in the modeling scenarios, waiting to restore will result in lower elevation marsh, and loss of interim habitat for the Saltmarsh Sparrow at the period when it is most needed (ACJV 2020).

The risk of catastrophic dike failure is likely to increase the longer we wait to restore the impoundments. While it is difficult to quantify the risk of storm impacts due to changing global climate conditions, recent storms (e.g., Sandy, Irene, Grayson) are indications that storms will be more frequent, higher intensity, and take new paths not previously recorded. The risk of catastrophic failure is highest with North Pool and Bill Forward Pool, where the main tidal creeks feeding the impoundments have exhibited significant erosion and widening. The marsh abutting the dike is also relatively narrow (297 m), reducing the ability of the marsh to attenuate storm forces. If a catastrophic failure occurs because of storm

surges or other events, we expect a precipitous drop in elevation, rapid vegetation dieback, and loss of root mat as documented at Prime Hook NWR (USFWS 2015). Without salt marsh and impoundments as buffers, flooding water would flood the fields to the east, potentially impacting the access and integrity of the refuge road.

The Massachusetts Department of Environmental Resources (DEP) estimates that as much as 80 to 90% of coastal wetlands have impacted tidal flows due to development and other disturbances. Restoring hydrology to these areas includes restoring the full range of tidal flows to promote vegetation development and sediment trapping (Fennessy & Lei 2018; Commonwealth of MA 2023).

Figure 5 Aerial image of marsh current conditions along the dike of North Pool and Bill Forward Pool.

2. Proposed Action Alternative

The Proposed Action involves accelerating the pace of saltmarsh restoration. This allows the marsh to adapt to increased flooding and inundation expected with the next Metonic cycle (starting in 2030). Eight years of monitoring data from pilot projects indicate that refuge restoration techniques will work in conjunction with natural marsh processes, providing tidal flooding and sedimentation needed for the marsh to keep up with sea level rise. The restoration will reduce or eliminate the clogging of ditches and impounding of water currently occurring with legacy haying infrastructure; restoring a channel network that is in equilibrium with the marsh area being flooded and drained, and a flooding and ebbing hydrology that will sustain *Spartina patens* and *S. alterniflora* and accelerated marsh accretion. High marsh communities (*S. patens,* Saltmarsh rush, Saltgrass) will dominate for the next 20 to 30 years under this alternative.

The Proposed Action also involves restoring tidal flow to the three impoundments, beginning with Stage Island. North Pool and Bill Forward will be done after the results of the Stage Island restoration are assessed. We propose the restoration of the Stage Island impoundment from the current 1.5-meter opening to a 40-meter opening by 2027. By 2035, we propose restoration of the North Pool and Bill Forward Pools from their current 1.5-meter openings to 16 meters and 6 meters, respectively.

This action will remove the risk of catastrophic dike failure once all the dikes are removed. This will restore ecological function, improve water quality, and improve the ability to keep pace with sea level rise; thus, ensuring long term sustainability of these units. Most of the management issues associated with maintaining the water control structures, dikes, and vegetation management within the pools will be eliminated. Asian Carp is a freshwater species and will be eliminated when North Pool is restored. Invasive plant management will be drastically reduced due to resulting changes in the plant community.

The refuge impoundments are 0.4 to 0.7 meters lower in elevation than the adjacent salt marsh. With tidal restoration, we expect significant sediment accretion immediately after restoration (Gerwing et al. 2020). Restoration sites in Canada and Belgium saw elevation gains of 11 to 67 cm per year, rates that are more than 10 times above adjacent salt marsh accretion rates (Virgin et al. 2020; Oosterlee et al. 2020). The rate of accretion is correlated with elevation and inundation depth, with lower elevation platforms receiving the highest accretion rates. As marsh elevation increased post restoration, accretion rates decreased proportionally (Oosterlee et al. 2020; Oosterlee et al. 2018; Virgin et al. 2020).

The accretion rate of restoration is also influenced by the size of the tidal opening. Some restoration projects may plan restricted tidal regime or regulated tide gate structures to achieve resource objectives (e.g., high marsh at a lower elevation to support nesting sparrows). Osterlee et al. (2020) found that full tidal restoration experienced sediment deposit volumes that were 25 times larger than marshes with regulated tides, with the elevation gain of 3.65 meters in 5 years in fully restored marshes, compared to 0.22 meters in 9 years in tidally regulated marsh. We expect an initial loss of marsh elevation as tidal flow is reintroduced to a fresh or brackish marsh, commensurate with salinity and organic peat content. Based on peat core analysis (Fitzgerald et al. 2017), we expect North Pool to experience the greatest elevation loss (freshwater marsh, high organic peat content), while Bill Forward (brackish marsh, mineral peat) will experience the least.

Salt marsh accretion depends heavily on sediment availability. While the suspended sediment in the Plum Island system is low (Schuerch et al. 2013; Langston et al. 2020), recent research indicates sediment influx from tidal flats and nearshore habitats currently make up 60% of observed marsh accretion (Hopkinson et al. 2018), and may increase with increasing storms (Zhang et al. 2020; Coleman et al. 2020).

We expect new tidal channel networks to develop naturally post restoration, reaching equilibrium with the tidal volume within two to four years (Oosterlee et al. 2020; Vandenbruwaene et al. 2012). We also observed this natural channel network and head channel formation with marsh restoration projects at Parker River Refuge from 2015 to 2020, and with natural breaching of mega-pools. Small pools are natural features on the marsh interior; however, large areas of pooled water have led to vegetation die-off and associated changes in marsh elevation.

The establishment and succession of the vegetation community post-restoration depends on the position of the impoundment elevation relative to the mean sea level (MSL), which will change over time. The hydrodynamic models developed by Woods Hole predicted a vegetation community based on

impoundment and marsh elevations and MSL as surveyed in 2015. The model incorporates accretion rates post restoration, based on rates measured in local salt marshes. The research literature indicates that we can expect a much higher accretion rate, and thus we are likely to achieve greater high marsh habitat than the model predicts.

If restoration were to occur immediately, Bill Forward and Stage Island Impoundments would restore to *S. alterniflora*, while North Pool would restore to a mix of *S. alterniflora* and *S. patens*. With further delay and loss of additional elevation, restoration may result initially in mudflats, but rapidly accreting sediment will allow *S. alterniflora* to establish within 1 to 2 years (Virgin et al. 2020). With the phased restoration of Bill Forward and North Pool Impoundments, model results would be updates to inform final design based on more recent field conditions. The ability of *S. patens* to establish is a function of elevation, frequency of flooding, and hydroperiod in the root zone (Virgin et al. 2020; Burdick et al. 2020; Morris et al. 2013; Dausse et al. 2008). Careful restoration design will maximize sediment accretion and provide a range of flooding frequency throughout the restored marsh to create favorable conditions for *S. patens*.

OTHER WETLANDS

OTHER Wetlands—Affected Environment

The only freshwater wetlands on the Parker River NWR are interdunal swales. These are low, shallow depressions that form between sand dunes as part of the barrier beach ecosystem. Most of these swales are cranberry bogs, and a small number act as vernal pools, providing breeding habitat for Eastern Spadefoot Toad and a source of freshwater for other wildlife within the otherwise very dry dune system. The swales are susceptible to invasive plants, including *Phragmites*, purple loosestrife, glossy buckthorn, and rusty willow. Well-developed foredunes reduce wash over and development of new interdunal swales. This may change with an increase in storm intensity predicted with climate change. If breaches do occur, saltwater intrusion into existing swales will likely cause diebacks of the less salt tolerant vegetation, setting back succession. Drought has the potential to reduce the health and extent of swale habitat. Thacher Island NWR has no significant freshwater wetlands.

Other Wetlands—Environmental Consequences

1. No Action Alternative

Current management identifies interdunal swales as high priority habitat. Invasive plant control of rusty willow, glossy buckthorn, and *Phragmites* using mechanical and chemical methods is conducted depending on staff availability. Baseline surveys and seasonal closures are used to monitor and protect populations of rare species (e.g., Eastern Spadefoot Toad, dragon's mouth orchid, invertebrates).

2. Proposed Action Alternative

Under the Proposed Action, we introduce prescribed fire as a tool to allow staff to better manage invasive plants and encroachment of other woody growth. Interdunal swales are embedded within other habitat types that include sandplain grasslands, dune grasslands, and maritime shrublands and thus are managed as part of these larger habitat complexes. Monitoring of prescribed fire is needed to assess intensity of fire in an interdunal swale and the potential impacts to the peat. Refuge staff are not

planning on using prescribed fire in salt marsh habitat since saltmarsh peat is a carbon sink, however, the fire plan incorporates all "burnable acres", and thus includes marsh habitat. Wildfires, caused by lightning or human activities, may also start in salt marsh habitat. A deep burning fire in the salt marsh would release decades or centuries of sequestered carbon into the atmosphere and cause loss of marsh elevation. This will ultimately lower the elevation table in these areas affecting the overall hydrology of the marsh (Watts et al. 2015).

THREATENED AND ENDANGERED AND OTHER SPECIAL STATUS SPECIES

Threatened and Endangered and Other Special Status Species—Affected Environment

Federal: The Piping Plover and Red Knot are listed as threatened, while the Roseate Tern and Northern Long-eared Bat are listed as endangered under the Endangered Species Act of 1973, as amended. Long-eared Bats are documented in the Hellcat area of the Parker River Refuge, while the other three species use the refuge beach, salt marsh, and impoundments. The Tricolored Bat, also found within the Hellcat area, was proposed for federal listing as endangered in September 2022. Little Brown Bats have also been documented within the Hellcat area, and they are currently under review for federal listing. Black rail is federally listed as a threatened; and while it did not historically nest in Massachusetts, a nest was confirmed in salt marsh just north of the Refuge in 2005, and the nesting range of this species is likely to shift north due to climate change. Saltmarsh Sparrow is a Candidate species, currently under review for federal listing. New England Cottontail was not federally listed but is of the highest conservation priority and the Service is actively working with partners to implement conservation actions identified in the 2012 Conservation Strategy (Fuller & Tur 2012). Both species are discussed under the Wildlife section.

Massachusetts: In addition to the species listed above, the following wildlife species are confirmed to occur on the Parker River Refuge and are listed by Massachusetts as endangered: American Bittern, Least Bittern, Pied-billed Grebe, Short-eared Owl, Eastern Small-footed Bat, and Little Brown Bat; and as threatened: King Rail, Northern Harrier, Northern Parula, and Eastern Spadefoot Toad State special concern species found on the refuge include Least Tern, Bald Eagle, Eastern Whip-poor-will, Peregrine Falcon, Saltmarsh Sparrow, Coastal Heathland Cutworm, Dune Noctuid Moth, and Sandplain Euchlaena. Multiple MA-listed plant species occur on the refuge including American bittersweet, sandplain gerardia, seabeach dock, and seabeach needlegrass.

Thacher Island: The federally and State-endangered Roseate Tern no longer nests on this island. Significant tern restoration efforts at other offshore islands in the Gulf of Maine and Long Island Sound have increased tern numbers in the past 30 years.

Threatened And Endangered and Other Special Status Species—Environmental Consequences

1. No Action Alternative

The recovery goal for Piping Plover in the 2007 HMP is a minimum productivity of 1.5 chicks per nesting pair over a five-year period on the Parker River Refuge (USFWS 2007). Working cooperatively with the State (Sandy Point Reservation), City of Newburyport, and Town of Newbury, the goal was to protect 9 miles of habitat for plovers and terns and maintain a Least Tern colony of 50-100 nesting pairs, with refuge staff assisting partners with fencing and predator control. The current management considers habitat restoration strategies (e.g., creating wash-overs, manipulation vegetation) to enhance nesting

areas for Piping Plovers, if determined necessary. We continue with studies on the impact of human disturbance on shorebird use of the refuge beach and rocky shore.

The 2007 HMP does not specifically address the other rare species listed under Affected Environment. However, Red Knots and other migrating shorebirds benefit from the beach closures and other methods that help deter human disturbance. American and Least Bitterns, Pied-billed Grebe and other wading and water birds, and shorebirds benefit from maintaining high water levels in the North Pool Impoundment, as has been occurring since 2006. However, the populations of marsh and wading birds in North Pool have been declining. Bats, toads, raptors, and other rare species continue to benefit from the protection of a mosaic of habitats including maritime shrublands and forests, grasslands, and interdunal swales.

2. Proposed Action Alternative

The recovery goal for Piping Plover in the Proposed Action is, over a 5-year period, an average of 30 nesting pairs producing an average of 40 fledglings annually. The refuge will rely on dynamic, natural processes of erosion and deposition and control of invasive plants to maintain habitat conditions for plovers and Least Terns. Nesting plovers are protected through predator control and by preventing human disturbance through seasonal closures, public education, and monitoring. These efforts are focused on the refuge, as the State, City, and Town now conduct their own efforts to protect these species.

MassWildlife reports that 40% of State listed species depend on fire-influenced habitats (MassWildlife 2022). Prescribed fires will be conducted to enhance these habitats that occur on the refuge for priority resources of concern. Consultations with Ecological Services will ensure that activities will not adversely affect threatened, endangered, or special concern species. Controlling invasive plants and retaining mature trees in maritime forests and pitch pine forests will benefit roosting and migrating bats. Rare invertebrates documented in dunes and sandplain grasslands will be protected through invasive plant management and public access restrictions as needed. Efforts to evaluate the feasibility of reintroducing rare plants, such as the State-listed dragonmouth orchid, may increase resilience of these rare populations.

Removal of the impoundments will eliminate the freshwater/brackish wetlands and mudflats used by shorebirds, wading, and water birds; however, as documented, our ability to manage the impoundments for these species is diminishing and we anticipate that many shorebird and waterfowl species will continue to use the refuge's salt marshes, beaches, mudflats, and tidal creeks. Black Rails and American Bitterns use salt marshes, but other marsh and wading birds would likely decline. King Rails have been documented breeding in salt marshes, but they are more closely associated with freshwater marshes. The corresponding increase in salt marsh habitat will benefit Saltmarsh Sparrows, Black Rails, shorebirds, and waterfowl.

