Chapter 4

USFWS

Northern red-bellied cooter on Massasoit National Wildlife Refuge

Environmental Consequences

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Introduction

This chapter describes the environmental consequences that we predict from implementing the two management alternatives presented in chapter 3. Where detailed information is available, we present scientific and analytic comparisons between alternatives and their anticipated consequences which we describe as "impacts" or "effects." In the absence of detailed information we make qualitative comparisons based on our professional judgment and experience. Specifically, we predict the effects of implementing the management actions and strategies for each of the alternatives: "Alternative A, Current Management," which serves as the baseline for comparing "Alternative B, Expanded Management" (Service-preferred alternative).

This chapter is organized by major resource headings. Under each heading, we discuss the beneficial and adverse effects likely to occur over the 15-year life span of the plan. Beyond the 15-year planning horizon, we give more speculative (greater uncertainty) descriptions of the direct, indirect, and cumulative effects expected. Table 4-1 at the end of the chapter is a side-by-side summary comparison of the expected effects by alternative. Concluding the chapter, we identify the irreversible and irretrievable commitment of resources from our proposed actions, as well as the relationship between short-term uses of the environment and long-term productivity, their cumulative effects, and the relationship to environmental justice.

As required by CEQ and Service regulations for implementing NEPA, we assessed the importance of the effects of the CCP alternatives based on their context and intensity. The scale of impacts ranges from local and site-specific to regional.

This chapter does not describe in any depth the consequences of certain types of actions that do not individually or cumulatively have any significant environmental impacts and are common to both alternatives described in chapter 3 for either alternative, especially "Service-preferred alternative." Each could be categorically excluded if proposed as a stand-alone action, and include:

- Research, resource inventories, monitoring and other resource information collection.
- Routine, recurring management activities and improvements such as planting native species or controlling invasive species.
- Small construction projects (e.g., fences, kiosk, interpretive signs).
- Issuance of new or revised management plans when only minor changes are planned.
- Law enforcement activities.

Effects on Air Quality

We evaluated the alternative management actions proposed that have the potential to improve or cause adverse air quality effects locally, in the region, and globally, including:

- Maintaining 209 acres of essentially continuous, natural vegetative cover across the refuge.
- Applying prescribed fires to manage mixed pine-oak shrubland, woodland, or forest areas.
- Applying herbicides to control invasive plants.
- Increased emissions from motor vehicle and motorized equipment use.

Air Quality Impacts Common to Both Alternatives

Massachusetts' air quality, including the refuge and immediate vicinity, is considered generally good, except ground level ozone. The nearest air quality monitoring station to the refuge in Brockton, Massachusetts has not however recorded an ozone standard violation over a 3-year average (MADEP 2012).

There will be minor air quality benefits from the pollutant filtering effects of maintaining 209 acres of upland and wetlands vegetation and coastal ponds. Trees (vegetation) filter some air pollutants and reduce the concentration of ambient ozone, SO_2, NO_2, CO, and fine particulate matter (PM10 and PM2.5), primarily through direct uptake and adhesion to stems and leaves (Escobedo et al. 2007).

Libby Herland/USFWS

Controlled burn underway at Massasoit National Wildlife Refuge

Potential air quality impacts from prescribed fire on human health and public welfare range from occupational exposure to smoke for firefighters to public health, soiling of materials (economic losses), public nuisance, and highway safety impacts from reduced visibility. Sandberg et al. (2002) provide a comprehensive overview of current knowledge about the effects of wildland fires (including prescribed fires) on air quality. The major pollutant of concern is fine PM—both PM10 (fine-10 micrometers or less) and PM2.5 (very fine—2.5 micrometers or less) particles (Sandberg et al. 2002). Studies indicate that 90 percent of all smoke particles emitted during wildland burning are PM10, and 90 percent of that PM10 particulate matter is PM2.5 (Ward and Hardy 1991). Particulates can reduce visibility or cause negative health effects for people with respiratory or cardiovascular illnesses (Hardy et al. 2001). Several population subgroups are more sensitive to fine particulates include asthmatics, children, the elderly, and individuals with cardiopulmonary disease.

The air emissions of greatest interest from prescribed burning include fine particulates (PM10 and PM2.5), CO, methane (CH_4), NO_x, SO_2, and other greenhouse gases including carbon dioxide that forms when elemental carbon combines with oxygen already in the atmosphere. While CO overexposure causes serious health problems and can prove fatal, CO is diluted and disperses rapidly as it mixes with ambient air downrange from the combustion source. As such, CO emissions are primarily an occupational health concern for prescribed burn personnel, not for the general public.

Prescribed fire can produce trace amounts of many different hydrocarbon compounds, a few of which are known to be harmful or toxic at higher concentrations. Wildland fuels typically contain less than 1 percent nitrogen, of which approximately 20 percent is converted to NO_x during combustion. Both hydrocarbons and NO_x are believed to be precursors for ozone formation once exposed to sunlight and warm temperatures in the atmosphere (Hardy et al. 2001).

Although long-term health effects from occupational smoke exposure remain unknown, evidence to date suggests that brief, intense smoke exposures can exceed short-term exposure limits in peak situations, such as for firefighters holding firelines downwind of an active prescribed burn. Work shift-average

exposure only occasionally exceeds recommended instantaneous exposure limits set by the American Conference of Governmental Industrial Hygienists, and rarely exceeds Occupational Safety and Health Administration time-weighted average (TWA) limits (Reinhardt and Ottmar 2000; Reinhardt et al. 2000). Overexposure increases to 10 percent of the time if exposure limits are adjusted for hard breathing, extended hours, and high elevations which intensify the effects of many of the health hazards of smoke (Betchley et al. 1995, Materna et al. 1992, Reinhardt and Ottmar 2000, Reinhardt et al. 2000). Smoke exposure is a hazard for only short periods, is predictable, and therefore manageable. Fireline practices such as crew rotation, awareness training, and carbon monoxide monitoring can mitigate the hazard, allowing firefighters to focus on fire containment by lessening the distraction, discomfort, and health impacts of smoke exposure (Reinhardt and Ottmar 2000). The long-term health effects of occupational smoke exposure to wildland firefighters are unknown in spite of anecdotal evidence suggesting a greater incidence of cardiopulmonary disease and death compared to the general population (Sandberg et al. 2002).

Deposition of smoke particles on building surfaces, automobiles, clothing, and other objects reduces aesthetic appeal and can damage a variety of objects and structures (Baedecker et al. 1991). Smoke may also discolor artificial surfaces such as building bricks or stucco, requiring cleaning or repainting that can become an economic burden and reduce the useful life of soiled material (Maler and Wyzga 1976). Soiling from smoke also changes reflectance of opaque materials and reduces light transmission through windows and other transparent materials (Beloin and Haynie 1975). When very fine (PM2.5) smoke particles infiltrate indoor environments, soiling of fabrics, painted interior walls, and works of art may occur.

Nuisance smoke is the amount of smoke in the ambient air that interferes with a right or privilege common to members of the public, including the use or enjoyment of public or private resources (USEPA 1990). Nuisance smoke complaints are linked to impaired visibility, odors, and ash fallout. Acrolein (and possibly formaldehyde) in smoke at distances of 1 mile downrange from the fire source can cause eye and nose irritation, amplifying nuisance conditions (Sandberg and Dost 1990). Individuals within 1 mile of prescribed burn operations on Massasoit NWR may experience the irritating effects of acrolein or formaldehyde with unexpected wind direction shifts.

Smoke becomes a potential problem when it drifts into areas of human habitation. Perhaps the greatest nuisance effect of prescribed fire smoke is local, temporary visibility reduction in areas impacted by the dispersing smoke plume. Visitor enjoyment and satisfaction in the vicinity of the refuge may be diminished by reduced visibility (Sandberg et al. 2002). Smoke can impede drivers' ability to see the roadway and can contribute to loss of life and property damage at concentrations far below NAAQS. At night, smoke can be entrapped near the ground, combine with fog, and rapidly create low visibility leading to roadway accidents. The potential exists for limited smoke intrusions onto the public roads from refuge prescribed fires.

Potential impacts from long distance transport of "regional haze" on Class 1 areas such as national parks, monuments, or certain units of the NWPS are discussed later under Cumulative Effects.

Fires emit pollutants that are precursors for ozone formation such as volatile organic compounds and NO_x Burning during the summer "ozone" season has potential to cause greater impact to air quality when hot (e.g. above 90 °F), stagnant atmospheric episodes (and State issued air quality alerts) are more

common. Ground-level ozone, a criteria NAAQS pollutant, has had past violations in eastern Massachusetts. Emissions from burning wildland fuels (especially NO_x) subjected to sunlight and warm temperatures, mixing with the regional atmosphere, as well as nitrate and indirectly sulfate aerosols, contribute to ozone formation (Sandberg et al. 2002). Stith et al. (1981) mapped ozone mixing ratios in an isolated, fresh, biomass-burning plume and measured low or negative changes in ozone values, attributed to titration by NO and low ultraviolet (UV) intensity. Near the top of the plume, 10 km downwind, and in smoke less than 1 hour old, they measured increases in ozone as high as 44 parts per billion. Ozone changes were positively correlated with high UV. Uncertainty still surrounds the magnitude of ozone formation in the smoke plume, the degree of mixing with pre-existing urban ozone sources and other precursors, and downward transport of ozone to ground level (Sandberg et al. 2002), such as during atmospheric subsidence events.

Fire behavior is the manner in which fire reacts to the fuels available for burning (DeBano et al. 1998), and is dependent on the type, condition, and arrangement of fuels, local weather conditions, topography, and in the case of prescribed fire, ignition pattern and rate. Important aspects of fire behavior include:

- Fire intensity (rate of energy release per unit area or unit length of fire perimeter, generally during the flaming combustion period).
- Rate of spread (rate of advancement of flaming front, length per unit time), crowning potential (involvement of tree and shrub foliage and spread within the canopy), smoldering potential (smoldering combustion of fuels that have been preheated or dried during the flaming stage).
- Residual smoldering potential (propagation of a smoldering combustion front within porous fuels such as rotten logs or duff, independent of preheating or drying).
- Residence time in the flaming, glowing, and smoldering (residual) stages of combustion (Sandberg et al. 2002).

These factors influence combustion efficiency, and the resulting pollutant chemistry and emission factor (Sandberg et al. 2002). Fire behavior guides Service and fire team smoke and emissions management efforts to minimize air quality impacts. The Eastern Massachusetts National Wildlife Refuge Complex Fire Management Plan (USFWS 2003) states, "The goals of smoke management on the refuges will follow goals enumerated by the National Wildfire Coordinating Group (2001): reduce fire emissions, enhance the dispersal of smoke plumes, steer smoke plumes away from smoke-sensitive areas, and coordinate the ignitions of prescribed burns. Smoke management practices will include maximizing combustion efficiency (to reduce particulate emissions)." Service staff and the fire management team choose fire and fuels manipulation techniques that complement meteorological scheduling for maximum smoke dispersion and favorable plume transport. Burn plans specify no burning when poor atmospheric mixing conditions are forecast. We use smoke dispersion and air quality information generated by the National Weather Service. We are required to obtain a "Spot Weather Forecast" prior to implementing any prescribed burn.

Prescribed fire emissions, including those from the refuge, are subject to regulation nationwide under the CAA by the USEPA and the MADEP in the interest of protecting human health and welfare. Massachusetts has an approved State Implementation Plan for Ozone Attainment (2008).