WILDLIFE AND AQUATIC SPECIES

Wildlife and Aquatic Species--Affected Environment

The unique and diverse habitats at Parker River and Thacher Islands NWRs support a high diversity of vertebrate and invertebrate wildlife species. Chapter 2 of the 2023 HMP describes the animal

communities documented on the two refuges. Tables 3-3 and 3-4 in Chapter 3 of the 2023 HMP list the resources of concern (species) that were identified by the refuge staff as priorities for management. The Great Marsh (20,000 acre estuary and dunes including the Refuge) is designated as part of the Western Hemisphere Shorebird Reserve Network, largely due to the extensive salt marsh, high density of invertebrates supported by tidal flooding, and its geographic location.

Wildlife and Aquatic Species—Environmental Consequences

1. No Action Alternative

The refuge will continue to conduct annual inventories of select suites of wildlife species depending on data needs. We will continue to manage for priority focal species and the habitats that sustain them as identified in Table 3.1 of the 2007 HMP (USFWS 2007). Balancing conflicting management needs continues under this Alternative—balancing specific wildlife needs with restoring biological integrity for all species; maintaining impounded wetlands to benefit marsh and wading birds and shorebirds vs risking loss of habitat for all wildlife in case of catastrophic failure. In case of an unplanned breach of the impoundments, rapid oxidization of fresh or brackish peat will lead to hypoxia (lack of oxygen) and sudden drop in elevation, causing dieback of plants as well as many aquatic species. Restoring habitat to support wildlife after an unplanned breach can be substantially more costly than a planned breach. The delay to restoration to obtain funding and permits will also cause additional ecological damage and increase cost.

Without accelerated marsh restoration, the Saltmarsh Sparrow population is expected to decline as available nesting habitat converts to more inundated marsh and open water. As these trends are occurring range wide, affecting the global population of Saltmarsh Sparrows, these impacts are expected to have population level impacts, potentially leading to extinction of this species.

Without increased capacity to captive breed more New England Cottontails (NEC) to re-establish and augment wild populations, New England Cottontails are at great risk of local extirpation. By 2006, NEC were absent from 93 percent of their historically occupied patches (Litvaitis 2006). Many populations in Maine, New Hampshire, and Rhode Island rely on augmentation from the regional captive rearing program to persist on the landscape. Currently, the captive rearing facilities produce one-third of needed rabbits for augmentation (Holman 2022). Additional captive rearing facilities are urgently needed.

If Thacher Island becomes a captive rearing facility, rabbits for reintroduction will likely come from one of the other captive rearing facilities (pens, zoos, and offshore islands). These populations are carefully monitored to ensure genetic diversity and robust populations. If rabbits are translocated from the wild, each State agency determines that the donator population is sufficiently robust to allow for removal of individuals. These impacts are further discussed in the final Environmental Assessment for establishing a population of New England Cottontail on Nomans Land NWR (USFWS 2018).

2. Proposed Action Alternative

The refuge will focus management efforts on a set of priority species, with other species benefiting as identified in Tables 3.1 and 3.2 in Chapter 3 of the 2023 HMP (USFWS 2023). To ensure that wildlife are able to adapt to rapidly changing condition driven by climate stressors, the refuge will protect natural

processes and maintain ecological diversity and environmental health . Where appropriate, the refuge will restore natural processes to improve BIDEH and climate resiliency (such as with salt marsh, impoundments, pitch pine forests).

A wide variety of management tools (including invasive plant control and prescribed fire) will be used to improve habitat conditions in all habitats. We introduce prescribed fire as a tool to benefit native wildlife and their habitats with a recognition that there may be some short-term impacts. We time burns to have the lowest impact on native wildlife such as when they are not active and use low-intensity techniques that allow animals to move away from the burn area. We anticipate that some species will quickly return to burned areas to forage on exposed prey or regenerating vegetation (e.g., Northern Harriers, small mammals) (Smith & Lyon 2000). Prescribed fires also reduce fuel loads that otherwise can lead to more intensive and ill-timed wildfires that have a much larger impact on wildlife.

Removal of the impoundments and transition to salt marsh will likely reduce the use of these areas by secretive marsh birds and roosting birds, while providing new habitat for waterfowl, shorebirds, Willets, fish, and shellfish. Other species that currently use the impoundments, such as shorebirds and waterfowl, will shift to other habitats (salt marsh, tidal creek, mudflats, beach) on the refuge and adjacent lands and waters. The large flocks of Tree Swallows that currently roost in the North Pool are drawn to the refuge by the berries and insects in the Martime Shrub habitat. When the North Pool is restored, they will likely shift to other roosting sites (such as shrubs, or the *Spartina alterniflora* marsh at Stage Island).

Accelerated marsh restoration will contribute significantly to the viability of the Saltmarsh Sparrow population, which is expected to reach a critical threshold by 2030. The Great Marsh supports 5% of the global population, so marsh restoration efforts on the refuge and partner marshes will sustain this imperiled species, giving it more time to adapt to changing habitat conditions. While the refuge manages over 2,700 acres of salt marsh, not all acres are suitable for Saltmarsh Sparrow nesting as some marsh surfaces flood too frequently to support nesting sparrows. With sea-level rise, the percent of suitable habitat is expected to decline. Restoring salt marsh across the refuge, including in the current impoundments, allows natural processes that build elevation and allow for marsh migration, thus improving the chances of successful sparrow nesting.

Black Rails (federally listed, threatened) do not routinely nest in Massachusetts, although one was confirmed in the Great Marsh in 2005. Salt marsh restoration may benefit this species in the long run as warming climates and marsh loss in their southern range pushes this species north. Impoundment restoration will benefit many aquatic species, including American Eel, Mummichog, Atlantic Silverside, Grass Shrimp, sticklebacks, clams, and mussels. It will also eliminate the invasive Asian Carp from the refuge as freshwater impoundments are converted to salt marsh. Breaching the impoundments to restore salt marsh, particularly Stage Island Pool, is likely to benefit Atlantic Sturgeon, which are active in the Plum Island sound area.

The refuge will maintain the remaining grasslands to benefit nesting and migratory birds as well as pollinators; some grasslands have succeeded to maritime shrubland as desired, to benefit fruit-eating migratory birds. We will assess methods to improve soil and hydrology of the remaining grasslands to support more native grassland communities and pollinator species without requiring intensive invasive plant management.

The addition of Thacher Island as an island captive rearing facility would contribute to meeting the objective of annually producing 250 New England Cottontails for augmentation and reintroduction (currently 90 are produced per year) (Holman et al 2022). Following reintroduction of 26 and 75 rabbits within a few years, NEC populations have increased rapidly on two offshore islands, without the high management costs and problems experienced at zoos and outdoor breeding pens (Holman et al. 2022).

The reintroduction of a tern nesting colony on Thacher Island would provide a buffer against catastrophic loss (weather or disease) at existing nesting islands in New England. However, the Common Tern population has been increasing in the last 30 years. In 2021, there were over 20,000 nesting pairs of Common Terns in Massachusetts nesting at 33 sites and the species is not at eminent risk of collapse (Mostello et al. 2023). However, Roseate and Artic Terns only nest in robust Common Tern colonies, and restoration of a tern colony at Thacher Island is likely to benefit these two federally listed species in the long term.

VEGETATION

Vegetation—Affected Environment

Parker River NWR has a diverse array of habitats typical of a coastal barrier island, including sandy beaches, dunes, sandplain grasslands, interdunal swales, maritime forests and shrublands, and salt marshes. Human altered and managed habitats include old fields and impounded wetlands. Invasive plants are a continuing and growing problem as existing populations expand and new species arrive. We expect new and more vigorous invasive plant species with warming temperatures.

Tables 3-1 and 3-2 in Chapter 3, 2023 HMP describe the plant communities associated with each habitat type on the two refuges.

Vegetation—Environmental Consequences

1. No Action Alternative

Most of our proactive vegetation management includes invasive species control and salt marsh restoration (~300 acres in the next 10 years). Without accelerated restoration, we would expect a shift from high marsh vegetation to low marsh (*Spartina alterniflora*) or open water as the marsh fails to keep up with sea level rise; but a vegetated marsh platform is expected to persist for hundreds of years. The focus of our invasive plant management is on perennial pepperweed, black pine, black swallowwort, and *Phragmites*, using cutting, girdling, pulling, and herbicide application. We focus on early detection and eradication and cultural practices (changing environmental conditions vs. controlling plants directly) for long term success and reduced herbicide use. Salt marsh restoration strives for a mix of high and low salt marsh vegetation. Grasslands are managed through annual or other cyclical mowing cycles. Maritime shrubland and forest are managed for native fruiting trees and shrubs primarily through invasive plant control and an annual deer hunt to reduce over browsing on native plants.

2. Proposed Action Alternative

The increased pace of salt marsh restoration in the Proposed Action Alternative (2,500 acres within next 10 years) will maintain the vegetated marsh platform and high marsh vegetation for more decades than under Current Management. Salt marsh restoration under this Alternative will significantly shift the

plant community from unvegetated and *S. alterniflora* dominated marsh to high marsh species (*S. patens*, saltmarsh rush, saltgrass). We will also shift 266 acres from brackish/freshwater vegetation in the impoundments to salt marsh vegetation once restoration is completed.

In addition to our current management efforts described above, we anticipate that with the addition of prescribed fire as a management tool we will have a positive impact on native plant communities in our various habitats, by controlling invasive plants, discouraging woody growth where desired, and promoting regeneration of native plants. Prescribed fire and associated management will have the greatest benefit to pitch pine communities where the current understory is dominated by invasive shrubs, hindering seedling recruitment, and outcompeting native wildflowers. Dune grassland may also benefit by reducing woody plant succession. We anticipate the need to use prescribed fire in conjunction with other tools (e.g., mechanical, herbicide) as well as repeat treatments, at least initially, to control invasive plants. We recognize that some invasive plants, such as leafy spurge and spotted knapweed (Emery & Gross 2005; Wolters et al. 1994) do not respond to burning and will adjust treatments accordingly.

Reintroduction of New England Cottontails to Thacher Island may negatively impact vegetation, particularly from winter browsing. However, we expect to mitigate this impact by removing rabbits from the island for reintroduction on the mainland.

GEOLOGY AND SOILS

Geology and Soils—Affected Environment

The geology and soils of these refuges are described in the 2007 and 2023 HMPs. Most soil on the refuge is sand or mucky peat. Periodic severe storms are short-term phenomena that may erode a sand spit or reduce or move a dune, a process that leads to continually shifting sands, reshaping of topography, and plant communities adapted to these dynamic conditions. We have documented significantly more frequent erosion and accretion cycles on the refuge beaches since 2011 and we expect these to increase based on climate projections (Psuty et al. 2017). We do not use beach nourishment or sand fencing.

Recent investigations have determined that much of the salt marsh peat has been altered by past agricultural (salt marsh haying) practices (Adamowicz et al. 2020) and mosquito control. Ditches and embankments created by past farming practices and mosquito control districts either drained or inundated the upper root zones, leading to decomposition or vegetation die back, both leading to subsidence of wetland soils.

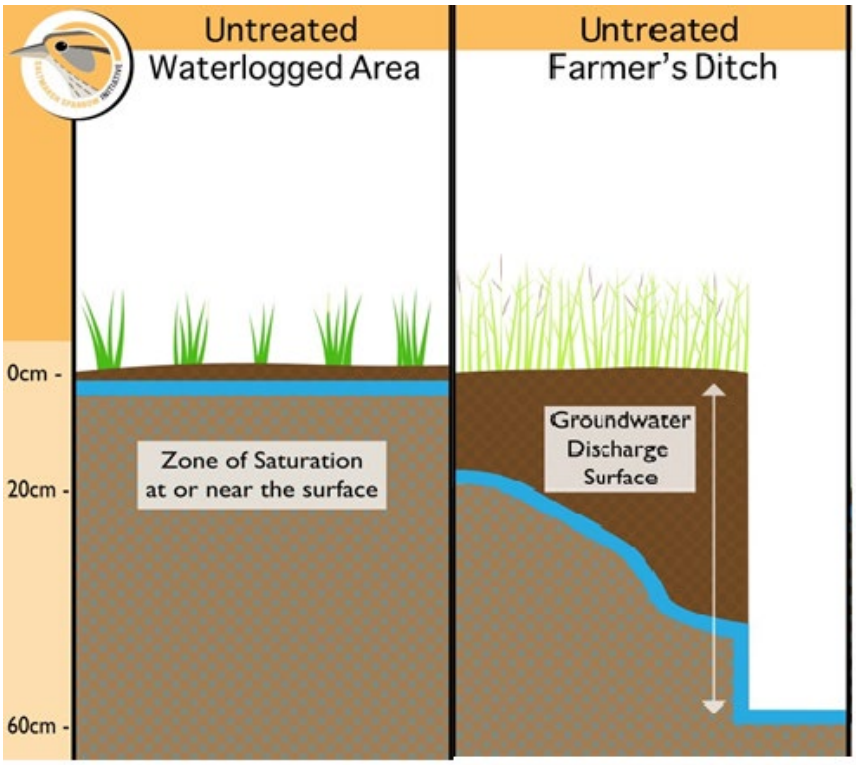

Figure 6 Effects of legacy farming infrastructure on the peat in salt marshes. In the left panel, embankments and clogged ditches do not allow water to drain during ebb tides, holding ground water close to the marsh surface. In the right panel, high density ditches drain to peat deeply, resulting in oxidation and decomposition of peat.

Geology and Soils—Environmental Consequences

1. No Action Alternative

We anticipate the continued effects of climate change leading to more frequent and intense storm surges and greater movement of sand. On the beach, we expect more sand movement and more frequent reshaping of the foredune and beach profile with increasing storms. Over washes and breaches may become more prevalent. Review of shoreline change over the last century (CZM 2013, 2020) and monitoring of shoreline position at the refuge in recent decades have not suggested a westward migration of the barrier island. This may continue in the future or may shift as the offshore sand bars are eroded or mined for beach nourishment.

In the salt marshes, without comprehensive tidal restoration to most of the marsh, we expect to see multiple areas of vegetation dieback and peat subsidence under this Alternative, particularly coupled with increased flooding with peaks in the Metonic cycle.

The impoundments have subsided up to 1.5 feet in the last 70 years, and we expect this subsidence to continue and increase as sea level rises. Compaction and decomposition of existing peat associated with impoundment water level management is causing loss of elevation within the impoundments. Additionally, whereas the tidally influenced salt marsh will adapt to rising sea levels by increasing

biomass production and sediment trapping, the impoundments are starved of these two natural processes that increase elevation.

The degree of impact to soil from unplanned wildfires depends on the intensity and duration of the fire. The current Fire Management Plan calls for immediate suppression of all wildfires. Response would likely to local fire departments, who are not typically trained on wildfire response. Wildfire may have unanticipated impacts on soils, such as compaction from fire and response itself. The degree of compaction depends on the soil type and equipment. Wet soils compact more than drier soils. Heavy equipment compacts more than the human footprint.

2. Proposed Action Alternative

Soil and geology for the beach ecosystem is the same as it would be under the No Action Alternative. Under the Proposed Action, we expect to see a significant benefit to salt marsh peat from accelerated implementation of restoration. The peat will be returned to inundation cycles commensurate with its habitat and elevation gradient and is expected to grow in elevation with increasing sea level rise. At some point, the rate of sea level rise is expected to outpace the ability of the marsh plants to trap sediment and increase biomass production, but restoration should delay that threshold for several decades.

Restoration of tidal flow to the impoundments will mobilize sediment, reworking tidal channels, and redistributing sediment within the impoundment. We expect direction of sediment transport to be mainly from the estuary to the impoundments, which are lower in elevation. The initial larger opening may cause some erosion in the main channel, but these are expected to reach equilibrium and stabilize as salt marsh plants revegetate. The restored tidal connectivity will allow the former impoundment to build peat, and adapt to changing climate conditions, increasing the resiliency of the habitat. The Massachusetts Healthy Soils Action Plan (Commonwealth of MA 2023) identifies restoring natural hydrology—to promote vegetation development and sediment trapping--as a key priority for the State's restoration efforts in coastal wetland ecosystems.

With the addition of prescribed fire as a management tool, we expect some soil disturbance, although it will be more carefully planned than is possible during the rapid response needed for suppression of wildfires. We anticipate that with the introduction of prescribed fire, the chance of wildfires is reduced given reduced fuels loads. Prescribed fires are designed to burn above-ground vegetation and are unlikely to transfer to the soil. As described in the 2023 FMP, we will limit fire lines to existing roads or natural features whenever possible to minimize environmental damage, and mainly use wet (vegetation) lines for containment. The use of retardant, dozer or plow lines will not be permitted on Service lands except to protect life or improvements such as buildings to minimize soil disturbance. When possible, we will avoid using disced fire lanes; if used they will be compacted as soon as possible and overturned sod resulting from plowing will be rolled back with a grader or by hand and compacted to preserve native grass root stock.

AIR QUALITY

Air Quality—Affected Environment

The Massachusetts DEP operates a network of air monitoring stations throughout the State; until 2018 one was located on Plum Island. The State typically meets all air quality standards for pollutants except ozone (MADEP 2023). In 2021, there were four days when the 8-hour ozone standard was exceeded. However, based on the most recent three years of data (2019 to 2021), no monitoring locations violated the standard. Typically, Massachusetts ozone exceedances occur on hot, sunny days when smog-forming chemicals are carried long distances by wind. In 2021, Massachusetts also experienced elevated levels of fine particles resulting from wildfire smoke originating in western US states and Canada (MADEP 2023).

Salt marshes are one of the best carbon sequestration habitats in the world, burying up to 500 kg of carbon per acre per year (Forbrich & Giblin 2015). The 3,000 acres of salt marsh on the Parker River NWR sequester roughly 1.5 million kg of carbon each year, enough to offset annual energy use for 3,127 homes or annual fuel expenditure of 5,545 vehicles (EPA 2023). Additionally, refuge salt marsh peat can be up to 40 feet deep and represents over 3,000 years of carbon sequestered. We expect a slight decrease in carbon sequestration in unrestored marsh areas from vegetation dieback or conversion to open water in the next decade. Over longer time frames, these areas may convert to low marsh (tall *S. alterniflora*) sooner, which may suppress carbon sequestration (Forbrich et al. 2021).

Activities on the refuge comply with all applicable federal, State, and local air pollution control requirements as specified in Section 118 of the Clean Air Act, as amended. Specific guidance pertaining to smoke management with wildland fires is addressed in the 2023 FMP and further specified when a prescribed fire plan is prepared.

Air Quality—Environmental Consequences

1. No Action Alternative

No changes from existing conditions are anticipated. In case of a catastrophic breach of the impoundment dikes, we would expect a measurable increase in methane and carbon dioxide as peat decompose with a sudden influx of saltwater. Delays in restoring a functioning marsh would increase this additional carbon input.

2. Proposed Action Alternative

We anticipate modest positive impact in Air Quality from restoration of habitats that currently require routine and intensive management, such as impoundments and grasslands. Eliminating the need for weekly water level management, annual or biannual mowing, and herbicide application reduces fossil fuel consumption used in equipment and vehicles.

Smoke is the main concern for air quality when implementing prescribed fire strategies. The amount of smoke produced from fires depends on the amount of fuel consumed, fire behavior, current conditions, and the area burned. All components of smoke from fires, except for carbon dioxide and water, are generated from the inefficient combustion of biomass fuels (Sandberg et al. 2002). The major pollutant of concern in smoke from fire is fine particulate matter (Sandberg et al. 2002). Particulates are particles of ash, partially consumed fuel, and liquid droplets, which can reduce visibility and impact health of the

public nearby. Several human health studies on the effects of particulate matter (PM) indicate that fine particles, especially PM2.5, are largely responsible for health effects including mortality, exacerbation of chronic disease, and increased hospital admissions (Dockery et al. 1993; Schwartz et al. 1996).

One of the highest priorities when dealing with wildfires is the consideration of firefighter and public safety. In the Prescribed Fire Plan (step down to FMP to be developed in 2-5 years), the refuge will examine pre-burn fuel characteristics which determines the fuel consumption and the expected smoke levels. Immediately prior to prescribing fire, we consider wind speed, wind direction (i.e., wind blowing smoke out toward the ocean), and other environmental factors to minimize smoke impacts to neighboring communities. Any impacts to air quality during a fire event will be minor and short-lived. The use of prescribed fires will reduce fuel loads that otherwise can lead to hotter and more intense wildfires that result in greater impacts to air quality.

We anticipate a significant positive impact on greenhouse gas emissions from reduced fossil fuel and the restoration of over 2,500 acres of salt marsh. The ability of the marsh to flood and ebb will promote biomass primary production, removing more carbon from the air, and sequestering it in the peat. We anticipate our restoration efforts will delay the conversion of high marsh to low marsh in the Plum Island area by a few decades, and significantly reduce vegetation diebacks and open water, which releases buried carbon into the atmosphere. The restoration of impoundments to salt marsh will increase the carbon capture capability of the system, and mitigate the risk of carbon and methane release from an unplanned breach.

WATER RESOURCES AND WATER QUALITY

Water Resources and Water Quality—Affected Environment

Parker River NWR is rich in water resources with 1,237 acres of tidal river, bay, and estuary habitats and 2,735 acres of salt marsh with many natural and human-created pools, creeks, and ditches. Over 75% of Parker River Refuge is estuarine marsh and deep-water habitat, while only 5% is freshwater marsh. Four major rivers (Merrimack, Parker, Rowley, and Ipswich) influence the hydrology and ecosystem function within the refuge. With both Parker River and Thacher Island Refuges located on the ocean, habitats are also heavily influenced by tidal forces. Hydrology is restricted on the three impoundments on Parker River Refuge.

Water quality is considered very good in most areas in the Parker River watershed and in Plum Island Sound, although some areas are at risk of nutrient enrichment leading to algae blooms. Parker River Refuge has four areas of potential concern regarding environmental contaminants on the refuge; these are described in the 2007 HMP. In addition, the refuge has high levels of methyl mercury which is accumulating in Saltmarsh Sparrows. The altered tidal hydrology in salt marsh threatened the long-term resiliency of the marsh and its ability to adapt to changing climate conditions.

Erosion from wildland fires is considered a non-point source form of pollution by the federal Environmental Protection Agency. Recently burned areas can erode when heavy precipitation occurs. Additionally, fire retardant chemicals and foams that may be used in wildland fire activities may pose a threat to water resources; but we do not expect to need to use fire retardant, except as a last resort to protect the Visitor Contact Station or maintenance buildings. Wildfires are a very rare occurrence at Parker River NWR and tend to be very small in size when they do occur. Typically, they can be

extinguished using water with no need to use additional fire retardants. Prescribed fire events will be managed in such a way to have the least possible impact to the surrounding water resources, including using only water for extinguishing and avoiding times when heavy precipitation is likely to occur soon after a fire. All fire management actions comply with regulations in the Clean Water Act.

Water Resources and Water Quality—Environmental Consequences

1. No Action Alternative

In general, refuge management activities protect or improve water quality, as we leave intact natural systems (particularly soil and microbes) that clean and filter any pollution from off-refuge runoff. All refuge management activities with potential negative impacts will continue to comply with the Clean Water Act through project permitting. The amount of herbicide that we use to control invasive plants is small (less than 1 gallon annually, but up to 25 gallons in years where we are treating invasives in maritime shrublands or impoundments) and is carefully applied by licensed applicators to avoid impacts to water. In all situations, we follow stricter constraints and use rates much lower than those specified on manufacturer labels.

2. Proposed Action Alternative

In addition to the No Action Alternative, we will follow the guidelines in the 2023 FMP to protect water quality. We anticipate that removing the impoundment dikes and restoring tidal flow will have a positive impact on our water resources by creating a more natural system and allowing for proper flushing and replenishing of nutrients. Accelerated restoration of tidal hydrology in salt marsh will allow the marsh to keep apace and adapt to changing flooding conditions.

Table 3 Affected natural resources and anticipated impacts of the two Alternatives for the Parker River Refuge.

	NO ACTION ALTERNATIVE	PROPOSED ACTION ALTERNATIVE
Impoundments		
Objective	Manage water levels and invasive plants to benefit migrating shorebirds and waterfowl and breeding wading and waterbirds.	Manage the restored salt marsh to benefit Saltmarsh Sparrow, migrating shorebirds and waterfowl, and to maintain BIDEH.
Strategy	Maintain the 266 acres of impounded freshwater/brackish water.	Restore 3 impoundments to salt marsh: Stage Island by 2027, North Pool and Bill Forward Pool by 2035. Restore from current 1.5-meter openings to 40m, 16m, and 6m openings, respectively

	NO ACTION ALTERNATIVE	PROPOSED ACTION ALTERNATIVE
Strategy	Continue to deal with aging infrastructure, eutrophication, silting, subsistence, poor water quality, lack of fresh water, invasive plants.	Over time rely on natural processes to maintain system; removes management issues associated with the dikes and water control structures.
Risk/Benefit	Risk of catastrophic dike failure/maintains breeding habitat for Virginia and sora rails.	Removes risk of catastrophic dike failure. Ecosystem is more resilient with changing climate.
Salt Marsh		
Objective	Manage 2,735 acres of salt marsh.	Manage 3,001 acres of salt marsh, include restoring 266 acres of freshwater/brackish marsh to salt marsh.
Strategy	Restore hydrology to 300 acres of salt marsh in next 10 years.	Restore hydrology to 2,500 acres of salt marsh in next 10 years
Risk/Benefit	Loss of high marsh to open water and low marsh and degraded habitat for various bird species, loss of nesting habitat for salt marsh species.	Maintain high marsh acres and wildlife habitat. Marsh is more resilient and able to keep up with sea level rise. Over-draining with too many runnels can cause elevation loss.
Other Wetlands		
Strategy	Continue to protect exemplary interdunal swales through closures as the only freshwater wetlands on the refuge, which also supports rare species.	Consider restoring rare plants to interdunal swales.
Strategy	No prescribed fires.	Carefully consider use of prescribed fire to restore disturbance regime that maintains barrier island habitat.
Water Resources and Water Quality		
Strategy	No prescribed fires.	Follow 2023 FMP to protect water quality during wildfire and prescribed fire events.

	NO ACTION ALTERNATIVE	PROPOSED ACTION ALTERNATIVE
Strategy	Impoundments are maintained with resulting impacts to water quality.	Restore hydrology and tidal flow as part of decommissioning the impoundments.
Threatened and Endangered Species and Other Special Status Species		
Objective	Piping Plover recovery goal: 1.5 chicks per nesting pair over 5 years.	Piping Plover recovery goal: avg. 30 nesting pairs produce 40 fledglings annually, averaged over 5 years.
Objective	Maintain a Least Tern colony of 50-100 pairs.	Same as No Action
Objective	Continue to monitor population trends and productivity of Saltmarsh Sparrows	At least 1000 acres of suitable breeding habitat for Saltmarsh Sparrow with 775 adults and 45% annual nest success
Strategy	Assist State and local communities with protecting nesting plovers and terns on their lands.	Protect nesting plovers and terns with a focus on refuge lands.
Strategy	Consider habitat manipulation to improve nesting for plovers.	Rely on dynamic natural processes and invasive control to maintain plover and Least Tern nesting habitat.
Strategy	Maintain North Pool impoundment to benefit State-listed species.	Restore impoundments to salt marsh to benefit Saltmarsh Sparrow, Red Knot and Black Rail in future.
Strategy	All wildfires are suppressed and no use of prescribed fire.	Use prescribed fire to enhance globally rare habitats for species such as rare plants and state-listed Lepidoptera.
Strategy	Continue to monitor other federally listed species such as Red Knot, Northern Long-eared Bat, Roseate Tern, Atlantic Sturgeon, and evaluate need for recovery actions.	Same as No Action
Wildlife and Aquatic Species		

	NO ACTION ALTERNATIVE	PROPOSED ACTION ALTERNATIVE
Objective	No change from existing condition anticipated; priority species are identified in Ch 3 of the 2007 HMP.	Priority species are identified in Ch 3 of the 2023 HMP.
Strategy	Marsh and wading birds, migrating shorebirds, and waterfowl continue to benefit from impoundment management, but with increasing difficulty to sustain habitat conditions.	Removal of the impoundments will reduce breeding habitat for some species of marsh and wading birds and increase habitat for salt marsh and aquatic species. Shorebirds and waterfowl are expected to use the newly created salt marsh.
Strategy		Greater benefit to pollinators and songbirds via management of grasslands and maritime shrublands, respectively.
Vegetation		
Objective	No change in management. Continued succession of grasslands to maritime shrubs and forests. Restore native communities through control of invasive plants.	Shift from 266 acres of impounded freshwater/brackish water vegetation to salt marsh. More vegetated salt marsh platform resulting from restoration.
Strategy	All wildfires are suppressed and no use of prescribed fire.	Use existing natural disturbances (salt spray, winds, shifting sands) and managed disturbances (prescribed fire) to control invasive plants and promote natural vegetation composition and structure.
Geology and Soils		
Strategy	Continued subsidence in the impoundments and potential future subsidence in salt marsh.	Removal of impoundments will reverse subsidence and begin process of rebuilding peat. Salt marsh restoration will allow marsh platform to keep up with SLR for longer.