Past refuge prescribed burning was conducted in late fall or early spring. Prescribed burning during the growing season is proven to have the greatest effect on plant (especially understory plants) mortality, overall stand structure and composition change and therefore may be used under either of the alternatives. Burning during the summer "ozone" season has potential to cause greater impact to air quality when hot, stagnant atmospheric episodes (and State issued air quality alerts) are more common.

The refuge obtains an annual air quality permit from the MADEP, and a burn day authorization from the Plymouth Fire Department, and conducts burning operations in accordance with those authorizations. These permitting processes consider the expected quantity of emissions released over time (source strength), smoke plume rise, trajectory, and down range concentration (dispersion). We consider the current and expected daily air quality index issued by the MADEP, especially if burning during the summer ozone season. We avoid burning when air quality alerts are forecast or issued for the region, and are unlikely to be granted a burn permit anyway. If conducted on warm summer days, there is a very low chance refuge prescribed burn emissions may contribute to down range ground level ozone formation if actual atmospheric and weather conditions depart from those forecasted.

Under worst case scenarios prescribed burning efforts on Massasoit NWR over a 15 year period are not expected to adversely affect the region's air quality index (combines PM2.5 and 8-hour ground level ozone) given anticipated dispersion, atmospheric mixing, and the seasonal timing and frequency of prescribed burning under either alternative. No more than 50 refuge acres will be prescribed burned on any given day or in any one year under either alternative. Low intensity prescribed burning would release inconsequential amounts of other gases (Sandberg et al. 2002). Appropriate smoke management can minimize or nearly eliminate those negative effects. The consideration of wind speed, direction, and mixing heights is important in managing smoke. In planning our prescribed burns, we consider all these factors, and other environmental and geographical factors. We expect prescribed burning at the refuge to produce no significant long-term adverse air quality impacts. Neither management alternative would adversely affect regional air quality, including regional haze over the long term. Neither alternative would NAAQS for criteria air pollutants; both would comply with the CAA.

Air Quality Impacts of Alternative A (Current Management)

Beneficial Impacts

Hazardous Fuel Loading Reduction — Applying low to moderate intensity prescribed fire every 5-7 years on approximately 50 acres of the Crooked Pond parcel to reduce the excess buildup of woody debris (hazard fuels) in the understory on the refuge will decrease the long-term likelihood of large emission episodes, from large uncontrolled, high intensity wildfires. Less frequent, large, high intensity wildfires consume greater fuel (biomass) quantities and release greater total emissions in a short time period than do more frequent, but lower intensity and smaller prescribed burns.

Adverse Impacts

Hazardous Fuel Loading Reduction — Prescribed burning on 50 acres will be performed on a (5 to 7 years) rotational basis. There may be some localized (generally downwind, and within 10 miles or less), short duration (minutes to hours) decrease in air quality or brief, localized visibility impairment from fine particulates.

Particulates, consisting of small particles of ash, partly consumed fuel, and liquid droplets, can reduce visibility or cause negative health effects for people

with respiratory illnesses. Carbon monoxide, carbon dioxide, hydrocarbon, and small nitrogen oxide releases are expected. However, low intensity prescribed burning, (such as the current refuge program), releases inconsequential amounts of these gases (Sandberg et al. 2002). Any short-term exposure, acute impacts likely include discomfort, and possibly health effects for some individuals, without violating NAAQS. At present, prescribed fires are not considered to be a significant cause of local/regional NAAQS nonattainment (Sandberg et al. 2002).

Under alternative A, the use of prescribed fire will continue within the Crooked Pond parcel as in the past decade. There are homes adjacent to refuge boundaries except where the MSSF abuts the refuge. It is standard protocol to notify the public in advance about any management efforts that may impact the surrounding area, especially when prescribed burning occurs. The fire team's knowledge of fire behavior (e.g., fire intensity, residual smoldering, rate of spread and crowning potential) and smoke management helps minimize air quality impacts and human exposure to smoke. Additional steps taken to reduce emissions include reducing fuel hazards through mechanical means prior to burning and keeping burn units small (Sandberg et al. 2002).

Emissions (hydrocarbons) released from heavy equipment and power tools during initial firebreak and fuelbreak establishment and periodic maintenance are expected infrequently for brief periods, but are not expected to significantly impact local or regional air quality.

Refuge Access and Public Uses — The refuge will remain closed to the public, therefore no additional transportation-related emissions generated by refuge visitors are anticipated.

Refuge Administration — Current management activities do not adversely affect local and regional air quality. A small amount of hydrocarbon emissions result from refuge activities, primarily emissions from vehicle transportation to and from the refuge, especially during the spring, summer, and fall when trips may occur weekly. Adverse air quality impacts would be very limited and temporary. The vehicle fleet at the refuge headquarters is becoming cleaner as older vehicles are replaced by low (hydrocarbon) emission hybrid vehicles. Refuge vehicle-related hydrocarbon emissions may actually decrease slightly from current levels, over the 15 year plan period.

Air Quality Impacts of Alternative B (Expanded Management, Service-preferred Alternative)

Beneficial Impacts

Habitat Management and Hazardous Fuel Loading Reduction — Applying low to moderate intensity prescribed fire every 5-7 years on up to 200 refuge acres for both habitat management and to reduce the excess buildup of woody debris (hazard fuels) in the understory will further decrease the long-term likelihood of large emission episodes, from large uncontrolled, high intensity wildfires.

Adverse Impacts

Habitat Management — Alternative B incorporates invasive plant treatment as necessary to maintain quality habitat and to promote biological integrity. Invasive plant treatment impacts to air quality would be localized and short-lived. Mechanical removal of invasive species would likely inject some dust and soil particles into the air for short periods (lasting only as long as required to remove the targeted plants). Chemical application in accordance with labeling and approved Pesticide Use Proposals would likely involve backpack sprayers to obtain optimal target specificity. There is still some potential to impact a wider area than is targeted from spray drift, to non-target sites. By not treating on windy days, and through careful calibration of spray nozzles to achieve the

correct droplet size and application rate, spray drift is effectively minimized (USFWS 2009).

Products used are USEPA approved and labeled for the appropriate use. Some of the herbicides the Service most commonly uses are glyphosate, triclopyr, and imazapyr, but herbicide use is not exclusive to these chemicals. Service choice of methods of invasive species control is based on best management practices at the time of management and choice of herbicides is based on the invasive species present. We anticipate insignificant short-term, localized impacts to air quality from treating invasive plants.

Hazardous Fuel Loading Reduction — Under alternative B, there would be as much as 200 acres burned following the development of a HMP and the spatial FMP. Prescribed burning on up to 200 acres over the entire refuge will be performed on a (5-7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Total prescribed burn impacts to air quality over the planning period may be as much as four times greater than alternative A. There may be some localized (generally downwind from burns, and within 10 miles or less), short duration (minutes to hours) decrease in air quality or brief, localized visibility impairment from fine particulates from individual burns.

Particulates, consisting of small particles of ash, partly consumed fuel, and liquid droplets, can reduce visibility or cause negative health effects for people with respiratory illnesses. Carbon monoxide, carbon dioxide, hydrocarbon, and small nitrogen oxide releases are expected. However, low intensity prescribed burning, (such as the current refuge program), releases inconsequential amounts of these gases (Sandberg et al. 2002).

The goals and practice of smoke management on the refuge discussed previously for alternative A apply to alternative B also. The fire team's knowledge of fire behavior (e.g., fire intensity, residual smoldering, rate of spread and crowning potential) and smoke management helps minimize air quality impacts and human exposure to smoke. Additional steps taken to reduce emissions include reducing fuel hazards through mechanical means prior to burning and keeping burn units small (Sandberg et al. 2002). Prescribed burn plans under alternative B would also address all conditions under which a burn would occur, and employ advanced public notification of any management practice, including prescribed burning efforts that may impact them. This is especially true in areas close to residential or commercial development such as the residential subdivision on the northern border of the Crooked Pond parcel and homes located on the ponds where the Service owns shoreline. Public outreach efforts would include factual information about potential human health impacts from prescribed fire smoke. Advanced notice will serve as a means of protecting the public from and minimizing human exposure to health effects that may occur should smoke drift towards the homes.

Stephanie Koch/USFWS

Fuel break along a previously burned unit

Although up to 4 times greater over the plan period than under alternative A, alternative B air quality impacts are not expected to be significant due to burn and smoke management measures, and public notification and outreach procedures the Service already has in place and is already implementing.

Emissions (hydrocarbons) released from heavy equipment and power tools during initial firebreak and fuelbreak establishment and periodic maintenance are expected infrequently for brief periods, but are not expected to significantly impact local or regional air quality.

Refuge Access and Public Uses — Under alternative B, wildlife observation and photography, interpretation, environmental education would be conducted on the Crooked Pond parcel by refuge or partner-led guided trips. Most of the Crooked Pond parcel could be opened seasonally for hunting, particularly deer and turkey hunting, following the completion of an assessment of all hunt seasons, preparation of an environmental assessment, completion of a public comment period, and development of a refuge hunt plan. It is anticipated that the majority of refuge visitors would be local residents. Therefore new refuge visitors under alternative B are not expected to generate significant increases in transportation-related (hydrocarbon) emissions that adversely impact air quality.

Refuge Administration — Increased hydrocarbon emissions from expanding refuge activities and staff site visits to provide enforcement and habitat management are expected. The vehicle fleet at the refuge headquarters is becoming more efficient, and cleaner as older vehicles are replaced by low (hydrocarbon) emission hybrid vehicles, offsetting hydrocarbon emissions from the slightly increased refuge staff trips and vehicle use. It is anticipated that the alternative B impacts on air quality would remain insignificant over the 15 year plan period.

Effects on Water Quality

We evaluated the alternative management actions that have the potential to help maintain and improve, or have potential to cause adverse effects to water quality in the ponds on or abutting the refuge, including:

- Maintaining 209 acres of essentially continuous natural vegetative cover, surface litter, and duff layers on refuge lands through area closures and applying BMPs.
- Mechanical vegetation treatments — cooter nesting site improvement, fire breaks and fuel breaks
- Use of herbicides to manage invasive species.
- The use of prescribed burns near the ponds' edges.
- Trail maintenance.

Water Quality Impacts Common to Both Alternatives

Local water quality benefits from the pollutant buffering and filtering effects of maintaining essentially continuous upland and wetlands vegetation across the 209 acre refuge landscape are expected. Trees (vegetation) filter some air pollutants that can enter ponds by atmospheric deposition. Vegetation, surface litter, and duff also slow, intercept, and filter out some pollutants from surface runoff before it can reach downslope waterbodies, or rainfall and runoff as it infiltrates the soil before it moves into the groundwater aquifer.

Because Crooked Pond is located within the parcel interior, surrounding vegetation and habitat serves as a buffer to the pond. Any drawdown or pollution

Crooked Pond on Massasoit National Wildlife Refuge

Kourtnie Bouley/USFWS

to the groundwater in the Plymouth area close to the refuge would more likely have a greater impact to Crooked Pond water levels and water quality than refuge management activities. Sources of pollution from nearby residential homes are more likely to impact the water quality on all refuge ponds but especially Gunners Exchange, Island, and Hoyt, with their residential shoreline development. Some year-round and summer homes on these ponds that can potentially adversely impact water quality within these ponds and groundwater quality, from septic systems, landscaping activities, swimming, or boating in the ponds. The Service has no direct authority over the use of ponds by residents who own shoreline and/or land abutting Gunners Exchange, Hoyt, and Island Pond or outside refuge boundaries. The Service is therefore dependent upon partnering with local and state government, our refuge neighbors, and non-government organizations to address any concerns with water quality in these ponds and surrounding lands. Water quality and land use regulation to protect water quality in these ponds rests with local government (Plymouth Conservation Commission), and the MADEP, and is therefore beyond the scope of this CCP (see also Cumulative Effects later in this chapter).