	NO ACTION ALTERNATIVE	PROPOSED ACTION ALTERNATIVE
Strategy	Unplanned wildfires have potential to have larger impact due to build up of fuel loads.	Some additional, but negligible, soil disturbance with prescribed fire, although we anticipate reduced impacts from wildfires as fuel loads are managed with planned fires.
Air Quality		
	Local fire crews assist with fire suppression and smoke management for wildfire events.	Local fire crews will continue to assist with wildfire suppression.
	Prescribed fire is not currently used as a refuge management tool.	Prescribed fire is added as a management tool, guided by a Fire Management Plan; trained Service, local and partner fire personnel will manage fires and smoke.
	Given the infrequency of wildfires we believe there is negligible impact to air quality.	Despite this increase in planned fire events, we anticipate impacts to air quality will be limited in time and have a negligible impact on regional air quality.

Table 4 Anticipated impacts of the two Alternatives for Thacher Island NWR.

NO ACTION ALTERNATIVE	PROPOSED ACTION ALTERNATIVE
No prescribed fire	Evaluate feasibility of using prescribed fire to enhance habitat.
Initiate restoration of a Common and Roseate Tern colony	Re-evaluate staff resources and regional priority for initiating restoration in 2027.
No strategy for New England cottontail	If feasible, restore New England cottontail to the island.

VISITOR USE AND EXPERIENCE

Visitor Use and Experience—Affected Environment

Parker River NWR is open to all six of the System's priority public uses (hunting, fishing, wildlife observation, wildlife photography, environmental education, and environmental interpretation) with about 300,000 people visiting the refuge annually. Wildlife observation, especially birdwatching, is one of the most popular visitor activities. A 2012 Visitor Survey found 33% of all Refuge visitors to participate in birdwatching, with an additional 35% involved in other wildlife observation and enjoying nature trails. Other popular activities include beach use, surf fishing, kayaking the salt marsh creeks, hunting. Although most people travel around the refuge by personal vehicle, some visitors enjoy walking or bicycling the main road.

The refuge also hosts a visitor services program, providing numerous public programs and tours each month. Visitor use is directed to trails, beaches, and a few viewing locations to reduce impacts (see Accessibility Guide). Off-road vehicle (ORV) use for fishing was discontinued on the refuge beach in 2022 due to changing beach conditions (see Compatibility Determination). Additional information on seasonal closures and other public access restrictions is documented in Chapters 4 and 5 of the 2023 HMP.

Thacher Island Refuge is located at the northern end of Thacher Island, a 50-acre island located one mile off the coast of Massachusetts. The town of Rockport owns the remaining 28 acres of the island, which is managed by the Thacher Island Town Committee and the Thacher Island Association as a historic site and tourist destination; they provide transportation to the island for the public, which receives about 1,500 visitors annually.

Visitor Use and Experience—Environmental Consequences

1. No Action Alternative

The visitor demand is currently above Refuge parking capacity, and temporary closures are implemented for public safety. We expect visitor demand to remain high and increase in the next 15 years. Seasonal closures and other public access restrictions continue to be used to protect priority species, habitats, and ecosystems on the Parker River Refuge. ORV use on beach was discontinued in 2022. Signage and public educational programs are used to raise awareness among visitors as to the importance of these measures. Trails, boardwalks, and parking areas continue to be maintained to achieve a high level of visitor experience while protecting sensitive areas.

Continued succession of maritime shrubland and forest will provide additional birding opportunities, especially for Neotropical migrants. This will allow the visiting public to spread out across the refuge, reducing some of the congestion and crowded experiences that currently mar some visitors' experiences. The viewshed in the Stage Island and Nelson Island fields will be reduced as shrub and forest species re-establish. We plan to maintain the viewshed from Stage Island toward Cross Farm and Grape Island, and at Stage Island bluff.

2. Proposed Action Alternative

In addition to the above, additional seasonal closures and access restrictions may be needed to ensure we meet recovery goals and to protect rare species. Transitioning 266 acres from freshwater/brackish marsh to salt marsh with the decommissioning of the three impoundments will change the birding

experience at those sites. Currently they are popular locations for viewing waterfowl, wading birds, and shorebirds. Many of the same species will utilize the new salt marsh habitat, and the refuge will continue to provide viewing opportunities of these areas, however, visibility may decline over time as healthy salt marsh vegetation replaces mudflats and shallow water of impoundments. Current viewing infrastructure, including the observation towers and blinds, the marsh spur in North Pool, and the publicly accessible portions of the dikes, will remain in place. We are actively pursuing funding for a foot bridge to enable continued pedestrian access to the Stage Island Trail post-restoration to support public use.

Improvements to the pitch pine and sandplain communities will increase habitat for the Eastern Whip-poor-will and American Woodcock, which should in turn provide increased opportunities to view them. We expect an increase in wildflowers and insects because of management actions under the Proposed Action, which will draw people interested in nature observation.

The only temporary impact to visitor experiences will be during a prescribed burn event. Depending on the location of the burn, a portion of the refuge may be temporarily closed to public use for safety reasons. Refuge staff and the regional fire crews will work to minimize impacts to visitors as much as possible, but safety will take a higher priority over recreation.

The introduction of a New England Cottontail population to Thacher Island would provide opportunities for visitors to learn about this New England native rabbit. Translocation of wild animals comes with some risks, including introduction of disease or ticks from one area to another. However, the Captive Rearing Working Group has developed detailed standard operating protocols to mitigate these potential negative impacts. These include quarantining any rabbits that would be relocated for a minimum of seven days for observation of any diseases, such as Tularemia, and treating for ticks during the quarantine period. Prior to any release of rabbits, a Captive Rearing Management Plan would be developed, which would include preventative and contingency plans for diseases.

CULTURAL RESOURCES

Cultural Resources—Affected Environment

Parker River NWR has a long history of human use, beginning with Native Americans. Seventeen precontact Native Americans sites have been identified within the refuge, consisting of shell middens, camps, larger habitation sites, lithic workshops, and human burials. Shell midden deposits have been identified in most habitats on the refuge. Twenty-nine post-contact Euro-American sites have been documented, including seasonal camps, farmsteads, shipwrecks, life-saving stations, aids to navigation, salt works, and a grain mill. Many camps were present when the refuge was established and have been progressively removed, with the last removed in 2016. The only historic period structure remaining on the refuge is the Light Keeper's Dwelling on the north end of Plum Island.

Through our marsh restoration work, we have identified two types of historic farming infrastructure in salt marshes: ditches and "embankments" (see 2023 HMP Ch. 2 Site Capabilities-Historic Influences). Embankments are long berms made by excavating marsh peat and piling it on the marsh surface. We see evidence of many embankments running across ditches. The embankments and ditching network were meant to keep tidal waters out (for the most part) and were abandoned in the 1800s and eroded by natural processes.

Additionally, information on Indigenous Tribe use is included in the Indian Trust Resources section below.

Cultural Resources—Environmental Consequences

1. No Action Alternative

As a federal agency, we follow strict federal and State historic resource protection standards to protect, preserve, and document archeological resources. This involves review by the USFWS Historic Preservation Officer for the following situations:

- Removal of any structures 50 years or older
- Excavation or digging of any kind, including digging for planting, and installing posts.
- Consultation with State Historic Preservation Office (SHPO) and Tribes for any new proposed projects that involved ground disturbance.

A comprehensive cultural resource review and 2010 report summarizes all pre-contact indigenous resources found on the refuge and surrounding areas, providing refuge staff guidance when working in culturally sensitive areas.

As part of our salt marsh restoration investigations, refuge partners "re-discovered" pervasive human infrastructures in salt marshes from salt marsh haying era. These include ditches and embankments used to control hydrology (click here for example from Canada). The legacy infrastructure that was systematically constructed throughout salt marshes from Canada to Georgia are accelerating marsh degradation in the face of climate change. Since the 1800s, they have been largely lost to marsh processes, tides, and from human memory. Our restoration techniques (small notches in embankments and placing hay in some ditches) will slightly alter a small percentage of these infrastructures. If these alterations are not implemented, these infrastructures are likely to be lost more quickly to rising seas, along with the salt marsh system and the wildlife that depend on it. In communicating the need for restoration, salt marsh ecologists and land managers have been highlighting these historical practices lost to the collective memory. In 2021, USFWS consulted with the State Historical Preservation Office and federally recognized tribes on the impact of all future marsh restoration on legacy infrastructures in salt marshes.

2. Proposed Action Alternative

Impacts to cultural resources for proposed action are the same as those described for No Action Alternative. The Proposed Action incorporates the use of prescribed fire as a habitat management tool. As fire containment strategies rely on wet lines, and minimize mechanical fire lines except on existing trails, we do not expect to have negative impacts on cultural resources.

INDIAN TRUST RESOURCES

Indian Trust Resources—Affected Environment

The indigenous people that lived in Northeast Massachusetts where Parker River and Thacher Island NWRs are located are known as the Pennacook (also called Merrimac), located around Concord, NH to north central Massachusetts. Parker River Refuge is in the general vicinity of the historical village of Kwaskwaikiken (anglicized to Quascacunquen), translated as "best place for planting corn", and

Waodagw8mek (anglicized to Agawam), translated to "other side of the marsh" (INHCC 2022; Lepionka 2023). The Penacook were part of the larger Abenaki Nation which stretched from Maritime Canada to central Massachusetts and belonged to the Algonquian (Algic) tribe of languages.

The U.S. Fish and Wildlife Service has a trust responsibility to consider whether its proposed actions have the potential to affect the interests of any federally recognized Tribal Nations, and to consult with Tribes if this potential exists. This is specified in the Service's Native American Policy (510 FW 1), in Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments), and elsewhere. The federally recognized Tribes in Massachusetts are the Wampanoag Tribe of Gay Head (Aquinnah) and the Mashpee Wampanoag Tribe. The tribe that historically lived in the refuge area, the Pennacook-Abenaki Band (Cowasuck Band 2023).

Indian Trust Resources—Environmental Consequences

No change from existing conditions anticipated under both Alternatives. As part of routine management, the Service's cultural resource office is consulted to ensure that no management action negatively impacts cultural resources or Indian Trust Resources. Consultations with recognized Federal tribes are initiated if determined necessary. The Service has consulted with the federally recognized tribes for all proposed marsh restoration work.

For the Proposed Action Alternative, areas of sensitive Indian Trust Resources will be identified, and briefing provided to all fire crews. These areas are to be avoided to the maximum extent possible (no ground disturbance) during prescribed fire strategies.

REFUGE MANAGEMENT AND OPERATIONS

Refuge Management and Operations—Affected Environment

Parker River NWR is currently staffed by ten permanent employees and several temporary employees. The staff consists of administration, management, maintenance, biology, visitor services, and a varying number of seasonal positions and interns. Parker River NWR has an annual budget of $1.2 million, which includes management of Thacher Island NWR, Great Bay, and Wapack Refuges. Thacher Island, Great Bay and Wapack NWRs have no dedicated employees, instead being managed by the Parker River Refuge staff.

Refuge Management and Operations—Environmental Consequences

1. No Action Alternative

Staffing and budgets influence the level of operational capacity the refuge has in any given year. Several activities are prioritized and occur each year, including monitoring and management of Piping Plovers on the beach, water level management in Bill Forward and Stage Island Pools, mowing of the old field habitats, and monitoring of marsh restoration and species and habitats of concern. Marsh restoration has been occurring slowly as funding and staffing capacity allows. The level of invasive species management that occurs each year is dependent upon funding and staffing, with the greatest effort expended on perennial pepperweed. Maritime shrubland/forest restoration has allowed the refuge to decrease time and money spent on mowing these fields, although operational costs related to invasive

species management in these areas has increased as staff work to suppress invasive species and encourage native species in the early years of restoration.

2. Proposed Action Alternative

In the long run, operational costs will decrease under the Proposed Action as we restore toward more functional and resilient ecosystems. Restoration of the impoundments will eliminate the need for constant water levels and invasive species management in these areas. In the short term, impoundment restoration will increase operational needs as refuge staff implement restoration and monitor the resulting changes. The same will occur with salt marsh restoration, as the various techniques are implemented and monitored. After restoration has been fully implemented and the results are found to be satisfactory, operational needs will decrease significantly in perpetuity.

Using prescribed fire as a management tool will increase operational needs to plan and conduct a burn; however, adding fire as a strategy to be used in conjunction with other mechanical, chemical, and cultural strategies may allow us to achieve improved ecological conditions, which will reduce treatment frequency in the long term. Additionally, completing a fire management plan will allow staff in FWS's fire program and their resources to be expended on the refuge.

SOCIOECONOMICS

Socioeconomics—Affected Environment

Parker River NWR is in the towns of Newbury, Rowley, and Ipswich and the City of Newburyport, Massachusetts in Essex County. Thacher Island is in the town of Rockport, Massachusetts in Essex County. Essex County was the third most populated county in the state in 2020 with 809,829 residents (USDC 2023). The population of Newbury was 6,716, Rowley was 6,161, Ipswich was 13,785, Newburyport was 18,289, and Rockport was 6,992. All towns and the City of Newburyport have had increased residential development since 2010, leading to an increase in population in all.

The predominant land uses near the refuges are residential and commercial development. Tourism plays a major role in the local economy, with local Chambers of Commerce citing Parker River NWR as one of the area's major attractions. Total expenditures from Parker River NWR visitors were $7.4 million ($2.3 million from residents and $5.1 million from non-residents) in 2006 (Carver & Caudill 2007) and $10.1 million in 2012 ($3.1 million from residents and $7 million from non-residents). Visitors spend money on lodging, restaurants, gifts, supplies, equipment rentals, gas, and other goods and services in the local communities. The beaches and marshes in these communities are a draw for tourists and the tax revenue generated from beach-front properties are increasingly important to their tax base. The refuge offers beach parking for 250 vehicles, supplementing the limited parking offered at the north end of Plum Island, and provides a beach, wildlife viewing, and natural vista experience that is unique from other North Shore beaches.

All six communities within the Great Marsh watershed have had strong identity and socioeconomic ties to the health and resiliency of the marsh since the 1600s (Schottland et al. 2017). These communities' economic sensitivity to climate hazards is intrinsically linked to the health and resiliency of their natural systems, especially beach/dune and salt marsh habitats. The local economy has a long tradition of relying upon its "relationship with the land and the sea" – a tradition that continues to this day with shell fishing and agriculture. These are primarily "bedroom" communities for people that commute to

the Boston metropolitan area, because of the rural character and scenic qualities. If these natural systems are negatively impacted by climate change, property values would likely decrease.

The beaches, dunes, and salt marshes of Parker River NWR and the larger Great Marsh provide several ecosystem services such as storm water retention, flood abatement, storm surge attenuation, and carbon sequestration. These marshes directly protect hundreds of homes and critical public infrastructure in Newbury, Rowley, and Ipswich.

Socioeconomics—Environmental Consequences

1. No Action Alternative

No change from existing conditions anticipated.

2. Proposed Action Alternative

The accelerated marsh restoration under the Proposed Alternative will greatly reduce the vulnerability of coastal communities in Essex County. The project will improve the resilience of coastal ecosystems, allowing the salt marsh to adapt to climate change. Several researchers have found that salt marshes are the most effective of shoreline protection against storms (Möller et al. 2014; Fagherazzi 2014). Whereas beaches and dunes dissipate lower energy waves but erode during high energy storms, a vegetated salt marsh platform, especially one with thick root mats and above ground vegetation such as that which exists in the Great Marsh, attenuate waves in all types of storms. Fitzgerald (2017) further highlighted the importance of having both a healthy foredune (beaches and dunes) and extensive salt marsh system, each providing protection and wave attenuation to the other.

Donatelli et al. (2020) and Leonardi (2015) stressed that marsh size and extent and the percent of vegetated marsh is exponentially linked to the ability of the marsh to persist under climate change conditions. The accelerated marsh restoration and breaching of the impoundments to restore tidal flowwill directly protect both marsh size and extent of the salt marsh system. Benefits to surrounding communities include: (1) Increased flood protection against storms by restoring resiliency to the marsh, (2) Increased carbon sequestration value of salt marsh (Forbrich et al. 2018b; Forbrich et al. 2018a), as salt marshes are twice as effective as forests in sequestering carbon (up to 40 feet of peat is currently sequestered, 4,000 years worth;if marsh is lost, the stored carbon will be released to the air), (3) Increased socioeconomic health of communities and local tourism tied to fishing (striped bass), shell fishing (softshell and razor clams), recreation (birding, hiking, kayaking, beach use), and tourism industries, and (4) Increased resilience of several critical infrastructure components identified by local towns in the Great Marsh Coastal Adaptation Plan. The economic value of salt marshes has been estimated at $5 million per square kilometer (Costanza et al. 2008).

In a 2012 visitor survey, birdwatching accounted for 32% of all refuge visitation; and 40% of those visitors were non-resident. While the shift from impoundment to salt marsh may shift some bird use in the impoundments, we do not anticipate a major change in birdwatching opportunities. The transition of the impounded areas to tidal flow and salt marsh, as well as adjacent natural area, will continue to support birds and this draw visitors interested in birdwatching and nature observation. We anticipate that visitation will remain high or increase for the other popular activities, including beach-going, hiking, and fishing. Currently, the visitation at the refuge exceeds the parking capacity, resulting in many closures during the summer months. We expect this demand to increase in future years.

The restoration projects proposed under this alternative are expected to create many jobs within the next 10 years. For salt marsh restoration, as many as 10-15 early career professionals and five machine operators and support staff are expected per year to complete restoration.

ENVIRONMENTAL JUSTICE

Environmental Justice—Affected Environment

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires all federal agencies to incorporate environmental justice into their missions by identifying and addressing disproportionately high or adverse human health or environmental effects of their programs and policies on minorities and low-income populations and communities. The refuge does not disproportionally impact minority or low-income populations; rather, the refuge provides a low-cost nature experience to all visitors and strives to be a good neighbor in the local community. The Service and staff actively seek to increase visitation and community services (off-refuge experiences) to under-served communities.

Environmental Justice—Environmental Consequences

No change from existing conditions anticipated under both Alternatives.

CUMULATIVE IMPACT ANALYSIS

Cumulative impacts are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7).

SALT MARSH RESTORATION

The Parker River Refuge is located within the Great Marsh, the largest contiguous salt marsh in New England and one of the world's most productive environments. Refuge staff are working with partners to restore 8,000 acres of salt marsh in the Great Marsh, including 2,500 acres on the refuge, using hydrological restoration techniques piloted by refuge staff and partners. We will continue to fine-tune and share these restoration techniques.

Restoring natural hydrology is a key priority for USFWS, NOAA, and many State agencies (MassWildlife) in coastal wetland ecosystems. The refuge's planned decommissioning of the impoundments and restoring tidal flow contributes to this State-wide goal (Commonwealth of MA 2023). The proposed alternative will contribute significantly to the USFWS's Saltmarsh Sparrow (SALS) Plan and the Massachusetts SALS Plan (ACJV 2022).

CLIMATE CHANGE

As coastal areas face rising sea levels, storm surges, and temperature changes, human responses to such climate changes could either increase or reduce adaptive capacity of these natural systems. Climate change is expected to have a significant impact on the geographic range, abundance, and diversity of

marine species off the New England coast. Several species rely on the coastal wetlands and seagrass beds for spawning, rearing, and foraging, so habitat changes will impact the broader coastal and marine systems. Increasing sea level rise can alter the extent and composition of coastal marshes within the refuge and alter freshwater flows into Plum Island Sound.

Collectively, the goals, objectives, and strategies in the 2023 HMP aim to increase the resilience and health of the barrier island ecosystem at Parker River Refuge in the face of climate change. This will restore and maintain natural processes and functions and allow for adaptive management as environmental conditions change from year to year, and sometimes in unpredictable ways.

The removal of the impoundments and transition to salt marsh are anticipated to have a positive impact on climate change. Saltwater wetlands including salt marshes have lower methane emissions than freshwater wetlands because the abundant sulfate ions in seawater limit microbial methane production. For this reason, some scientists argue that replicating and restoring salt marshes is more effective at sequestering carbon and reducing overall greenhouse gas emissions on relevant time scales than replicating or restoring freshwater wetlands (Kroeger et al. 2017). In Australia, Cadier et al. (2022) found that freshwater coastal wetlands had 100-fold higher methane emissions compared to tidally connected mangroves and salt marshes, concluding that restoring impounded wetlands will likely result in significantly less greenhouse gas emissions.

MONITORING

Refuge staff will implement the HMP in concert with implementing the Inventory and Monitoring Plan (IMP) (Pau 2021b). The IMP describes specific surveys and programs to monitor population trends, frequencies, and abundance for our highest priorities: barrier beaches and salt marshes (Pau 2021b), guiding which surveys are needed to help inform management actions. Surveys selected are closely tied to priority habitats and species, and habitat objectives.

The refuge's Habitat Work Plan (HWP) includes a review of the habitat management activities from the previous year, an evaluation of monitoring programs, and specific recommendations for habitat and wildlife management strategies and prescriptions for the coming year. It is a tool to implement and fulfill goals and objectives established in this Habitat Management Plan. The work plan incorporates adaptive management practices by evaluating the success or outcomes of specific management strategies and prescriptions that were implemented.

SUMMARY OF ANALYSIS

The purpose of this EA is to briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI).

ALTERNATIVE A – NO ACTION ALTERNATIVE

The No Action Alternative means that the refuge will continue to implement the goals, objectives, and strategies described in the 2007 HMP (USFWS 2007). The focus is on restoring existing salt marsh; maintaining the three impoundments; controlling invasive plants; protecting and monitoring breeding

Piping Plovers and Least Terns; protecting beach habitat for migrating shorebirds; implementing closures to protect sensitive and unique habitats; and mowing grasslands.

It is likely that the refuge would continue to uphold its responsibilities as a steward of trust resources and fulfill its designated mission. However, continuing with the current management limits our ability to utilize some tools, such as prescribed fire, to manage habitats and restricts our capacity to respond to climate change impacts. It requires us to spend increasing resources and staff time on management issues related to the impoundments and risking catastrophic failure of the dikes. Current management also does not fully incorporate recovery goals and conservation strategies for Piping Plover and other rare species. Overall, the No Action Alternative would not improve the Service's ability to meet its legally mandated mission to protect other trust resources, maintain biological integrity, diversity, and environmental health, and maintain functioning ecosystems across the refuge in the face of climate change.

ALTERNATIVE B – ACTION ALTERNATIVE

As described above, the Proposed Action is to implement the goals, objectives, and strategies in the 2023 HMP. The refuge will manage toward a set of *desired habitat conditions* that will sustain the ecosystems and natural processes over time and help meet other fundamental objectives, including recovery of federally threatened and endangered species, and support of migratory birds and other priority resources of concern, and maintaining biological integrity, diversity, and environmental health. The strategies are intended to focus on the highest habitat priorities on the refuge: barrier beaches and salt marsh, and their associated species.

The three impoundments will be decommissioned and converted from freshwater-brackish marsh to salt marsh to benefit associated plant and animal species and to improve climate resilience. Invasive plant species will be controlled to restore native plant communities, allowing for natural regeneration. Prescribed fire will be added as a management tool, in concert with allowing natural processes to maintain dynamic habitat conditions in the barrier beach ecosystems.

Seasonal closures and other public access restrictions (including no ORVs on the beach) will be continued and modified as needed to protect trust resources and the ecosystem health of rare and unique plant communities.

The Service is entrusted by Congress to conserve the entire suite of biodiversity and natural processes occurring within the Refuge System; protect migratory birds, federally listed threatened and endangered species, inter-jurisdictional fishes, and certain marine mammals; and fulfill refuge purposes. This Proposed Alternative aspires to meet those goals.

LIST OF SOURCES, AGENCIES AND PERSONS CONSULTED

LIST OF PREPARERS AND CONSULTATION

- Ellen Snyder, Contractor, Ibis Wildlife Consulting
- Nancy Pau – Wildlife Biologist, USFWS Parker River NWR
- Katlyn Hojnacki – Contractor, Employee from 2008-2018, USFWS Parker River NWR
- Noah Kahn – Conservation Planner, USFWS Northeast Regional Office

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STATE COORDINATION

As part of the Comprehensive Conservation Planning started in 2010, we consulted with Massachusetts Department of Fish and Wildlife (MassWildlife) and Massachusetts Department of Conservation and Recreation (DCR), and representatives of those agencies served on the core planning team. When we shifted to completing the HMP first, we continued to consult with MassWildlife on issues of concern to them. Specifically, we met several times on our plans for the management of the refuge's three impoundments, and the strategies and objectives in the Proposed Alternative reflect discussions with MassWildlife.

TRIBAL CONSULTATION

There are two federally recognized Tribes in Massachusetts; the Wampanoag Tribe of Gay Head (Aquinnah) on Martha's Vineyard and the Mashpee Wampanoag Tribe based in Mashpee on Cape Cod. These tribes will be consulted as part of the tribal consultation process for this EA. The Cowasuck Band will be notified as a member of the public.

PUBLIC OUTREACH

The planning for this HMP started as a comprehensive conservation planning process that would have incorporated all aspects of refuge management. When that process was discontinued, we decided to finalize the HMP to incorporate shifts in management since the 2007 HMP. As part of the CCP, we held several scoping and listening meetings with the public and met with conservation partners. Issues and concerns raised during those meetings related to biological management of the refuge were considered in the development of alternatives. The development of restoration techniques for salt marsh restoration had extensive outreach and coordination with researchers, conservation partners, and key stakeholders. These included many presentations, workshops, and site visits to share findings and discuss the best strategy forward for marsh resiliency.

This HMP and EA was released for public review for 30 days (September 28 to October 28); advertised in the local paper, on our website, and in multiple Facebook postings. Copies of the HMP were made available through multiple venues, including online, hard copies at the Refuge, Town offices, and local libraries. We hosted two in-person information sessions on October 11, 2023, and at the request of some visitors, hosted a third virtual info session via Zoom on October 25, 2023. Fifteen people attended the two in-person sessions, 125 people joined the Zoom session, and 145 people submitted comments in writing.

In reviewing the written comments, 107 submittals were strongly opposed to breaching the impoundments. Thirteen people expressed support for the HMP, including the proposed actions on the impoundments, but some of these people were sorry that this decision had to be made. Most of the opposition to the impoundment proposal is due to the anticipated impacts it will have on existing bird use as well as associated birding opportunities. Several people provided bird observation data from the

last 20 years, highlighting the importance of the impoundments to bird use and bird watching opportunities.