Under both alternatives, a network of constructed firelines (1.11 miles), constructed shaded fuelbreaks (2.49 miles), and existing roadbeds (1.57 miles) will be maintained to facilitate wildland fire suppression and prescribed burning. Machinery will be used to mow or masticate understory vegetation every 5-7 years on approximately 13.6 acres (6.5 percent) of the refuge to keep the network passable for fire equipment and personnel. Litter and duff layers remain largely undisturbed and intact. Slight increases in surface runoff are expected from this fuel and firebreak network for 1-2 growing seasons following treatment. Protective litter and duff layers will largely prevent post treatment soil erosion and downslope sediment transport in runoff into refuge waterbodies.

Refuge firelines (2.68 miles) typically have a 1.5 foot strip from which the protective litter and sometimes the duff layer are removed using leaf blowers

and rakes, potentially exposing mineral soil in order to slow or halt the spread of a fire through surface fuels on up to 0.49 acres (worst case estimate). Between fires, firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically, potentially exposing mineral soil, some soil erosion from these firelines could be transported downslope in surface runoff into refuge ponds from soil exposure until the next autumn "leaf-drop" (6-12 months).

Prescribed burns proposed in both alternatives are more frequent, smaller, less intense, and consume less vegetation, litter, and duff (fuel) than past large, high intensity wildfires. Prescribed burning water quality impacts will be less than those from past, higher intensity wildfires. Some research suggests that prescribed fire does not significantly impact the overland transport of nitrogen, phosphorous, or cations often released during fires (Kolka undated) to the degree seen from large, high intensity wildfires (Kolka undated, Richter et. al.1982). Decreasing the likelihood of large high intensity wildfires through hazard fuel reduction under both alternatives also reduces the long-term likelihood of large overland pollutant transport episodes to refuge ponds.

Neither management alternative would contribute to water quality degradation. Neither management alternative will violate Federal or State water pollution control regulations; and both will comply with the Clean Water Act.

Water Quality Impacts of Alternative A (Current Management)

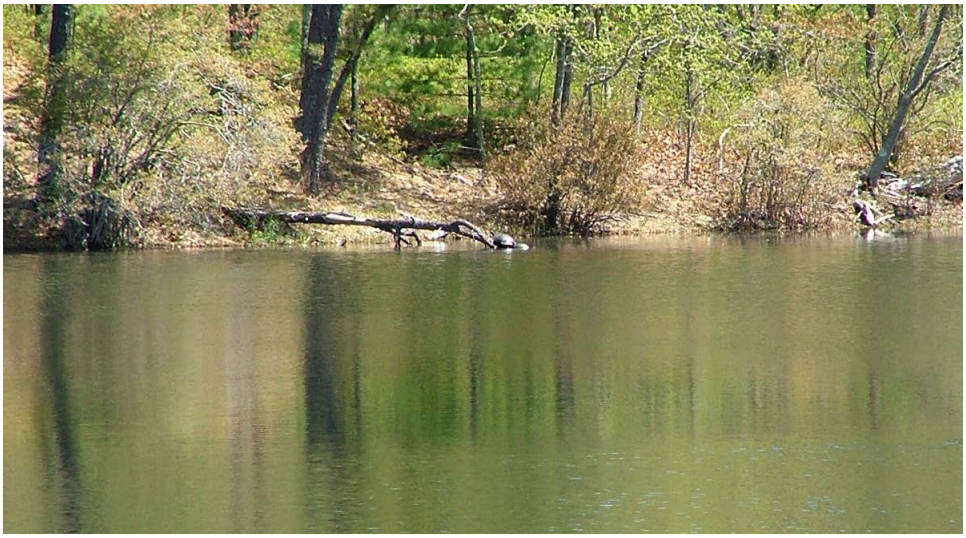
Beneficial Impacts

Refuge Access and Public Uses — With little to no public use authorized, the generally good refuge water quality is likely to be protected. The Service will continue to enforce the laws that protect the natural resources, including those for which they have jurisdiction. Already, the Service abides by 660-FW 1 Wetland Policy and Action Plan (USFWS 1994b) which prevents further degradation of the ponds, especially Crooked Pond and its associated buffer zone, where the Service has full authority.

Adverse Impacts

Habitat Management — Mechanical clearing of brush, trees, and other vegetation to create canopy openings and improve northern red-bellied cooter nesting sites near Crooked Pond totals ¼ acre. Temporary disturbance of the sandy shoreline vegetation and soil in close proximity to the ponds could result

Northern red-bellied cooters basking on a log



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in some small-scale instances of erosion, and small quantities of soil sediment entering Crooked Pond. Vegetation closest to the shoreline is not disturbed, and root systems of shrubs on the pond shoreline are kept intact to help hold exposed soil in place. This minimizes or completely prevents sediment runoff from entering the pond, and any impacts are very localized and temporary, and therefore not significant.

Hazardous Fuel Loading Reduction — The impact of prescribed fire on water quality is directly linked to the impact on soil and resulting sediment in runoff (refer to Effects on Soils below) from burned areas. With any heavy precipitation event immediately following prescribed burning there may be an increase in runoff potentially impacting local water quality over the short-term (until vegetation recovery). Prescribed burning efforts are limited to current levels (50 acres) on the Crooked Pond parcel. Prescribed burning of two burn units will be performed on a (5-7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. These two burn perimeters combined require 0.99 miles, 0.50 miles, and 0.45 miles respectively of the refuge fireline, existing roadbed, and 100 foot wide shaded fuelbreak network. This network requires (worst case estimate) up to 0.27 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 7.68 acres for shaded fuelbreaks and access roads. In the intervals between fires, firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically, potentially exposing mineral soil, some soil erosion is possible from these firelines that could be transported downslope in surface runoff into refuge ponds from soil exposure until the next autumn "leaf-drop" (6-12 months). Protective vegetative and litter cover typically recovers within 1 growing season following mechanical cutting of shaded fuel breaks, or prescribed burning.

Due to the dense post-burn vegetative cover, intact duff and litter layers, and gentle slopes of the treated burn units, no concerns with sediment-laden runoff from prescribed burn units into local water bodies are expected.

Refuge Access and Public Use — The refuge remains closed to public uses. Therefore any impacts to water quality from public use will be from unauthorized, illegal activities such as littering of pond shorelines from trespassers, oil or gas leaks from illegal ORVs near the pond edges, horseback riding, or pollution from swimming or boating.

Water Quality Impacts of Alternative B (Service-preferred Alternative)

Beneficial Impacts

Habitat Management — Native aquatic plants are an essential part of a freshwater aquatic system that provide habitat and refuge for aquatic wildlife, are a food source, and recycle oxygen and carbon dioxide (Rhode Island Department of Environmental Management Office of Water Resources 2014). Aquatic invasive plants can disrupt the ecosystem by out-competing beneficial native vegetation. Under some circumstances, if left unchecked aquatic invasive plants can "choke out" native plants and begin to cover a pond that would have otherwise been clear (Rhode Island Department of Environmental Management Office of Water Resources 2014). At this time, it is unknown what if any aquatic invasive plants exist in Crooked Pond. Refuge staff would monitor for invasive aquatic plants within Crooked Pond. If aquatic invasive plants become a concern, the Service would act in accordance with the IPMP, in collaboration with refuge partners and neighbors, to remove or control such species, protecting water quality and restoring the natural ecosystem function for the long-term.

Adverse Impacts

Habitat Management — Using herbicides or mechanical methods to control invasive plants could incur some short-term and localized risk to water quality (Shepard et al. 2004). Before any chemical is applied to refuge lands, Service policy and required project review ensures that water quality risk is evaluated and minimized. All products are used according to label instructions to minimize impacts on ground and surface waters (USFWS 2009). Only those herbicides specifically labeled for aquatic application are used on or near refuge waters. When used appropriately, these products pose negligible directly or indirectly impacts on water quality. Very often, herbicides are not needed. But when required for effective control, the Service selects the herbicide application that is most effective for the target species and least harmful to non-target organisms. Risk reducing measures include choosing optimal times of year to apply herbicides, reducing spray drift, and applying the minimum amounts needed to effectively control the target species. If chemical application is deemed necessary, it would likely be applied using backpack sprayers to obtain optimal target specificity from the close range of application.

Mechanical clearing of brush, trees, and other vegetation to create canopy openings and nesting sites for the northern red-bellied cooter near the shorelines of Crooked Pond, Hoyt Pond, and Island Pond total 1 acre. Temporary disturbance of the sandy shoreline and soil in close proximity to the ponds could result in some small scale instances of erosion, and small quantities of soil sediment entering the ponds. Service staff takes every precaution to minimize disturbance while conducting habitat management. Vegetation closest to the shoreline is not disturbed, and root systems of shrubs on the pond shore are kept intact to help hold exposed soil in place. This minimizes or completely prevents sediment runoff from entering the ponds, so any impacts are very localized, temporary and therefore not significant. Therefore, these impacts to water quality would be very localized and short-term, minimal and temporary, and therefore not significant under alternative B.

Hazardous Fuel Loading Reduction — Prescribed burning efforts would expand to most refuge upland acres (up to 200 acres) following HMP and spatial FMP completion. The impact of prescribed fire on water quality is directly linked to the impact on soil and resulting sediment in runoff (refer to Effects on Soils below) from burned areas. About 60 percent of this acreage drains into water bodies across moderate slopes (D. Walker 2013 personal communication). With any heavy precipitation event immediately following prescribed burning there may be an increase in runoff potentially impacting local water quality over the short-term (until vegetation recovery). Prescribed burning of 10 to 20 individual burn units will be performed on a (5-7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. These burn perimeters combined require up to 1.11 miles, 1.57 miles, 0.57 miles, and 1.92 miles respectively of the fireline, existing roadbed, 100 foot wide and 12 foot wide shaded fuelbreak network, with only a portion (20-50 percent) needed in any single year in the absence of a large wildlife. This network requires (worst case estimate) up to 0.49 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 13.6 acres for shaded fuelbreaks and access roads. In the intervals between fires, mineral soil firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically to expose mineral soil, some soil erosion from these constructed firelines that could be transported by surface runoff into downslope waterbodies is possible from soil exposure until the next autumn “leaf-drop” (6-12 months). Protective vegetative and litter cover typically recovers within 1 growing season following mechanical cutting of shaded fuel breaks, or prescribed burning.

Due to the dense post-burn vegetative cover, intact duff and litter layers, and gentle slopes of the treated burn units, no concerns with sediment-laden runoff from prescribed burn units into local water bodies are expected. There is a low to moderate risk that nutrients released during prescribed burning may be transported overland into ponds and waterways downslope. However, this would be buffered by the duff and litter layer remaining following the prescribed burn (D. Walker, 2013 personal communication).

Refuge Access and Public Use — Under alternative B, the Crooked Pond parcel would be opened for staff or partner-led trips for wildlife observation and photography, interpretation, environmental education. We would assess opening most of the Crooked Pond parcel for hunting in accordance with State regulations, with an emphasis on deer and turkey hunting. Public use would be limited and light. Therefore water quality impacts from refuge public use are limited. New refuge visitors under alternative B are not expected to significantly impact existing water quality, with their impacts similar to those they are having on the adjoining MSSF. The limited wildlife observation, photography, environmental education and interpretation trips hosted by the Service or our partners will have no detectable impact to the water quality because access to the ponds, especially Crooked Pond, would remain restricted.