Staff reviewed all submitted comments and spent considerable time considering these comments for new information and perspectives, and making edits to the HMP and EA, where appropriate. Substantial comments and responses are summarized in Appendix A.

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DETERMINATION

This section will be filled out upon completion of any public comment period and at the time of finalization of the Environmental Assessment.

☑ The Service's action will not result in a significant impact on the quality of the human environment. See the attached **"Finding of No Significant Impact".**

☐ The Service's action **may significantly affect** the quality of the human environment and the Service will prepare an Environmental Impact Statement.

Action	**Signature/Date**
Prepared By:	NANCY PAU Digitally signed by NANCY PAU Date: 2024.02.12 06:14:05 -05'00' Wildlife Biologist, Parker River NWR
Submitted By:	MATTHEW HILLMAN Digitally signed by MATTHEW HILLMAN Date: 2024.02.12 09:49:36 -05'00' Project Leader, Parker River NWR
Reviewed By:	STACEY LOWE Digitally signed by STACEY LOWE Date: 2024.02.13 16:26:22 -05'00' Refuge Supervisor, North Zone
Approved By:	SCOTT KAHAN Digitally signed by SCOTT KAHAN Date: 2024.02.15 09:29:54 -05'00' Regional Chief, National Wildlife Refuge System

APPENDIX A.

SUMMARY OF COMMENTS RECEIVED AND REPONSES

SUMMARY OF PUBLIC COMMENTS AND RESPONSES

This is a summary of public input based on three public listening sessions (two in person sessions on Oct 11 and one via Zoom on Oct 25, 2023) and comments summited in writing during the public comment period (September 28 to October 28). Fifteen people attended the two in-person sessions, 125 people joined the Zoom session, and 145 people submitted comments in writing.

In reviewing the written comments, 107 submittals were strongly opposed to breaching the impoundments. Thirteen people expressed support for the HMP, including the proposed actions on the impoundments, but some of these people were sorry that this decision had to be made. Most of the opposition to the impoundment proposal is due to the anticipated impacts it will have on existing bird use as well as associated birding opportunities. Several people provided bird observation data from the last 20 years, highlighting the importance of the impoundments to bird use and bird watching opportunities.

With some exceptions, most people that commented were respectful and added thoughtful comments. It is clear that everyone that commented really cares about the Refuge and wishes to see the best management decisions for the Refuge. Despite the large number of people that oppose removing the impoundment, almost everyone seemed to support the overall HMP, many commenting on its thoroughness and the hard work that went into it.

The summary of comments below is divided into topics with subheadings. We tried to capture the flavor of the comments. Some of the summary statements reflect one or two commentors and others represent many people.

Impoundments

Why Not Improve the Impoundments

- Many feel that the impoundments have been extremely successful, even if not meeting one of the original goals for black duck nesting.
- Perhaps creating the impoundments was not the right thing to do, but nature adapts and now they provide critical habitat.
- Many asked why the USFWS can't improve the impoundments and water control structures so that they can be retained.
- Instead focus on controlling the invasive plants and animals.
- Suggest another option for the plan, to strengthen and raise the dikes, and find ways to increase water flow, management invasives and sedimentations.
- The impoundments are not natural, but "management" often requires modifying natural environments to benefit wildlife.
- Several people suggested maintaining the Bill Forward pool even if you breach the other dikes.
- Don't use the term "restoring impoundments" as the impoundments will not be "restored." Many people refer to the "destruction" of impoundments.
- Wish for a deeper evaluation of the plan to remove the impoundments.

In response to the overwhelming request to reconsider breaching the impoundments, staff have consulted experts and literature again and considered the pros and cons of not restoring tidal flow in the

impoundments. We still believe the proactive transition of the impoundments to a functioning estuarine habitat is the best way to ensure sustainable, functioning habitat for the wildlife. We have changed the term “restoring impoundments” to “restoring tidal flow” or “decommissioning the impoundments”.

Refuge staff did not arrive at the decision to decommission the impoundments lightly. Since the 1980s, staff have consulted with the nation’s leading expert on impoundment management, Leigh Frederickson, to improve conditions in the impoundments. After a decade of failed strategies, Dr. Frederickson first suggested returning the North Pool to salt marsh in the 1990s. Staff initially resisted this suggestion and eventually reconsidered.

For Bill Forward and North Pools, the risk of a breach comes from the Sound side. It is not the dike that is protecting the impoundment, but rather the salt marsh west of the dike that is providing protection against storm erosion. Raising the dike would temporarily stave off risk of failure from overtopping for some years; but we will still lose management capacity as the elevation delta increases. Further delay will only increase the cost of restoration and reduce the probability of restoration success. Furthermore, as these actions are costly and do not improve coastal resiliency, they are not likely to compete well for grant funding. The Stage Island Impoundment is vulnerable to breach from the ocean at 3 locations, and restoring a healthy salt marsh is the best strategy for protecting the road and access to Sandy Point.

The HMP proposes to phase decommissioning of the 3 impoundments, largely in consideration of the strong opinion previously expressed by the birding community about the value of the impoundment and loss of viewing opportunities. Phasing the restoration will allow us to understand bird and other wildlife response and the timeline for the transition of a freshwater impoundment to functioning salt marsh and allow the birding community to enjoy the current wildlife use in the other two impoundments longer. The timeframe for restoring the other impoundments is a place-holder and will be adjusted based on monitoring of the transition of Stage Island to estuarine habitat as well as the risk of breaching for the other two impoundments.

Loss of Habitat for Migrating Shorebirds and Waterfowl, Nesting Habitat for Marsh and Wading Birds, Waterfowl

- The freshwater impoundments are at the very core of the purpose of the Refuge. They are the key habitat that best demonstrates the whole reason the Refuge exists.
- Recognition of climate change, but removal of the impoundments will only harm those birds that use them.
- Local ornithologists have 40-50 years of documentation of bird use of the pools. Importance as high tide roost (esp Bill Forward Pool) for more than a dozen species of shorebirds; 50,000 shorebirds or more use the pools each year; perhaps most important site north of Cape Cod; one of few sites where long-billed dowitchers and stilt sandpipers seen during migration.
- Most people voiced concerns over loss of habitat to shorebirds, particularly high tide roost and foraging areas.
- Nesting habitat for gadwalls and mallards; migratory habitat for thousands of waterfowl.
- Many of these species using the impoundments are also in serious decline.
- Uncertainty as to whether these birds will shift to other habitats on the Refuge.
- No other protected freshwater habitat for these species in the region; concern for shorebirds that are pushed to beach/dunes and exposure to human disturbances.
- A few people mention the NJ Audubon report that highlights the importance of coastal impoundments, including at Parker River.

Construction of the impoundments is a deep-rooted legacy of US Fish and Wildlife Service and particularly the Refuge System. When most refuges were established in the 1940s and 50s, the predominant conservation belief was that humans can improve upon nature, and the focus was to increase waterfowl production by intensive management practices such as discing, mowing, seeding, pesticides, and water-level manipulations. By the 1970s, conservation ethics had broadened to be more holistic (to include non-game species) and habitat-based. Also, biologists better understood that the majority of waterfowl breeding was occurring in the Upper mid-west and Canada. The management of most impoundments on the East Coast shifted to supporting migrating and wintering waterfowl and shorebirds, primarily through water level manipulation. As many commenters noted, the impoundments hosted large concentrations of birds that were easy to view and survey during this period; but it is increasingly more difficult to manage the impoundment water levels to achieve biological goals, and we have observed a decline in peak bird use over the years. More urgently, the increasing subsidence of the impoundments relative to the adjacent salt marsh and increasing storm activity presents significant risk of system failure if we continue with the status quo.

Many people expressed concern over the presumed negative impact to shorebirds currently using the impoundments, if the dikes are breached. While much of past refuge survey data focuses on impoundments due to visibility and ease of surveying, a few efforts to survey shorebird use across different habitats indicate that shorebirds use other more extensive habitats at the refuge, including salt marshes, tidal creeks, and beaches. Refuge staff are confident that shorebirds will continue to use the mudflats that will be available post transition. These tidal flats will receive regular flooding and ebbing on a daily and monthly cycle, bringing in nutrients that support robust invertebrate populations, which are a primary shorebird food source. Iglacia and Winn (2021) noted that these invertebrates thrive in intertidal zones regularly submerged by ocean water and exposed to air and sun. Shorebird use at the Salt Pannes Observation Area post restoration is a good example of how these flats will continue to support shorebirds. As these flats transition to salt marsh over time, shorebirds will concentrate in flats adjacent to tidal creeks and salt pannes and pools that form in the marsh. As we are phasing the breaching of impoundments, we will have data on how shorebirds, waterfowl, and other birds respond to the shift in habitat with Stage Island Impoundment, prior to making changes to North Pool and Bill Forward impoundments.

Several people expressed concern that without the impoundments, shorebirds would not have undisturbed roosting areas during high tides. Within a natural estuary like Plum Island, there are many supratidal areas (areas that are not flooded during a normal high tide), including portions of beaches, tidal flats, and salt marshes, largely inaccessible by public, that will shelter roosting shorebirds during high tide. In many salt marsh pools, tidal flats will continue to be exposed during daily high tides. The Great Marsh (which includes the refuge) is designated as a regionally important site for shorebirds in the Western Hampshire Shored Reserve Network, largely due to the extensive salt marsh and related estuarine habitat (28,000 acres) and its geographic location. Shorebirds will continue to stop in the Great Marsh including the Refuge during migration, attracted by the diversity of healthy estuarine habitats, and the high density of invertebrates supported by tidal flooding.

Not Consistent with Refuge Mission, Biodiversity, Environmental Health,

- Several people recognized the important work of Refuge staff over the years, but don't agree with this management direction. They voiced that it is not consistent with why the Refuge was created or purpose of NWRs in general, including protection for migratory birds.
- Loss of 3 billion birds in North American since 1970…..don't add to the loss.
- Converting impoundment habitat to salt marsh reduces the diversity of habitats on the Refuge.
- Biodiversity is a goal, yet removing the impoundments will remove one of the most important habitats, raise the potential that storm surges will harm Hellcat Swamp, and reduced mowing has reduced the diversity of grassland birds.
- How will restoring ecological function and managing for invasive species help the birds and mammals currently on the Refuge?
- Is water quality or subsidence really an issue if all these birds are using the impoundments?

The primary mission of the US Fish and Wildlife Service and the National Wildlife Refuge System is to provide habitat for migratory birds for present and future generations of Americans. As the primary agency responsible for conserving migratory birds, the USFWS has developed a flyway approach to bird conservation. In collaboration with other agencies, non-profit organizations, academic researchers, and international partners (Canada and Latin America), bird conservation strategies are developed at various geographic scales for each category of birds. In this framework, USFWS seeks to preserve biodiversity at national and global scales. It is more effective and sustainable to protect and enhance bird populations where they are naturally the most abundant. The priorities for bird conservation at regional and national scales are stepped down to the network of over 500 refuges, as well as disseminated to partner organizations and lands. For Parker River, the highest priority bird species are black ducks and salt marsh sparrows, as well as shorebirds, waterfowl, and songbirds that use shrub habitat. We have revised the description of the prioritization processes detailed in Chapter 3 to clarify the link between managing for wildlife and the habitats that they depend on.

Biodiversity and environmental health are intrinsically important to conservation as it allows wildlife populations and ecosystems to adapt and evolve with stressors. Extreme weather and disease associated with climate change are already disrupting and shifting wildlife populations and plant communities. In the last 10 years, scientists and managers have documented many examples of how resilient and adaptable healthy habitats and wildlife populations are compared to human-engineered structures. These insights have further supported the philosophy that Land Managers must allow change to occur in the face of future climate stressors and restore healthy natural systems where we can. Although humans tend to think of biodiversity in the form of charismatic wildlife such as birds and large mammals, diversity is driven by abiotic factors in any habitat. Non-living organisms like soil, hydrology, and landforms determine plant communities and microbes, which in turn, determine the type of wildlife that will use a particular location. To meet the USFWS mission of conserving biodiversity on a national and regional scale, the HMP focuses on maintaining and restoring these basic building blocks of biodiversity, allowing nature and wildlife to adapt to future stressors.

What are the True Risks of Catastrophic Failure.

- What is difference between a catastrophic breach and the planned breach in terms of timeframe for salt marsh restoration in the pools?
- Concerns about how a planned breach would occur and if some of the negative impacts from a catastrophic breach might also occur with a planned breach.
- Will the breach in the dike not continue to erode?
- Has there been a successful planned impoundment breach and salt marsh restoration in the NWR System.
- Prime Hook is not a good example.
- Why not allow the breaches to occur naturally, over time?
- Question as to whether a failure of one or more of the dikes is an okay tradeoff given the current importance of the impoundments to other species.
- How realistic is a storm surge in these locations?
- The dike has been in place and worked flawlessly for more than 70 years. Will sea level rise really over-top the dikes?
- Some confusion about from where and how storm surges would come from and impact the dikes. Some feel that the existing salt marsh and lack of fetch in the Sound will limit any potential damage to the dikes. What is the structural integrity of the dikes?
- Some call for more detailed engineering studies of the dikes to determine if susceptible to failure.

Because the dikes have held for 70 years does not mean that they are not vulnerable to future storms; past experiences are no longer an indicator of future storm conditions. Numerous un-precedented storms in the past decade have demonstrated that we will experience more storms in coming years and that storms will be stronger than those historically experienced or modelled. In researching the question of impoundment vulnerability, refuge staff have consulted with several academic experts. The consensus among Coastal Geomorphologists (scientists that study the movement of landforms in response to storm and wave action) and Salt Marsh Ecologists is that the vulnerability of the impoundments is tied to the width of the salt marsh adjacent to the dikes. As the salt marsh gets narrower, that protection decreases exponentially. The erosion of marsh at the base of the dike at the main creek channel is also a factor in dike vulnerability. Simultaneously, increasing storm intensity increases the chance of a storm that can top the dike with each passing year.

For the last 20 years, USFWS has considered allowing the breach to occur on its own and has determined that it is not a responsible strategy given the increased risk due to increased storminess and the domino effect of negative consequences to the system. Researchers studying a barrier island in NJ like Plum Island, concluded that the longer a system is starved of sediment, the faster it drowns, and the longer it takes to recover after restoration (Meselis and Lorenzo_Truba 2017).

A carefully designed tidal inundation is different from an unplanned breach (as would happen in a storm) in several ways. In an unplanned breach,

- Breach location and size may be insufficient or too large, resulting in more open water and marsh loss. For Stage Island, the risk of breach is from the ocean. There would be a large conversion of marsh to open water, subsidence, and additional erosion.
- It may take many years to obtain funding and permitting to fix the breach. In that 3 to 7-year period (if we can obtain funding), hypoxia (dead zones) and significant loss of sediment is

anticipated, increasing the cost of restoration by orders of magnitude. The road and access to Sandy Point would be either cut off or highly vulnerable to breach depending on location of breach.

In the case of a carefully design breach,

- Location of the breach opening and size corresponds to that needed to fully inundate and drain the impoundment area, allowing vegetation to colonize. Sediment is expected to be imported to the system, allowing the marsh to recover from past subsidence and keep up with sea-level rise.
- The initial mudflats will be inundated by tidally-influenced water, creating robust invertebrate-rich tidal flats that will attract many shorebirds. Clams, snails, and mussels are also expected to recolonize these areas. Waterfowl will feed on these shellfish as well as the fish and seeds of vegetation colonizing the flats.
- Initially, we do expect a drastic change to the system and die back of much of the *Phragmites* and cattail that dominate this system; but some brackish species (like marsh fleabane and sedges) may survive, and salt marsh species (*Spartina*) will colonize over time. It may take a few years for the system to adjust to the new equilibrium and for vegetation succession to start. Careful monitoring will ensure that the hydrology and biogeochemistry is on the right trajectory, and we will have secured funding and permits to implement any needed adaptive management strategies.
- Because we are restoring the full tidal prism (not restricted which increases water velocity) and the tidal flow will be at equilibrium, the bank erosion at the opening is expected to be minimal. These details will be further refined during final design and permitting.

Impacts to Maritime Shrub/Forest in Hellcat Swamp

- Concerns that during storm events tidal waters will flood Hellcat Swamp, inundating and killing the vegetation.
- strong concern that breaching the North Pool will negatively impact Hellcat Swamp in future with sea level rise

Current hydrodynamics models indicate that Hellcat Forest will not be affected by restoring tidal flow to this area. However, increased inundation from sea-level rise (SLR) and marsh migration may affect this area. As this action is at least 10 years out, we will have better data to predict these impacts when design of this project is being finalized. To address these concerns, we have added the following strategy under the Impoundment (p129) and Maritime Shrub and Forest (p119) Objectives in Chapter 5:

- As part of modeling and final design for decommissioning of North Pool, explore vulnerability of Hellcat Forest to dieback with tidal restoration. Explore options to reduce impacts to Hellcat Forest both immediately post tidal restoration and under future SLR scenarios.

Inquiries about habitat and post breach

- How will you measure success of the Stage Island breach?
- Since the impoundment marsh elevations are far below current salt marsh levels, what is the timeline for new marsh areas to match existing marsh. What's to be done with excavated material. How will breach help raise elevation in former impoundments.
- If you get the right superstorm coming to the Refuge, the results will be catastrophic no matter what management plans you employ.

Final design and permitting for the Stage Island Impoundment will provide exact details on how the project will be implemented. Assuming that the soil is free of contaminants, any excavated material will be beneficially used on the marsh surface to create a diversity of microtopography. Extensive monitoring will ensure that the project is progressing as anticipated and adaptive management will be implemented to address any issues.

A successful project for Stage Island would be a tidal regime where the flooding and ebbing tides are in equilibrium. Visually, the former impoundment would have a mosaic of mudflats and vegetated marsh (*Spartina* and other saltmarsh species). The area is expected to have extensive mudflats immediately after tidal flow is restored. As much as possible, we will allow flooding tides to form tidal channels inside the impoundments, and deposit sediment on the marsh surface; thus, raising marsh elevation. Any area that revegetates in *Spartina alterniflora* will trap additional sediment and add biomass to marsh accretion (at rate of 6-10 mm per year or higher). The Stage Island Impoundment is currently losing elevation at rate of 2-3 mm per year.

In the event of a superstorm that breaches dunes, having a healthy salt marsh platform is the best protection for adjacent roads and dunes. Unlike human-made structures such as freshwater impoundments, which can fail if the storm exceeds its protective threshold, salt marsh attenuates and dissipates wave energy, particularly during large storms where the energy hits above the marsh platform and is slowed down by the friction of millions of flexible marsh grasses (Möller 2014, Baker et al 2022). In the event of a breach or dune roll-over, sand deposited on top of a salt marsh will be incorporated into the peat, as documented in peat cores on Plum Island, thus accelerating elevation gain.

Threatened and Endangered Species

- How is the Refuge balancing the conservation of state-listed species versus federal species of concern?
- Refuge has been successful at helping the endangered piping plovers, why helping to save other T&E species such as those that use the pools.
- EA says breaching the impoundments and restoring salt marsh there will benefit red knot and Atlantic sturgeon…how?
- Marsh and wading bird that annually breed in the impoundments include Least Bitterns, Virginia Rails, Soras, and less frequently American Bitterns, King and Clapper Rails, Common Gallinules, Pied-billed Grebes and American Coots.
- Least bittern are documented nesting in North Pool (ebird records) and have shown uptick after completion of the Hellcat boardwalk ; as well as nesting marsh wrens and Virginia rails.

As detailed above, the USFWS preserves biodiversity on regional and national scales. While many of the marsh and wading species mentioned by concerned birdwatchers are rare or difficult to observe in coastal Massachusetts, they are widespread both in the US and world-wide. North American Bird Conservation Initiatives (based on 50+ years of breeding bird surveys) lists Virginia Rail, Sora Rail, Least Bitterns, Pied-billed Grebes, and American Coots as common and widespread in the US with populations stable or increasing. American Bittern and Common Gallinules are also classified as Species of *Least* Concern, but population trends indicate a small decline in the US. All these species are also classified as Species of *Least* Concern globally, by the International Union for Conservation of Nature (IUCN).

Several individuals indicated that Least Bitterns were detected in North Pool in 2019 and 2020, and that the construction of the Hellcat Boardwalk may have decreased breeding numbers. In reviewing this comment, we realized that while the HMP correctly identified Least Bitterns and Virginia Rails as being detected in 2019 and 2020 in surveys conducted by MassWildlife staff; the EA had an error, replacing Sora Rails with Least Bitterns. We've corrected the graph in the EA and the paragraph. As noted above, the major driver for the decision to restore tidal flow is to minimize risk of catastrophic failure and restore healthy, functioning habitats. Thus, this correction did not substantially change the decision.

USFWS has been coordinating with MassWildlife on the development of this HMP and the management options for the impoundments. MassWildlife withdrew their opposition to the proposed breach after a series of meetings between the agencies. Additional review under Mass ESA will occur with the final permitting for the project (Water Quality Certification).

Some species, such as American bittern, King and Clapper Rails, and Marsh Wrens will continue to use the salt marsh. Use of the salt marsh by rails will likely increase; however, detectability may be low due to the dense vegetation preferred by these species.

Red knots and Atlantic sturgeon are species that currently use salt marsh and tidal creek in Plum Island Sound. Post tidal restoration, the tidal creek and tidal creeks created in the new tidally connected estuary would support these federally listed species.

Loss of Birding Opportunities, and Reduced Support for the Refuge

- Loss of landscape aesthetics, wildlife viewing experiences.
- A place of peace for people to be out in nature.
- Refuge, aka Plum Island, is a place where I find happiness, inspiration, joy, and the "wonder and wow" of all that Nature offers us.
- Globally, nationally, and locally significant birding experience.
- The Refuge draws many first-time birders, which builds foundation for environmental support here, and elsewhere.
- Brings ecology and ornithology classes to see the diversity of birdlife in the impoundments and elsewhere on the Refuge; the freshwater impoundments are what makes Parker River unique.
- Concerns that this [impoundment] change will reduce support for the Refuge. Please recognize that you currently have world-class support for this Refuge, which would likely change (this was conveyed as a gentle message not antagonistic).

Refuge staff are gratified to hear how special and important Parker River NWR is to so many visitors and recognize the responsibility of managing a refuge beloved by so many. We further recognize that the breaching of the impoundment to shift these freshwater and brackish impoundments back to salt marsh will change the wildlife use and wildlife viewing opportunities. However, refuge staff believe that the Parker River NWR will continue to provide world class birding experiences, and that the changes proposed in the HMP, including making the impoundments resilient to future climate threats, are the best strategies for supporting future wildlife and wildlife viewing.

After initial transition, much of the former impounded wetland will be mudflats in Stage Island. As demonstrated in the Salt Pannes Observation Area after hydrological restoration in 2019. These mudflats will support both shorebirds and waterfowl depending on the tidal stage, and will provide great viewing opportunities for 2-5 years post tidal restoration. The initial flush of saltwater will kill a majority of *Phragmites* currently occupying the Stage Island Impoundment, improving wildlife viewing

initially. Post tidal restoration, we anticipate salt marsh plants (mainly tall *Spartina alterniflora*) to colonize the mudflats where elevation is above mean low water. Tidal water will bring in sediment that will build up elevation in the pool over time. As elevation increases, additional mudflats will be colonized by salt marsh plants. This revegetation may hinder wildlife viewing opportunities; but the elevated tower at Lot 7 and the Observation Platform at Stage Island will provide excellent views into this transitioning habitat that will support a suite of different bird species as it transitions from brackish marsh to salt marsh.

Potential impacts to the many bird species and groups identified in the comments are discussed above. We do recognize that opportunities to view some marsh and wading bird species associated with freshwater wetlands, such as Least Bittern, Virginia Rail, and Sora Rail will diminish; but other marsh and wading birds, such as King and Clapper Rails, American Bitterns, and Marsh Wrens readily use salt marsh habitat. Some species such as Clapper Rail and federally listed Black Rail are likely to use the restored salt marsh habitat, particularly tall *Spartina alterniflora* marsh, which the impoundment will initially shift to.

Importance of the Phragmites Stands to roosting Tree Swallows and Northern Harriers.

- North Pool cattails and Phragmites beds are used by an estimated ¼ million swallows as a night roost during migration. Also used by northern harriers as a night roost during winter
- Some research shows that Phrag helps with erosion control and climate change resiliency.
- No indication that the Phrag is harming birds, just the opposite.
- Doesn't think Phrag are currently being controlled by salt water as sees the plant all around the Sound.

While *Phragmites* do accrete sediment; the freshwater peat it currently builds will deteriorate quickly and decompose in the case of an unplanned breach. This rapid decomposition can use up all dissolved oxygen and lead to hypoxia, leading to massive die-off of aquatic species. When conditions are favorable, such as those created in the impoundments, *Phragmites* forms monotypic stands and greatly reduces plant community diversity. Multiple studies have shown that the sulfide in salt water is toxic to *Phragmites* and that increased tidal flushing helps control *Phragmites*.

The swarming of tree swallows on the refuge, particularly as it's coming into the roost in the North Pool is an incredible wildlife experience. The tree swallows are drawn to Parker River for the berries and insects in the Maritime Shrub habitat and will continue to flock to Parker River when the impoundments are decommissioned. They will find new areas to roost (including shrub habitat) when the *Phragmites* and cattails in the existing impoundments transition to other plants; or they may continue to use *Spartina alterniflora* in these areas, which has a similar structure.

Northern harriers are a commonly observed species on the refuge, often seen foraging the salt marshes, dunes, and grasslands for small mammals. They will continue to use the refuge after the decommissioning of the impoundments.

Saltmarsh Sparrows

- Disagree with removing the impoundments and restoring to salt marsh to help Saltmarsh Sparrows, while losing all the other species that use the impoundments.
- There is plenty of salt marsh habitat for the sparrow.

- Recognize that Saltmarsh Sparrows also need help, but a small amount of salt marsh habitat will be gained for this sparrow, while the FW marsh is important for hundreds of other species and removal will be detrimental.
- How will restored salt marsh in the former impoundments help the Saltmarsh Sparrow if mercury levels are high?
- How is the Refuge planning to address the mercury on the Saltmarsh Sparrows?
- HMP states that a goal is to maintain at least 1,000 acres of suitable habitat for Saltmarsh Sparrows, but also states that Refuge currently manages 2,735 acres of salt marsh. How many acres of suitable SMSP breeding habitat is there currently on the Refuge?

The main decision to decommission the impoundments is due to the risk of failure with increasing storms and the goals of increasing climate resiliency and environmental health. Any benefits to salt marsh or Saltmarsh Sparrows would be supplementary. Having said that, we have documented Saltmarsh Sparrows using salt pools that breached and are recolonized by *Spartina alterniflora.* Use of *S. alterniflora* by sparrows for nesting has been documented by researchers in NY..

The refuge and the Great Marsh support the most robust population of Saltmarsh Sparrows in New England (50% of Massachusetts population, and 5% of its global population). Further, past studies have shown that the refuge serves as a source population to smaller populations from Maine to Long Island, preventing local extirpation of those populations (Walsh 2009).

While the refuge manages over 2,700 acre of salt marsh, not all acres are suitable for sparrow nesting as some marsh surfaces flood too frequently to support nesting. With sea level rise, the % suitable for nesting is expected to decrease; but allowing natural processes that build elevation and allow for marsh migration will improve chances of sparrow populations surviving and giving time to adapt to future conditions.