Effects on Soils

Soils are the structural matrix and nutrient source for plants and must be protected to sustain the variety of wetland, riparian, and upland habitats needed to meet refuge habitat and species management goals. Overall, refuge soils are productive and in good condition, with only localized erosion, compaction, or contamination problems.

We evaluated the alternative management actions with potential to benefit or adversely affect upland and refuge pond shoreline soils, including:

- Maintaining continuous vegetative cover, surface litter, and duff layers on refuge lands and applying BMPs.
- Using prescribed burning and mechanical methods to reduce fuel loads and restore mixed pine-oak habitats.
- Habitat management activities to benefit nesting northern red-bellied cooters, including tree-cutting, tree-girdling, and vegetation removal.
- Invasive species management.
- Refuge public use activities including environmental education, and interpretation, a public use trail connection, and seasonally opening part of the Crooked Pond parcel to deer and turkey hunting.
- Wildland fire suppression policies and methods.

Effects on Soils Common to Both Alternatives

Maintaining essentially continuous upland and wetlands vegetation across the refuge landscape as expected under both alternatives, helps protect against soil loss through erosion. Plant foliage and stems intercept rainfall, absorbing the impact that can erode underlying soil without protective vegetative cover. Vegetation, living and dead, especially plant roots help hold the soil in place when subjected to surface runoff, wind, or other erosive forces as well as helping maintain soil porosity and water holding capacity. When vegetative tissues die and are shed, they return organic matter and nutrients back into the soil that can be recycled and used by other plants and animals. These dead plant tissues are

also the source of the litter and duff layers that also help protect the soil surface from erosive forces and help retain soil water that is essential for plant growth.

Fire elevates surface temperatures; mineralizes detritus, litter, and standing dead material; volatilizes some nutrients and organic matter; alters soil water-holding capacity; and alters soil animal species (micro—and macro-fauna) populations (Barbour et al. 1999).The effects on organic matter depend on the intensity and duration of the fire. Intense, long-duration fires such as those associated with wildfires consume more organic matter than the short-duration, low intensity prescribed fires proposed for Massasoit NWR under both alternatives. Nitrogen compounds volatilize and are lost at temperatures (212° to 392 °F); while, calcium, sodium, and magnesium usually are deposited on the soil surface and quickly recycled during post-burn vegetative recovery. Fire usually elevates soil pH, because of cation release, particularly in acidic soils. At higher temperatures (392° to 572 °F), large amounts of organic substances are lost, which can reduce soil cation exchange and moisture holding capacity.

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Rototilling to prepare northern red-bellied cooter habitat

Removal of litter and duff may initially facilitate water infiltration; but, the loss of all litter and blackened soils may also accelerate evaporation, reducing soil water available for plant growth (water-holding capacity). There is little change in water repellency for most soil types, with cool fires (below 349 °F). Moderately hot fires (349° to 399 °F) increase water repellence, and extremely hot fires (above 399 °F) volatilize hydrophobic substances and may increase soil water repellence (Debano et al. 1998). After moderately intense fires, increased runoff may result in soil erosion.

Fire usually reduces soil fungi but increases soil bacteria, and may also remove pathogens. Fire often destroys nitrifying bacteria, so that post-fire soil nitrogen recovery is often dependent upon legumes and other nitrogen-fixing plants (Barbour et al. 1999). Fire may enhance soil microbial nitrogen fixation, due to the mineralization of nutrients and elevated pH levels in soils (Barbour et al. 1999). Prescribed fires conducted on the refuge under both alternatives should benefit soils in the short term by returning nutrients bound up in above ground plant biomass prior to the burn, back into the soil (Dudley and Lajtha 1993). The degree to which this occurs is dependent upon prescribed fire intensity (USFWS 2003b).

A risk of long-term soil damage (still evident on the refuge today from the catastrophic fires in the 1950's) from high intensity wildfires remains. But fuel load reduction planned under both alternatives will help minimize, but not eliminate that risk. Wildfires will be suppressed in a safe, prompt, and cost effective manner to minimize adverse impacts to resources and acreage. All initial attack or suppression will be done by the Plymouth Fire Department, and then the Massachusetts Department of Conservation and Recreation under existing agreements. Suppression methods chosen to accomplish safe, effective incident stabilization will leave minimum resource damage. The current Refuge Complex FMP (USFWS 2003b) provides more information on the refuge's objectives and strategies in regards to prescribed and wildfires.

Under both alternatives, a network of constructed firelines (1.11 miles), constructed shaded fuelbreaks (2.49 miles), and existing roadbeds (1.57 miles) will be maintained to facilitate wildland fire suppression and prescribed burning. Machinery will be used to mow or masticate understory vegetation every 5-7 years on approximately 13.6 acres (6.5 percent) of the refuge to keep the network

passable for fire equipment and personnel. Litter and duff layers remain largely undisturbed and intact. Slight, increases in surface runoff are expected from this fuel and firebreak network for 1-2 growing seasons following treatment. Protective litter and duff layers will largely prevent post treatment soil erosion.

Refuge firelines (2.68 miles) have a 1.5 foot strip from which the protective litter and sometimes the duff layer are removed using leaf blowers and rakes, potentially exposing mineral soil in order to slow or halt the spread of a fire through surface fuels on up to 0.49 acres (worst case estimate). Between fires, firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically, potentially exposing mineral soil to erosion from these firelines could be transported downslope in surface runoff into refuge ponds from soil exposure until the next autumn "leaf-drop" (6-12 months). Refreshing firelines as preparation for pre-planned prescribed burns would occur around the perimeters of burn units totaling no more than 50 acres in any given year under both alternatives. Wildfires are not predictable as to the time and place of ignitions, but the same network of firelines and methods will be used to suppress any unplanned wildfires within the refuge. Because the protective litter layer is removed periodically potentially exposing mineral soil, some soil erosion is possible from these firelines, from soil exposure until the next autumn "leaf-drop" (6-12 months).

Soil Impacts of Alternative A (Current Management)

Beneficial Impacts

Hazardous Fuel Loading Reduction — Prescribed burning would potentially return nutrients bound up in plant biomass back into the local soil, and locally enhance soil microbial nitrogen fixation in the short term on approximately 50 acres of the Crooked Pond parcel over the planning period. Given their short-term nature and the limited acreage, these are not expected to be significant beneficial soil impacts. Reducing hazardous fuel loading reduces the likelihood of high intensity wildfires, and the soil damage they can leave behind.

Adverse Impacts

Habitat Management — There may be some minor soil compaction and erosion on ¼ acre managed to create northern red-bellied cooter nesting habitat along the shoreline near Crooked Pond. The soil impacts will be temporary, localized, and therefore not significant. We expect none of the current management actions to significantly impact the soils over the long term.

Hazardous Fuel Loading Reduction — Refuge prescribed fires typically are low to moderate intensity fires, with limited surface soil temperature change (D. Walker, 2013 personal communication). Humidity levels and wind conditions are the greatest drivers of fire intensity, but a number of weather and fuel related parameters are identified and required for a prescribed burn. Low to moderate intensity prescribed burning will be performed on a (5-7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Prescribed burning is limited to the 50 acres (two burn units) in the northeast portion of the refuge which has little slope. Recent refuge prescribed fires consumed only part of the surface litter and duff layers, without transferring excessive heat into the underlying soils. Because a partial litter and a largely continuous surface duff layer will remain after burning, little soil erosion risk will result compared to that from a high intensity wildfire.

The two burn unit perimeters combined require 0.99 miles, 0.50 miles, and 0.45 miles respectively of the fireline, existing roadbed, and 100 foot wide shaded fuelbreak network. This network requires (worst case estimate) up to 0.27 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 7.68 acres for shaded fuelbreaks and access roadbeds. In

the intervals between fires, these firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer and sometimes the duff layer is removed periodically to expose mineral soil, some soil erosion from these firelines is possible from soil exposure until the next autumn "leaf-drop" (6-12 months).

Using heavy equipment to create fire breaks may scarify soils in some areas or potentially compact soils. Implementing Best Management Practices helps to limit the amount of soil disturbance from equipment, and using 'low ground pressure' equipment reduces soil compaction potential. Future fire break maintenance can be done with much smaller and lighter equipment that will have little to no soil impact.

The Service, assisted by our partners, has demonstrated success conducting small-scale, short duration low to moderate intensity prescribed fires on confined areas on the Crooked Pond parcel. Those fires consumed only part of the surface litter and duff layers, and without transferring excessive heat into the underlying soils. We will continue using prescribed fires under alternative A to remove litter and light fuels and reduce the risk of adverse soil effects from high intensity wildfires. We expect direct or indirect impacts on upland soils to be negligible and not significant, limited by the short duration and low to moderate intensity burns, confined to the small, designated project area.

Refuge Access and Public Uses — The refuge remains closed to public use. Therefore soil impacts from public use will be confined to unauthorized, illegal activity. Currently trespass takes place at Massasoit NWR by mountain bikes and ORVs, and to a lesser extent horseback riding, resulting in localized soil compaction and erosion. The current level of trespass and commensurate soil damage is expected to continue under alternative A. Illegally accessed trails are deeply worn exposing the roots of trees and void of protective duff and litter in several locations and where trails are on slopes, water runoff and erosion is occurring. At times these mountain bike and ORV riders will cause significant soil disturbance in the turtle nesting sites adjacent to the pond shoreline which may lead to soil sediment entering refuge ponds.

Soil Impacts of Alternative B (Service-preferred Alternative)

Beneficial Impacts

Hazardous Fuel Loading Reduction — Prescribed burning would potentially return nutrients bound up in plant biomass back into the soil, and enhance soil microbial nitrogen fixation in the short term on approximately 50 acres of the Crooked Pond parcel over the planning period. Given their short-term nature and the limited acreage, these are not expected to be significant beneficial soil impacts. Reducing hazardous fuel loading reduces the likelihood of high intensity wildfires, and the soil damage they can leave behind.

Adverse Impacts

Habitat Management — Increased mechanical vegetation removal, including invasive plants, using hand or power tools, or heavy equipment can potentially cause localized soil disturbance and erosion until new plants establish. More soil disturbance associated with higher levels of invasive plant control is expected under alternative B. Any soil disturbed by the physical removal of plants will be tamped down and compacted, a standard refuge practice for any mechanical removal operation.

Herbicides approved by the Service would be used to control invasive plants as warranted. While the refuge would consider using various Service-approved herbicides, based on current use within the Refuge System we expect to use the herbicide glyphosate, formulated as Roundup® or Rodeo®, most often over the

planning period. Other herbicides that could be used include imazapyr, triclopyr, and others approved by the USEPA. Research to find the best methods for controlling invasive plant species including chemical, mechanical, and biological means is ongoing. The best methods available at the time of application will be used. The level of review that Service policy requires before we can apply any chemical or biological methods on refuge lands ensures that the environmental risk is minimized, and all facets of the proposed use have been examined and justified. All products are used according to label instructions and approved Pesticide Use Proposals, to minimize impacts to soil.

There may be some minor soil compaction and erosion on 1 acre managed to create northern red-bellied cooter nesting habitat along the refuge pond shorelines. The soil impacts will be temporary, localized, and therefore not significant.