Refuge staff worked with EPA and other partners to investigate the pathways of mercury bioaccumulation from 2004-2016 (Pau et al 2021). We did not find upland sources of mercury input, but better identified environmental factors that made mercury available for uptake in the food chain. While high mercury concentration does negatively impact sparrow behavior and potential breeding success, these impacts are outside the ability of management actions to address. Therefore, the best strategy for enhancing sparrow populations is to provide nesting habitat that is not flooding too frequently, and allow time for sparrows to adapt to changing habitat conditions.

Climate Change

- Sea level rise may impact the Refuge Road more than the habitats.
- What has the Refuge been doing prior to 2007 to mitigate for climate change?
- What is the difference between marsh conversion and marsh loss?
- How is marsh migration modelled and how is it expected to occur on the Refuge?

Natural habitats, especially those where natural processes are intact, will adapt to sea level rise, and be more resilient compared to human structures, like the Refuge Road. An extensive and healthy dune and salt marsh system is the best storm protection for the road; the wider the buffer from open water, the more protection the road receives.

Since 2008, refuge staff have been monitoring how each habitat on the refuge responds to climate change, and this HMP summarizes the vulnerability of each habitat based on those studies. Prior to 2007, regional climate data is not sufficient to accurately identify impacts at a local scale.

Marsh loss occurs when vegetated salt marsh converts to open water or mudflats. Marsh conversion can cover many types of changes, but in the HMP, it generally refers to when one type of salt marsh (i.e. *Spartina patens*) converts to another type (pool or *Spartina alterniflora*).

There are several good marsh migration models developed for Massachusetts. Two that help guide refuge management is the Mass Coastal Zone Management's statewide SLAMM model, and The Nature Conservation's marsh migration model. Both models show significant marsh migration potential west of the refuge boundary, as well as potential for the salt marsh to migrate easterly towards the existing dunes (although the road is likely to be a barrier for this migration). The Service owns very little upland habitat where marsh migration will occur to the west, but we will work to facilitate that in future where we do own upland. Protecting migration pathways through land acquisition is a high priority for several partner organizations, including Greenbelt, Mass Audubon, and MassWildlife.

Political/Funding Decisions

- Concerns that the decision to remove the impoundments is based on lack of staff and funding to fix and maintain the impoundments.
- Will there be funding for breaching the dikes but not for building the bridges for public viewing?
- Is this proposal due to a federal mandate to restore salt marsh?
- The HMP may be more aspirational than realistic given climate change and that most coastal resiliency funding goes to protecting human infrastructure and not habitats.
- Several people noted the need for more funding for the Refuge and some even suggested raising private funding to save the impoundments and using volunteer labor to address staffing shortages.

Fiscal responsibility is a consideration for how staff manage the refuge; however, the decision to decommission the impoundment is largely driven by the risk of ecological damage in case of an unplanned breach. Protecting and restoring salt marsh habitat is one of the highest priorities for the USFWS, but decisions at the local refuge level consider many issues and actions. Decommissioning the impoundments and restoring ecological function and adaptive capability is the best strategy to ensure that space will continue to support future wildlife needs.

Many of the activities proposed in the HMP rely on Federal grant programs for funding. There are significant Federal and State funds to restore coastal ecosystems as it is widely recognized as the most cost-effective way to provide long-term protection to wildlife, ecosystems, and human infrastructure. Funding for reinforcing infrastructure tends to prioritize highly populated areas. Refuge staff are actively seeking funds for design and construction of a bridge to maintain access to the Stage Island Trail. Where feasible, we will incorporate bridge design and construction with requests for tidal restoration funding.

Support for Removing the Impoundments, Support for Salt Marsh Restoration

- Although a birder, recognizes the importance of restoring salt marshes, one of the most imperiled ecosystems in the world. The purpose is clear and the science is sound.
- Several people supported, but seem anguished by the choice, given loss of the freshwater habitats and associated birds (this included members of the Friends Group).
- Several people said originally opposed, but after reading the HMP and participating via Zoom, fully support the HMP – understand the scientific underpinnings and need to act sooner than later.
- Once one has read the supporting evidence and understand the urgency of acting sooner rather than later in the face of climate change, one must let go of nostalgia for how things used to be, and take the necessary action to protect the Refuge for future generations. I am deeply impressed by the years of research, and voluminous documentation that have gone into this proposal. Decisions such as these must follow the science, and I am convinced that this HMP does that.
- Supports restoring the impoundments to salt marsh…creating the impoundments originally was a mistake. The salt marsh, pannes, and mudflats are important for shorebirds. And invasive Phrag is a problem. Also suggests removing the entire dikes to fully restore the today flow.
- Support, but take an adaptive management approach – Stage Island first and wait several years giving time for thorough eval of results. Has experience with salt-water inundation of Phrag – works but not completely.
- Go slow.
- Focus restoration on edge of mainland where more room for saltmarsh migration to occur.
- Support the work of the refuge to restore salt marshes in places other than the impoundments.
- Support the Refuge salt marsh restoration efforts (excluding the impoundments).

Refuge staff appreciate the support and the understanding of the science that informed the decisions in the HMP. We understand this change is difficult for many and we will continue to use the best science to guide future management.

Grasslands

- Lack of mowing has reduced viewing of grassland birds, such as bobolinks
- Mowed fields were important to wintering raptors. Letting North Pool field go to shrubs has reduced optimal opportunity to see wintering raptors
- Grasslands receive no management, resulting in a loss of important habitat.

Grass species (mainly non-native) in the fields declined due to reduction in intensive farming practices (discing, seeding, etc.), and the soils and hydrology of the sites to naturally favor shrub species (see p 79 of HMP for details). The rationale for transitioning some of the units back to shrubs is detailed on page 70 of the HMP. To accommodate wildlife viewing, we will continue to maintain 3 fields and existing impoundment dikes (totaling 69 acres) for nesting Bobolinks. Cross Farm is being maintained as a grassland unit as it has the most potential to attract birds that require larger acreages (like Meadowlark and Savannah Sparrow), although significant management is needed to restore conditions to support these nesting species. Past funding requests for these grassland restoration projects have not been successful.

Maritime Shrub and Forest and Sandplain Grassland

- These habitats are critical, especially with future sea level rise, so make this a category I priority and focus on invasive plant control and management and monitoring of the native plants.

Maritime Shrub is a high priority habitat and supports migratory birds of high regional priority. The classification of this habitat as a Category II is because this habitat is healthy and self-perpetuating and does not require active management to maintain; not because it is not important to conservation. Chapter 3 of the HMP was revised to clarify this (page 64).

Prescribed Fire

- Would like more detailed maps of the prescribed fire units and plans.
- Concern about potential for a prescribed fire to get away (wasn't that why Refuge originally planted black pine) and about carbon emissions from fire.
- Does not support prescribed fires as a management tool.

Certain habitats at Parker River, such as the Pitch Pine Forest are fire adapted and reintroduction of fire will help stimulate plants native to that habitat. Because a Fire Management Plan is a long-term plan, 15 years or longer, all vegetated habitat is included in the plan. It includes both prescribed fire and management of a wildfire. After the HMP and EA are finalized, Refuge staff will work with the USFWS Fire Program staff to develop a Prescribed Fire Plan for Parker River. These shorter-term plans (typically 3 years) will describe in more detail the units to be burned and strategies to be used. To prevent escaped fire, the USFWS has very strict guidelines and conditions that need to be met before prescribed fire is put on a parcel.

Air quality impact from fire is discussed in the Environmental Consequences in the EA. We have added more details on impact of air quality from fire and mitigation measures, as well as impacts of carbon emissions and sequestration under both Alternatives.

Law Enforcement and Public Access and Outreach

- Lack of gate staff at times reduces income to the Refuge and reduces opportunity to educate visitors.

Presently, refuge staffing includes 1 permanent, year-round gatehouse staff member and 1 seasonal, full time gatehouse staff member. During a typical summer, up to two interns are hired, often from the local community. While we make an effort to staff the gatehouse during open hours within the busiest season (April – September), other duties including programming, environmental education, maintenance, administrative tasks, trainings, and meetings, resulting in some gaps in coverage and the need to prioritize accordingly. This spring the refuge will be adding a self-serve kiosk for visitors to purchase a pass using a credit card when the gatehouse is not staffed.

- Beach goers are abusing the rules – need more law enforcement.

From May to early August, volunteer beach stewards have been very effective at improving outreach and encouraging beachgoers to follow the regulations. Staff are also working with social scientists and other beach managers to improve compliance through more effective communication strategies and signs. While Parker River NWR Complex only has one full-time officer covering 4 stations in Massachusetts and New Hampshire, the refuge does draw on officers from other refuges during periods of unusual high visitation, such as summer holidays and certain weekends.

- A concern about roadkill on the refuge road.

In 2021, the refuge collaborated with the Volpe Center within the Federal Highway Administration to evaluate road safety including conflicts between wildlife and vehicles and identified short-and-long-term strategies to improve roadway conditions. The refuge is continuing to develop short-term traffic calming measures including deploying speedbumps, improving signage, and deploying messaging regarding traffic speed and road safety; longer-term improvements are under consideration.

- Refuge should allow year-round public access to the beach via motorized vehicles.

These decisions were made previously by Refuge Management and are not being considered in this HMP.

- Suggest more interaction between staff and visitors so there is more two-way communication.

As a high-use refuge, staff manage many public use issues, including those mentioned above (staffing of gate, road kills, speeding, trespassing, etc.). Staff have been developing more value-based messaging and outreach to increase compliance and appreciation of refuge resources. Members of the public are also welcome to volunteer to assist with public outreach based on their areas of interest.

Better aligning refuge outreach with ongoing biological management is a high priority for the visitor services team. Recently, this has included regular outreach around shorebird disturbance and migration, salt marsh restoration, and invasive species management. When feasible, refuge rangers are also providing "roving interpretation" at sites around the refuge. These efforts will continue alongside proposed actions in the HMP, and we welcome any feedback for specific questions, programs, or locations.

- Abutter requested improved boundary signage at Newbury Forest.

We will add this task to assess the boundary sign and replace or add where appropriate or where there are issues with trespass. In case of refuge visitors inadvertently passing into private property, please email the refuge directly at parkerriver@fws.gov

The HMP Process/ Socioeconomic Impacts

- People don't believe their comments will matter.
- Several comments that the draft HMP should have been made available sooner and more widely available.
- A few said they appreciated presentation by Nancy, but still don't support removal. Most people were considerate and thoughtful in their comments.
- Several people acknowledge the hard work that went into the HMP, recognize all the challenges but still don't support the impoundment removal as not realistic outcomes (unknowns and lack of funding).
- A few suggest that the HMP requires an EIS given the significant impact it will have on the local economy/human environment. Another suggests you need better economic data to show potential impacts.
- Many suggested that there would be local economic loss due to fewer visits by birders and others that patronize local restaurants, bars, gift shops, gas stations, lodging, etc. One person commented that the socioeconomic info in the EA is boilerplate.
- A third-party review of the HMP seems warranted.

- In the Alternatives, consider decoupling the ongoing salt marsh restoration from the impoundment decommissioning, as strong support for former, but not the latter.

Staff have been reviewing all submitted comments and have spent considerable time considering these comments for new information and perspectives, and making edits to the HMP and EA, where appropriate.

Staff made the HMP available through multiple venues, including online, hard copies at the Refuge, Town offices, and local libraries. The availability of the HMP and comment period was advertised in the local paper, on our website, and in multiple Facebook postings. Fliers were also posted at the Visitor Center. We hosted 2 in-person information sessions, and at the request of some visitors, hosted a third virtual info session via Zoom.

In developing the HMP, the Service has consulted many partner organizations and experts, in addition to pulling best available science from published literature and from federal, state, and regional strategic conservation plans. These consultations are detailed in the **Agencies and Persons Consulted** section of the EA. Where permitted by NEPA, we have shared the HMP with third-parties for review and comment prior to release to the public.

The analysis for socioeconomic analysis was based on targeted analysis completed specifically for the refuge and adjacent communities. We added sections to address concerns about economic loss due to fewer birding visitors. The refuge will continue to provide many wildlife viewing opportunities (as described in Visitor Use Experience in the EA) in its varied habitats and we anticipate demand for visitation to increase in future years.

Other Comments

- Someone asked about surveying opinions about hunting and beach closure on the Refuge.
- Comment requesting end of hunting on the Refuge and seeking alternative methods of population control.

Hunting is one of the 6 priority uses identified by Congress at a National Wildlife Refuge. Parker River NWR was purchased by proceeds from Duck Stamps, thus hunters contributed significantly to the preservation of the refuge. Additionally, alternative methods of population control (for deer) have not proven effective where they were tried.

- Boat wakes are causing marsh erosion. Should enforce no wake zones to mitigate this.

Enforcement of boat wakes is within the jurisdiction of each Town, as the Refuge does not own the creeks. Refuge law enforcement coordinates with Town harbormaster and encourages enforcement of boat speed regulations.

- Consider phasing out use of herbicides, similar to how mosquito spraying was stopped.

Refuge staff have significantly reduced herbicide use in the last 10 years, limiting its use to where it is critical for conserving biodiversity, using chemicals that are least harmful to the environment and humans. While we are exploring alternative methods of controlling invasive plants, judicious use of herbicides is still an important tool to conserve the habitats on the refuge.

- Some inconsistencies in the Animal Communities and T&E Species descriptions. Listing of Federally and State listed; and missing other

- The Three-spined stickleback on PRNWR is not state-threatened; the one in peril is a three-morph population found only in a pond in Boston.
- Pg 16 in EA mentions Bombay Hook…should this be Prime Hook?
- Add shining sumac to species list and discuss the purple martin nest sites.

Thank you for your thorough review. We've made edits to the HMP to correct the above inconsistencies; and clarified other sections.

Thatcher Island

- Rockport resident recommends restoration of terns and NE cottontail to Thacher Island.
- Another recommends against a tern colony due to proximity to mainland predators, potential persecution of gulls by USFWS. Also doesn't think terns and cottontails would go well together.

Thank you for your comments. USFWS will work with Thacher Island Association, the Town of Rockport, and the NEC captive rearing group to develop specific plans to establish a breeding colony of New England Cottontail on Thacher Island. Tern restoration is being postponed pending sustained additional staffing.