We expect negligible direct or indirect impacts on upland soils from habitat work. Expected soil impacts are limited in duration, of low to moderate intensity, and confined to small project areas. None of the proposed habitat management actions will adversely impact refuge soils over the long-term.

Hazardous Fuel Loading Reduction — Prescribed burning efforts would expand to most refuge upland acres (up to 200 acres) following HMP and spatial FMP completion. We would maintain all fires within their prescriptions to minimize the soil degradation, although impacts could occur in small areas. Low to moderate intensity prescribed burning of 10 to 20 individual burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Recent refuge prescribed fires consumed only part of the surface litter and duff layers, without transferring excessive heat into the underlying soils. Because a partial litter and largely continuous surface duff layer will remain after burning, little soil erosion risk will result compared to that from a high intensity wildfire.

Controlled burn on Massasoit National Wildlife Refuge

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These burn perimeters combined require up to 1.11 miles, 1.57 miles, 0.57 miles, and 1.92 miles respectively of the fireline, existing roadbed, 100-foot-wide and 12-foot-wide shaded fuelbreak network, with only a portion (20 to 50 percent) needed in any single year in the absence of a large wildfire. This network requires (worst case estimate) up to 0.49 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 13.6 acres for shaded fuelbreaks and access roads. In the intervals between fires, these mineral soil firelines are normally allowed to accumulate leaf litter every fall. Because the protective litter layer is removed periodically to expose mineral soil, some soil erosion from soil exposure until the next autumn "leaf-drop" (6 to 12 months). Protective vegetative and litter cover typically recovers within 1 growing season following mechanical cutting of shaded fuel breaks, or prescribed burning.

Using heavy equipment to create fire breaks may scarify soils in some areas or potentially compact soils. Implementing Best Management Practices helps limit the amount of soil disturbance from heavy equipment, and using 'low ground pressure' equipment reduces soil compaction potential. Using heavy equipment to establish fire breaks is likely a one-time activity that will have short term impacts. Future fire break maintenance can be done with much smaller and lighter equipment that will have little to no soil impact. Hazard fuel reduction may also be achieved through the mowing of understory vegetation. Care is taken during these operations to avoid disturbing the soils. The smaller size and weight of mowing equipment will help to reduce soil compaction. This activity will either be a 1 time non-recurring event in preparation for prescribed fire, or repeated every 5 to 7 years in areas where prescribed fire cannot be used effectively.

Any impact to the soils under alternative B would be similar to those under alternative A, but on an up to fourfold larger scale. Similar to alternative A, the Service would use prescribed fires to remove only some of the litter and light fuels and avoid the adverse effects of high-intensity, severe wildfires on soil resources. Conducting all prescribed burns within their prescriptions will minimize soil loss, although adverse soil impacts may occur in small areas. The adverse effects from higher intensity fires are only likely to occur in the presence of a natural or human ignited wildfire.

Refuge Access and Public Uses — Occasional staff or partner –led trips on the Crooked Pond parcel could in time adversely impact soils through compaction, erosion, and sedimentation if not addressed (Pickering et al 2010).. Long-term effects of trampling include soil impacts like diminished soil porosity, aeration, and water and nutrient availability for plant growth through soil compaction (Roovers et al. 2004, Kuss 1986) but these are unlikely, as refuge visitation is expected to be light. Foot travel can, over time create eroded conditions; lug soles on hiking boots can exacerbate the problem. Large group activities, such as guided interpretation or environmental education on any trail used, is more likely to impact soil to a greater extent.

Service staff would monitor the refuge for soil damage, minimize use if necessary, and mitigate damage with soil stabilization and control measures (water bars, steps, re-routing, etc.) as needed. This is expected to mitigate any significant long-term soil impacts from authorized public use.

Trespass by mountain bikes and ORVs, and to a lesser extent by horseback riding, occurs on the refuge, resulting in soil compaction and erosion. This illegal trespass is expected to decline, but not be eliminated under alternative B. Illegally accessed trails are deeply worn exposing tree roots and are void of protective duff and litter in several locations, and where trails are on slopes, erosion is occurring. At times unauthorized mountain bike and ORV riders will

cause localized soil disturbance adjacent to refuge pond shorelines. Greater enforcement and increased public outreach should reduce soil damage from illegal, unauthorized uses.

Effects on Natural Community Types and Vegetation

The variety of wetland and upland habitats and vegetative communities present on the refuge are essential to meeting and sustaining wildlife habitat and species management goals. Overall, refuge habitats remain productive and diverse as described in previous chapters. This section focuses on impacts to natural community types and current vegetation on the refuge. Wildlife impacts and responses to these structural and compositional vegetative changes are discussed under the Effects on Biological Resources section.

We evaluated the alternative management actions that have the potential to benefit or adversely affect key refuge pond shoreline and upland pine-oak communities, including:

- Utilization of prescribed burning and mechanical methods to reduce fuel loads and restore mixed pine-oak habitats.
- Habitat management activities to benefit nesting northern red-bellied cooters, including tree-cutting, tree-girdling, and vegetation removal.
- Invasive species management.
- Refuge public use activities including environmental education, and interpretation, a public use trail connection, and opening part of the Crooked Pond parcel to deer and turkey hunting.
- Wildland fire suppression policies and methods.

Effects on Natural Community Types and Vegetation Common to Both Alternatives

Pitch pine-scrub oak shrubland association (sandplain heathland community) often referred to as the "pine barren" community represents a unique ecological adaptation to dry, sandy soils and to fire, and dependence on fire for the maintenance of the natural community. The pine barren community (pitch pine-scrub oak shrubland association) is dominated by dense stands of native pitch pines which often have shoots that can regrow directly from the trunk after fire has killed the crown. The thick bark protects the trunk from damage unless the fire is very severe (TNC 2009). Basal stump sprouting following fire is also common for scrub oak. As the pitch pine-oak forest canopy becomes more open, shifting to a woodland structure over time with continuing mechanical thinning and prescribed fire management, understory vegetation (scrub oak shrubland and sandplain

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Mushrooms

heathland) will likely increase with more sunlight reaching the ground (Wildlife Management Institute 2012). Understory vegetation benefitting most are pitch pine-scrub oak shrubland association (and sandplain heathland community) plants, such as lowbush blueberry, black huckleberry, and scrub oak (refer to Natural Community Types and Vegetation section in chapter 2). Prescribed burning may over time also create more snags and downed trees that provide habitat for a variety of species (refer to biological impacts), although it often takes more than one season for snags to develop after burning (Carter et al. 2002).

White pines that tend to grow taller and create closed canopy conditions will be reduced (canopy cover and density) in white pine-oak and oak-pine forest areas managed using canopy thinning and prescribed burning.

Forest floor after a controlled burn on Massasoit National Wildlife Refuge

Libby Herland/USFWS

Under both alternatives, a network of firelines (1.11 miles), shaded fuelbreaks (2.49 miles), and existing roadbeds (1.57 miles) will be maintained to facilitate wildland fire suppression and prescribed burning. Machinery will be used to mow or masticate understory vegetation every 5 to 7 years to keep the network passable for fire equipment and personnel on approximately 13.6 refuge acres (6.5 percent) of the refuge's 209 acres. Refuge firelines (2.68 miles) typically have a 1.5 foot strip from which all vegetation and the protective litter and sometimes duff layer are removed on up to (worst case estimate) 0.49 acres. In the intervals between fires, these firelines are normally allowed to "go fallow." Wildfires are not predictable as to the time and place of ignitions, but the same network of firelines and methods will be used to suppress any unplanned wildfires within the refuge.

Unauthorized operation of ORVs occurs along the utility line right-of-way, unpaved roads, and unimproved trails on the refuge, creating problems on Massasoit NWR as on most public land in Massachusetts (MassWildlife 2015), and is likely continue under both alternatives. Specific impacts from mountain biking, dirt biking and all-terrain vehicle use include soil disturbance and compaction as well as trampling and killing of vegetation. Horseback riding damages plants, and horses may cause localized impacts to plants when confined. In pitch pine-oak upland forest habitats subjected to ORV traffic, the resulting disturbance of dry, nutrient-poor, sandy soils may take decades to revert to native vegetation once damaged. Such soil disturbance may also provide inroads for non-native invasive plant species. Exposed soil and an abundance of sunlight along roads and trails provide ideal conditions for establishment of invasive plant species that may be transported into the refuge in feed hay.

Impacts to refuge coastal pond hydrology and to habitat and vegetation structure from changing climate and land uses that are external to the refuge that would be the same for both alternatives are discussed under Cumulative Effects.

Natural Community Type and Vegetation Effects of Alternative A

Beneficial Impacts

Hazardous Fuel Loading Reduction — Essentially continuous forest cover will be maintained across the entire refuge (209 acre) land base throughout the plan period and in perpetuity. There will be shifts in natural community types and vegetation associations through mechanical cutting and prescribed burning efforts that will thin overstory and create canopy openings on 50 acres on the Crooked Pond parcel. Management will enhance pitch pine-oak woodland or forest association habitat on those 50 acres as periodic fire encourages restoration of fire-adapted plant species (Nowacki and Abrams 2008). An increase in canopy openings will result in an increased understory layer (scrub oak shrubland association, sandplain heathland community) beneath the canopy gaps across those 50 acres.

Adverse Impacts

Habitat Management — Mechanical clearing of brush, trees, and other vegetation on ¼ acre near Crooked Pond to improve northern red-bellied cooter nesting sites is at a very small scale, and vegetation impacts are not deemed significant.

Hazardous Fuel Loading Reduction — Prescribed burning two burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (two burn units) burned on any given day or in any one year. The two burn unit perimeters combined require 0.99 miles, 0.50 miles, and 0.45 miles respectively of the fireline, existing roadbed, and 100 foot wide shaded fuelbreak network. This network requires (worst case estimate) up to 0.27 acres of exposed mineral soil for firelines, and mechanical understory vegetation cutting on 7.68 acres for shaded fuelbreaks and access roadbeds. In the intervals between fires, these mineral soil firelines are normally allowed to accumulate leaf litter every fall. All vegetation, including roots and the protective litter layer is removed periodically to expose mineral soil.

Opening forest overstory and creating canopy gaps, changes forest to vegetation structure and composition. Periodic fire discourages fire-intolerant species (Nowacki and Abrams 2008) so a decline in canopy dominance of white pine is expected on the 50 acres treated on the Crooked Pond parcel. As white pine stem canopy dominance declines over time, refuge white pine-oak and oak-pine forest association acres are expected to decrease by approximately 50 acres (35 percent).

On the remaining untreated 150 upland acres, white pine-oak and oak-pine forest association will persist and continue succeeding to a more mature state. Now overly abundant white pines, artifacts of decades of wildfire suppression, would continue to grow and understory density will decrease further refugewide. Further loss of remnant plants associated with pitch pine-scrub oak shrubland, woodland, or forest association (sandplain heathland community), such as huckleberry, hillside and lowbush blueberry, or scrub oak will result (TNC 2009).

None of the habitat type shifts and or vegetation structure and composition impacts expected are significant however. Essentially continuous forest cover will continue to be maintained across the entire refuge land base throughout the plan period and in perpetuity under alternative A.

Refuge Access and Public Uses — The refuge remains closed to public use. Therefore vegetation impacts from public use will be confined to unauthorized, illegal activity. Currently trespass takes place at Massasoit NWR by mountain bikes and ORVs, and to a lesser extent horseback riding, resulting in localized vegetation destruction or damage. The current level of trespass and commensurate plant damage is expected to continue. Illegally accessed trails have exposed roots of trees, are void of above ground vegetation and compacted, and therefore deter revegetation in several locations.

Natural Community Type and Vegetation Effects of Alternative A

Beneficial Impacts

Habitat Management — Invasive species control will benefit native plant communities and refugewide floral diversity. Invasive plants such as glossy buckthorn, hairy cat's ear, butterfly bush, Morrow's honeysuckle, oriental bittersweet, black locust, common reed, and common mullein would decrease. Surveillance monitoring of aquatic plants in Crooked Pond, including invasive species, would alert the staff to any new invasive species concerns which could then be addressed sooner (see northern red-bellied cooters discussions).

Hazardous Fuel Loading Reduction — Essentially continuous forest cover will be maintained across the entire refuge (209 acre) land base throughout the plan period and in perpetuity. There will be shifts in natural community types and vegetation associations through mechanical cutting and prescribed burning efforts that will thin overstory and create canopy openings on up to 200 acres (refugewide). Management, will enhance pitch pine-oak woodland or forest association habitat on up to 200 acres (refugewide), as periodic fire encourages restoration of fire-adapted plant species (Nowacki and Abrams 2008). An increase in canopy openings will result in an increased understory layer (scrub oak shrubland association, sandplain heathland community) beneath the canopy gaps across the entire refuge upland (up to 200 acres).

Prescribed burning efforts would expand to most refuge upland acres (up to 200 acres) following HMP) and spatial FMP completion. Prescribed burning 10 to 20 individual burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Hazard fuel reduction may also be achieved through the mowing of understory vegetation with low ground pressure equipment with mower attachments. This activity will either be a one time non-recurring event in preparation for prescribed fire, or repeated every 5 to 7 years in areas where prescribed fire cannot be used effectively.

A refugewide increase in pitch pine-oak shrubland (sandplain heathland community), woodland or forest association acres corresponding with a decrease in more ruderal species such as white pine as described above for alternative A is expected. Refuge forest lands would in time more closely approximate the range of historic conditions typical of

Firefighters gather for a briefing before a controlled burn.

Libby Herland/USFWS

these pitch pine-oak associations at the time of European contact. Understory density and height would vary widely across the refuge with canopy opening percentage and time since last fire. Over the long term, there would increasingly be a more uneven aged, patch-mosaic, forest woodland structure due to the variations in timing and intensity of prescribed burning and mechanized thinning across the refuge. Refuge staff would work closely with the utility company to manage the acreage near the utility line for early successional, shrub habitat resulting in less overall vegetation removal along and within the utility line right of way, sustaining the shrubland habitat long term.

Refuge Access and Public Uses — Illegal access may decrease with more visitors on the refuge to detect and report illegal activity or whose mere presence may deter trespass. Periodic evaluations of the condition of the 1.1-mile public trail, as well as unauthorized trails and service access roads will be made. This will help detect and prevent invasive plant spread along and from the trail corridors.

Adverse Impacts

Habitat Management — Invasive species control would have short-term adverse, localized impacts on vegetation. These include the removal of plants, herbicide application, trampling, and other potential damage to plant structure. These short-term negative impacts would be offset by providing long term benefits to native plant diversity and health across the refuge.

Hazardous Fuel Loading Reduction — The more mature, eastern white pine-dominated forest would decrease by up to 200 acres (refugewide). Under alternative B, there would be as much as 200 acres burned following the development of a HMP and spatial FMP. Prescribed burning 10-20 individual burn units on up to 200 acres will be performed on a (5-7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Additional impacts to vegetation would occur within the areas designated as fire breaks, where vegetation is removed and maintained for the preventing wildfires. Mowing understory vegetation with low ground pressure equipment with mower attachments may be used to prepare for burning or where prescribed fire cannot be used effectively.

The 10 to 20 burn perimeters combined require (worst case estimate) up to 1.11 miles, 1.57 miles, 0.57 miles, and 1.92 miles respectively of the fireline, existing roadbed, 100-foot-wide and 12-foot-wide shaded fuelbreak network. Only a portion (20 to 50 percent) of these is needed for prescribed burning in any single year, in the absence of a large wildfire. This network requires worst case estimate) up to 0.49 acres of unvegetated soil for firelines, and mechanical understory vegetation cutting on 13.6 acres for shaded fuelbreaks and access roads. In the intervals between fires, mineral soil firelines are normally allowed to accumulate leaf litter every fall. Vegetative cover typically is restored within one growing season following prescribed burning or mechanical cutting of shaded fuel breaks.

Opening forest overstory and creating canopy gaps, changes forest vegetation structure and composition. Periodic fire discourages fire-intolerant species so a decline in canopy dominance of white pine trees is expected on up to 200 acres treated refugewide. As white pine stem canopy dominance declines over time, refuge white pine-oak and oak-pine forest association acres are expected to decrease by approximately 140 acres (98 percent).

Refuge Access and Public Uses — With increased public access and the possible opening of the refuge to hunting on the Crooked Pond parcel, vegetative communities could experience localized trampling, and possibly crushing

of individual plants in higher traffic areas. Short-term effects consist of deterioration of plant material itself. Long-term effects of trampling include direct vegetation damage, and indirect vegetation effects from soil compaction like diminished soil porosity, aeration, and water and nutrient availability for plant growth (Roovers et al. 2004, Kuss 1986). Compacted soils inhibit plants', particularly sensitive species', ability to revegetate affected areas (Hammitt and Cole 1998). Plant damage can include height and biomass reduction, species composition shifts, and the spread of weeds and plant pathogens (Pickering et al. 2010). Plants species adapted to wet or moist habitats are the most sensitive, and increased moisture content reduces the ability of the soil to support recreational traffic (Kuss 1986). Direct vegetation effects and indirect impacts from soil compaction would likely be localized, and not significant on a larger scale, because most of the refuge remains largely closed to public access, especially sensitive wetland and pond shoreline areas. The generally well to excessively drained sandy textured soils dominating the areas proposed for opening to public access are already impacted by illegal, unauthorized use and relatively resistant to further soil compaction.

Unauthorized, illegal activities may increase in terms of damage to refuge vegetation as more people "discover" Massasoit NWR. Damage from this activity that currently exists on the refuge includes vegetation trampling and breakage, and trail widening. Individuals engaging in unauthorized activities or trail use may find the openings created by additional fire breaks within the refuge forests particularly attractive. This could lead to further vegetation degradation through trampling and spread of invasive plants.

Opening portions of the refuge for public use creates the potential for spread and/or introduction of invasive species. Visitors could carry seeds in footwear, and unauthorized users could transport invasive plant seeds, horses can excrete seeds in their waste, and paddlers can spread invasive plants transported on contaminated canoes or kayaks. While any introduction or spread of invasive plants is a great concern, allowing limited public access as planned under alternative B is unlikely to result in any significant biological impact to the refuge natural community types and vegetation. Law enforcement will continue to patrol and monitor to deter unauthorized uses thereby reducing the risk for spreading or introducing invasive species. Removing downed brush and blocking trails can effectively reduce vegetation impacts of illegal uses. We will post and enforce refuge regulations and area closures as refuge resources permit. Increased education and awareness about refuge natural resources and reasons for refuge regulations may also decrease illegal activities.

Effects on Biological Resources

The various refuge pitch pine and pond habitats provide diverse habitat components to support northern red-bellied cooters, breeding migratory birds and other wildlife of conservation concern. We evaluated the alternative management actions that have the potential to impact northern red-bellied cooters, New England cottontails, migratory birds, mammals, fish, reptiles and amphibians, and invertebrates (including pollinators) including:

- Habitat management activities to benefit nesting northern red-bellied cooters, including tree-cutting, tree-girdling, and vegetation removal.
- Maintaining and enhancing open canopy (shrub) habitats within the pitch pine-oak forest through mechanical methods and prescribed burning.
- Controlling invasive species.

- Applying herbicides to maintain native species and control invasive plant species.
- Increased public use (wildlife disturbance).

Biological Impacts Common to Both Alternatives

A number of impacts to refuge coastal pond hydrology and to habitat and vegetation structure from changing climate and land uses that are external to the refuge will in turn impact refuge biological resources the same under both alternatives are discussed under Cumulative Effects.

For purposes of this impact analysis, it was assumed that species found in similar habitats located within MSSF likely also occur on the refuge.

Biological Impacts of Alternative A

Beneficial Impacts

Habitat Management — Northern red-bellied cooter — Clearing woody and herbaceous vegetation and allowing sunlight to penetrate to and warm the soil surface on ¼ acre along the Crooked Pond shoreline, will enhance cooter nesting and egg incubation benefitting hatching success and early hatchling survival (USFWS 1994). This can potentially shorten the incubation period, increase hatching success and early hatchling survival, and shift the current male-biased sex ratio of hatchlings toward more females. Using predator exclosures to prevent egg destruction and increase hatching success will also improve first year survival rates of northern red-bellied cooter hatchlings. Increasing the number of nests, nest hatching success, and first year hatchling survival all contribute to northern red-bellied cooter recovery objectives.

Mammals — Silver-haired bats that forage in fairly open habitat in mixed wood forest areas near ponds, and roost in hollow trees and cavities under loose bark or bark folds (Barclay et al. 1988) may benefit, if present, from clearing vegetation on ¼ acre near the Crooked Pond shoreline for northern red-bellied cooter nesting habitat.

Fish — There currently is no active management for fish in Crooked Pond, and only the shorelines of the other ponds are within Service jurisdiction. Therefore no impacts to fish species on the refuge are likely under alternative A.

Gray catbird

Bill Thompson

Hazardous Fuel Loading Reduction — Migratory birds — Prescribed burning and thinning 50 acres of mixed pine-oak forest will benefit early successional and shrub species such as prairie warblers and field sparrow, chestnut-sided warbler, black and white warbler, common yellowthroat, eastern towhee, and gray catbird. In a study by King et al. (2011), bird surveys conducted during pre — and post-thinning efforts combined with prescribed burns showed that early successional and shrub species such as prairie warblers and field sparrows were most abundant in scrub oak and thinned pitch pine conditions. Species such as chestnut-sided warblers, black and white warblers, common yellowthroats, eastern towhees, and gray catbirds were most common in the scrub oak communities. Prairie warblers, eastern towhees, and field sparrows were virtually absent in pitch pine forests prior to treatment, but occupied treated areas a year after thinning and increased thereafter. Research in the mid-1970s by Manomet Bird Observatory analyzed three pitch pine-scrub oak stands, comparing species abundance at intervals of two years, 10 years, and 20 years after a fire.

Kevin Fleming

Prairie warbler

The highest abundance and diversity were observed 10 years after the fire, and that regular fire disturbance enriched bird life, as long as the damage was not too devastating (Epsilon 2000). Representative species such as eastern towhees and prairie warblers, and other migratory birds preferring open canopy and dense understory, will potentially increase slightly (not significantly).

Eastern wood-pewee, another surrogate species, would benefit somewhat where canopy thinning creates open-park like areas on xeric (dry) sites with low shrub density (McCarty 1996; Robbins et al. 1989). In a Kendrick et al. (2013) study, there was no strong relationship between habitat measures studied and eastern wood-pewee nest success, clutch size, and fledgling rate, and they were common in both forest interiors and edges, over a wide range of tree cover, and insensitive to patch sizes (McCarty 1996; Robbins et al. 1989). Management practices that include thinning and removal of mature trees and woody growth will benefit wood pewee. As the recently burned 50 acres succeeds to a more dense state between prescribed fire treatments, it will likely temporarily (until the next fire treatment) support slightly increased eastern wood-pewee numbers. The remaining 150 acres of untreated mixed pine-oak upland forest will continue supporting breeding wood-pewee.

The remaining 150 acres of untreated mixed pine-oak upland forest will continue supporting breeding adult ovenbirds along with other surrogate bird species such as scarlet tanager that rely on closed canopy conditions. Juvenile ovenbirds use regenerating cleared areas that have a denser understory for foraging and predator protection near ovenbird breeding habitat (Pagen et al. 2000, Marshall et al. 2003), and will be able to find that on the 50 acres treated with prescribed burning and mechanical thinning. Alternative A will provide approximately 150 acres of interior closed canopy forests for breeding adult ovenbirds, and approximately 50 acres with more open canopy areas with denser shrubland nearby for juveniles. Other surrogate birds such as ovenbirds, more dependent on closed canopy conditions (Porneluzi et al. 2011), will benefit from allowing approximately 150 acres to succeed further toward forest interior conditions.

Mammals—While there is future potential on Massasoit NWR for New England cottontail and northern long-eared bat (federally threatened), neither species is currently known to occur on the refuge or in the vicinity. Monitoring to date shows no evidence of New England cottontail on the refuge or the adjoining MSSF. Prescribed burning and mechanical thinning on 50 acres will create several patches with more open canopies and dense shrub understory, potentially suitable for future occupancy by New England cottontail.

Bobcat

Gary Kramer/USFWS

There will be some beneficial impacts to other (non-listed) mammals under alternative A, especially to bats (see below). Based on preliminary acoustic data analysis (USFWS 2013a), bats believed present on the refuge include big brown, eastern red, silver-haired, tri-colored, and eastern small-footed bats. Bats will likely benefit somewhat from the creation of forest canopy openings on 50-acres where active vegetation management occurs. Canopy gaps created by thinning and prescribed burns may allow bats such as eastern red bat and big brown bat to forage more easily (Edwards et al. 2000). Decreased tree density and increased openings, may also

improve travel corridors for bats as more light reaches and warms roost trees, and increases insect prey diversity and abundance through increased herbaceous and shrub growth (Taylor 2006, Carter et al. 2002). Loeb and O'Keefe (2006) found bats were more likely to be recorded in areas with sparse vegetation, farther from roads, and in early successional stands. This was especially true for big brown bat and red bat where vegetation density best predicted bat habitat use. Big brown bat abundance decreases greatly from deciduous forest biomes to coniferous forest biomes (Kurta et al. 1989), and therefore will benefit from the area where the forest canopies are more open. Fire may create new bat roost trees and snags by direct or indirect fire mortality, (via disease, insect or fungal attack), although it may take one or more seasons to develop after burning (Carter et al. 2002).

Given the relatively small total and treated refuge acreage impacted, none of the above local (refuge-level) changes in bat species abundance are expected to be significant at the larger landscape or population levels.

Other mammals preferring more open canopy conditions and a denser understory layer such as mice and voles would also indirectly benefit from the prescribed fire regime and thinning treatments on 50 acres. Denser understory often allows for better protection from predators along with more food resources for small mammals, such as mice and voles.

Reptiles and amphibians—Areas where herbaceous ground cover and a dense shrub layer occur, systems of decaying roots and stumps, and mammal tunnels all serve as hiding places and hibernacula for amphibians and reptiles. Best management practices for amphibians and reptiles in pine forests such as those on the refuge include maintaining and creating canopy gaps that allow species that need sunlight such as American toad, Fowler's toad, and eastern hognose snake to thrive. The approximately 150 acres that will maintain a more closed canopy are likely to benefit such species as spotted salamander, spring peeper, wood frog, and milk snake (Mitchell et al. 2006). Additional inventories (last done in 2001 and 2002) will be needed to determine the extent and population of various amphibians and reptiles on the refuge to increase our certainty about impacts management actions would have on them.

Invertebrates, including pollinators—There has been no monitoring or inventory of invertebrates, specifically moth and butterfly species or other pollinators, leaving much uncertainty about possible impacts. However, a variety of species have been observed by staff during other management activities (see appendix A). For purposes of this impact analysis, it is assumed that species found in similar habitats located within MSSF likely also occur on the refuge.

Rare butterfly and moth species that depend on sandplain heathland community or pitch pine-scrub oak shrubland, woodland, or forest association habitats, such as the Pine Barrens buckmoth, Gerhard's Underwing moth, and others, would benefit slightly from prescribed burning and thinning on 50 acres. Individual moth and butterfly species are often specialists in a single microhabitat, such as frost barrens, river corridors, or late-successional stands and therefore are not found in all variants of pitch pine-oak association habitats. Many caterpillars (larvae) of these species eat only pitch pine, scrub oak, or other specific plant hosts found only or mostly in pitch pine –scrub oak shrubland association or sandplain heathland communities. Periodic fires are critical to prevent invasion by vegetation which could shade out the host plants. Thus, maintaining populations of these pitch pine-scrub oak shrubland and sandplain heathland community specialist lepidopteran species over time requires maintaining patches in various stages of post-disturbance recovery across large, relatively

contiguous sandplain landscapes. Prescribed burning and overstory thinning will allow more light to penetrate to the understory, favoring the host plants which attract these pollinators (Carter et al. 2002).

Refuge Access and Public Uses — Northern red-bellied cooter — Camera monitoring indicates some trespassing on the property. Temporary signs establishing visual and enforceable closures around the nesting sites during nesting and incubation seasons will help protect the cooter. Illegal collection of cooter eggs and other harassment by humans will be deterred, by keeping the refuge pond shorelines which cooters use for basking and nesting closed to public use, and by enforcing current regulations.

USFWS

American black duck

Migratory birds — The refuge will remain largely closed to public use year-round, minimizing human disturbance of migratory birds from authorized public use.

Mammals — The refuge will remain largely closed to public use year-round under alternative A, minimizing human disturbance of mammals from authorized public use.

Reptiles and amphibians — The refuge will remain largely closed to public use under alternative A, minimizing disturbance of amphibians and reptiles from authorized public use.

Fish — Crooked Pond will remain closed to public use, minimizing human disturbance to fish from authorized public use.

Adverse Impacts

Habitat Management — Northern red-bellied cooter — Locating and protecting existing cooter nests on the refuge and clearing ¼ acre of vegetation along Crooked Pond may disturb individual northern red-bellied cooters infrequently for brief periods, but no significant adverse impacts on the northern red-bellied cooter are expected.

Alternative A does not address the additional management needs mentioned in the 2007 Recovery Plan update (USFWS 2007) such as monitoring for predators, opening canopies along other refuge pond shorelines, monitoring and opening uplands for potential northern red-bellied cooter overland migration, and controlling invasive plants in the ponds.

Reptiles and amphibians — Herbicide use along the utility right-of-way may negatively impact invertebrate species to a limited extent, which will largely be mitigated through collaboration with the State and the utility company.

Hazardous Fuel Loading Reduction — Migratory birds — Migratory birds associated with closed canopy, forest interior conditions such as breeding ovenbirds and scarlet tanagers, will likely decline initially in the 50 acres treated with prescribed burning and mechanical thinning (King et. al. 2011, Pagen et. al. 2000, Marshall et. al. 2003). Forest interior breeding birds breeding in sub-optimal conditions, may experience lower nest productivity or fledgling survival. A key component to successful breeding of these birds is consideration of edges and patch sizes (Robbins et. al.1989). Prescribed burning will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year.

Mammals — There will be no significant adverse impacts to mammals, including bats. No adverse impacts to the New England cottontail are expected under this

alternative. Monitoring to date shows no evidence of New England cottontail on the refuge or the adjoining MSSF (MADCR 2011). The approximately 150 acres of refuge uplands remaining untreated will continue maturing, and degrading dense understory structure required by New England cottontails.

Management activities such as prescribed burns naturally present a low direct mortality risk to small mammals. The impact is minor at the population level and generally of short (weeks to months) duration. Most mammals scurry out of the way, go underground or burrow under the duff and escape injury as low to moderate intensity flaming fronts move across an area. Direct mortality of some mammals, such as rabbits and raccoons, may occur during prescribed burns but is rare. Prescribed fire removes some protective cover, potentially exposing small rodents and rabbits to predation and cold. The extent of exposure largely depends on the proximity of available cover and predator (raptors, foxes, and feral cats) density in the area. Prescribed burning will be performed on 50 acres on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Prescribed burns on the refuge will therefore be small (50 acres or less), which means alternate escape cover is never more than 700 feet away for small mammals temporarily displaced by a prescribed fire or other habitat treatment.

Prescribed burning 50 acres can have short-term detrimental effects on bats by eliminating some snags and stumps used for roosting (Taylor 2006). Roosting bats may also be killed under intense fire conditions. Firebreaks can be raked around snags, or the bases can be sprayed with retardant to protect the snags (Carter et. al 2002).

Prescribed burns conducted during hibernation periods may abnormally shorten torpor, and increase the frequency and duration of arousal periods. Juveniles and adults that depend on torpor, a diurnal hibernation-like state, may be especially at risk because of the time required to arouse from torpor and take flight (Dickinson et al. 2010). Flightless neonatal bats, too heavy for the mother to carry, may be at greater risk from smoke than adults and juveniles (USFWS 2014). Prescribed burns on up to 500 acres and fires occurring when bats are rearing young (April-July) or in deep hibernation (mid-winter) can therefore have negative impacts on local populations. In the southeastern U.S., red bats sometimes hibernate in leaf litter and may be unable to escape burns conducted on very cold days (Taylor 2006). To minimize losses, prescribed fires should be set during warmer days (above 50° F per Loeb 2013) when bats are not in the leaf litter. This impact will most likely be minimal because refuge growing season prescribed burns are unlikely during the times when neonatal bats are still in their roost (Dickinson et al. 2009), or during mid-winter deep hibernation periods.

For insectivorous bats, food is primarily available from late spring to early autumn and absent during winter. Bats survive this winter energetic bottleneck by building body fat stores (depot fat) in late summer and early autumn, and by conserving metabolic energy through winter hibernation. Hibernators do not remain torpid throughout hibernation. Bouts of torpor last from days to weeks, interrupted by brief arousal episodes. White-nose syndrome, an emerging infectious disease that has killed over 5.5 million hibernating bats is named for the causative agent, a white fungus [*Pseudogymnoascus destructans* (Pd) formerly known as *Geomyces destructans* (Gd)], that invades the skin of torpid bats. Several bat species believed present seasonally on the refuge are vulnerable to white-nose syndrome. A recent study predicted that a primary cause of the increased mortality/disease associated with white-nose syndrome is abnormally shortened torpor bouts due to more frequent arousal episodes (Reeder et al.

2012). Prescribed burns conducted during hibernation periods may increase the rate of arousal periods. Therefore, short-term losses from prescribed fires must be weighed with the long-term benefits to the ecosystem that could potentially support and increase bat habitat.

The approximately 150 acres of refuge uplands remaining untreated will continue maturing to more white pine dominated habitat without natural disturbances. Bats now present in these areas that prefer more open canopy conditions such as big brown bats, will likely decrease locally.

Reptiles and amphibians—Prescribed burning will be performed on 50 acres on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any 1 year. Limited research has been conducted regarding the impact of prescribed burning on amphibians and reptiles. Some studies show that unlike other larger vertebrates, smaller and less mobile vertebrates such as amphibians and reptiles were more likely to experience relatively high rates of direct mortality from fire (Lyon et al 1978, Sinsch 1990). The moist, permeable skin and eggs of amphibians increase their vulnerability to heat and microhabitat drying (Stebbins and Cohen 1995). However, another study (Komarek 1969) indicated that amphibians and reptiles were more likely to respond in an adaptive manner that minimized mortality and appeared less disturbed by approaching fire. Some studies conducted through pre—and post-burn surveys during prescribed burns, found no statistically significant differences in the various populations of amphibians including American toad and wood frog (Ford et al. 1999 and Keyser et al. 2004) and red-backed salamander (Keyser et al. 2004). Greenberg and Waldrop (2008) found similar results that showed relative abundance of total salamanders, common salamanders, and total amphibians were unchanged by the fuel reduction treatments.

Wood frog

Andrew MacLachlan/USFWS

We anticipate short-term impacts on amphibian species from refuge prescribed fire activities. However, given the low-intensity and short flame-front residence time (duration), and relatively small burn area, we do not consider this to be a significant impact. According to a review by Russell et al. (1999), there are few reports of fire-caused injury to reptiles and amphibians, even though many of these animals, particularly amphibians, have limited mobility. The Crooked Pond and other micro-site features within and surrounding burn units may provide protective refugia from fire for refuge reptiles and amphibians, and breeding by aquatic species is expected to continue uninterrupted by fire (Russell et al. 1999).

Invertebrates, including pollinators—The approximately 150 acres of refuge uplands remaining untreated will be increasingly dominated by more mature tree species such as the already common white pine. On these untreated acres, a further decline in the rarer butterfly and moth species, including Pine Barrens buckmoth and Gerhard's underwing moth is expected. Other pollinators and invertebrate species may be present on more closed canopy conditions. These species will remain largely undetected in the absence of monitoring and inventory.

Refuge Access and Public Uses — Operation of ORVs is common along utility line rights-of-way, unpaved roads, and trails, and is a problem on most public lands in Massachusetts (MassWildlife 2015). Utility rights-of-way, unpaved roads, and trails in pitch pine-oak upland forest systems often attract sensitive species for nesting (e.g., Eastern Box Turtle), basking (e.g., Eastern Hog-nosed Snake), or foraging where ORV traffic may result in destruction of nests and burrows, and in direct wildlife mortality.

Migratory birds — The refuge will remain closed year round to the public, minimizing human disturbance to migratory birds from authorized public. Unauthorized use could potentially disturb and harm migratory birds if the limited enforcement capacity leads to further increases in illegal use during nesting and young rearing periods within closed areas.

Mammals — Unauthorized use will continue to disturb mammals on the refuge to a limited (not significant) extent. Utility rights-of-way, unpaved roads, and trails in pitch pine-oak upland forest systems often attract sensitive species where ORV traffic may result in direct mortality.

Reptiles and amphibians — Unauthorized use will continue to affect reptiles and amphibians on the refuge to a limited (not significant) extent. Utility rights-of-way, unpaved roads, and trails in pitch pine-oak upland forest systems often attract sensitive species for nesting (e.g., Eastern Box Turtle), basking (e.g., Eastern Hog-nosed Snake), or foraging where ORV traffic may result in direct mortality.

Fish — Unauthorized use will continue to affect fish in refuge ponds to a limited (not significant) extent.

Biological Impacts of Alternative B

Beneficial Impacts

Habitat Management — Northern red-bellied cooter — The mechanical and prescribed burning measures under alternative B would benefit the northern red-bellied cooter by extending optimal sunlight conditions that cooters need for nesting and incubation to all existing refuge pond shores (1 acre), currently restricted to small portions (less than ¼ acre) of the Crooked Pond shoreline, and compared with alternative A.

Clearing woody and herbaceous vegetation and allowing sunlight to penetrate and warm the soil surface on 1 acre along refuge pond shorelines, will enhance cooter nesting and (egg) incubation, benefitting hatching success and early hatchling survival. This can potentially shorten the incubation period, increase hatching success and early hatchling survival, and shift the current male-biased sex ratio of hatchlings toward more females.

The addition of basking sites created by large downed trees anchored in shallow waters (USFWS 2004) during mechanical thinning treatments along refuge pond shorelines will also benefit breeding cooters. With adequate sunlight, cooters can also attain sexual maturity and enter the breeding population sooner, and breed more frequently (USFWS 1994).

Surveillance monitoring, including invasive aquatic plants in refuge ponds, will alert refuge staff sooner, allowing control measures to be taken before invasive plants can dominate the native milfoil and other native aquatic plants (MassWildlife 2008) that northern red-bellied cooters rely on for food.

Locating and protecting existing nests with predator exclosures will expand somewhat, increasing hatching success and survival probabilities for first year

northern red-bellied cooter hatchlings. Increased inventory and monitoring will assist in better understanding the impact of predators on northern red-bellied cooter nests and potential nest habitats created on refuge pond shorelines.

The range of potential northern red-bellied cooter habitats extends beyond refuge boundaries. Among the entire potential habitat for northern red-bellied cooters, only 10 percent is protected through permanent conservation. The remaining 90 percent of potential habitats are under private ownership, including as much as 50 percent of the population occurring in Federal Pond, a privately-owned pond owned by Federal Furnace Cranberry Company (USFWS 2007). For successful northern red-bellied cooter recovery, it is imperative that the Service, State, and other conservation organizations work with these private landowners to more fully engage them in recovery. Alternative B affords more opportunity to work with private landowners such as the nearby cranberry growers, residents along the shorelines of refuge and off-refuge ponds, and other landowners in the region interested in entering into management agreements. This alternative also increases law enforcement outreach with private landowners, further benefiting northern red-bellied cooter populations existing on nearby private lands. With increased research effort, Service conservation partners and refuge staff will become better informed to more strategically manage and protect the existing and potential cooter population rangewide, both on and off the refuge.

Mammals — Under alternative B, the Service would inventory and map invasive species and implement management efforts at priority sites on the refuge. Controlling invasive plants benefits mammals by maintaining the balance of food resources and native vegetative communities to which they are adapted for cover, nesting, and quality food resources. Those invasive species that pose the biggest threats to mammals are those that can quickly colonize an area and form dense, monotypic stands. Herbivorous mammals that depend on a variety of native food resources throughout the year would be adversely impacted by monocultures of invasive plants. For smaller insectivorous mammals, degradation of native plant diversity and structural integrity by invasion of exotics adversely impacts the biodiversity and availability of invertebrate food resources associated only with native floral assemblages. Early detection and control of invasive plants will help prevent non-native plant monocultures from displacing native plant and insect diversity which provides critical year round food resources for herbivorous and insectivorous mammals.

Silver-haired bats that forage in fairly open habitat in mixed wood forests near ponds may benefit if present, from clearing vegetation on 1 acre near refuge pond shorelines for northern red-bellied cooter nesting habitat.

Reptiles and amphibians — Controlling invasive species would benefit amphibians and reptiles by contributing to the restoration and propagation of native plants and associated insects that are essential food resources. Additional inventories will further inform the Service and our partners about the extent and population of various amphibians and reptiles, increasing certainty about management impacts on them.

Fish — If surveys proposed indicate a need for aquatic invasive plant control, fish favored by native aquatic plants would indirectly benefit indirectly from that control, but the benefit is limited and not expected to be significant.

Hazardous Fuel Loading Reduction — Northern red-bellied cooter — Prescribed burning and mechanical thinning on up to 200 upland acres will further benefit the northern red-bellied cooter, by extending increased sunlight reaching the forest floor beyond the immediate refuge pond shorelines. Most lands

surrounding refuge ponds are now closed-canopy pine forests. These closed canopy forested pond shorelines, if provided with adequate sunlight, could become suitable cooter nesting and incubation habitat. Incubation takes 73 to 80 days at an average temperature of 77 °F. The microclimate at nesting sites can affect the sex ratio of hatchlings (Graham 1993) with cool nests producing more males (a male-biased sex ratio is currently documented on the refuge), and warm nests more females. Research suggests that providing nesting habitat with ample sunlight may benefit both hatching success and early hatchling survival (USFWS 1994).

Migratory birds — Up to 200 acres, nearly all refuge forested habitat, will be managed using prescribed burning (primarily) and/or thinning treatments to open the forest canopy and encourage low, dense shrub understory growth. Prescribed burning and thinning up to 200 acres of mixed pine-oak forest will benefit early successional and shrub species such as prairie warblers and field sparrow, chestnut-sided warbler, black and white warbler, common yellowthroat, eastern towhee, and gray catbird. Representative species such as eastern towhees and prairie warblers, and other migratory birds preferring open canopy and denser understory, will potentially increase (King et al. 2011) refugewide (locally), but is not expected to be measurable at regional or continental population scales.

Bill Thompson

Eastern wood peewee

Eastern wood-pewee are also likely to thrive refugewide under alternative B. Variability in fire intensity during individual burns, combined with rotating multiple small burn treatments across the refuge landscape over several years will provide the heterogeneity in stand structure preferred by the wood pewee. Patches of intermediate age forest with more closed canopy left where lower intensity fire spread occurs, will be in close proximity to open, park-like patches, and the entire gradient of conditions between these.

Juvenile ovenbirds that use regenerating cleared areas with a denser understory for foraging and predator protection near adult ovenbird breeding habitat, will find that on up to 200 acres treated with prescribed burning and mechanical thinning. Also, the HMP will identify patches to be reserved for migratory birds needing a more closed canopy habitat. This ensures that dense shrub juvenile ovenbird foraging and escape habitat is provided proximally to forest interior ovenbird nesting habitat, that is expected to remain available through the planning period and beyond on adjoining public and private lands.


CraigL ewis/USFWS

White tailed deer

Mammals—Monitoring to date shows no evidence of New England cottontail on the refuge or the adjoining MSSF, so no significant direct short-term benefit to existing New England cottontail populations is anticipated under alternative B. However, under alternative B, treatments to create open canopies with a dense shrub understory, potentially suitable for future occupancy by New England cottontail would be extended to nearly all refuge forested uplands. This is consistent with the regional New England Cottontail Technical Team recommendations for the refuge and adjoining MSSF. Prescribed burning and mechanical thinning on up to 200 acres will create many patches with more open canopies and dense shrub understory, potentially suitable for future occupancy by New England cottontail.

The utility line present on the refuge, currently managed by the utility company and the State using mowing and herbicides to create a grass-shrub habitat, is also conducive to New England cottontail. By working collaboratively with utility right-of-way managers, the future potential for additional improved habitat connectivity and conditions for New England cottontail with the larger landscape surrounding the refuge increases.

There will be similar, but refuge-wide scale beneficial impacts to other (non-listed) mammals, especially to bats under alternative B. Bats suspected as present on the refuge (USFWS 2013) include big brown, eastern red, silver-haired, tri-colored, and eastern small footed bats. Bats will likely benefit from the creation of forest canopy openings on up to 200 acres where active vegetation management occurs. Canopy gaps created by thinning and prescribed burns may allow bats such as eastern red bat and big brown bat to forage more easily. Decreased tree density and increased openings, may also improve travel corridors for bats, as more light reaches and warms roost trees, and increases insect prey diversity and abundance through increased herbaceous and shrub growth. Fire may create new bat roost trees and snags by direct or indirect fire mortality, although it may take one or more seasons to develop after burning. Given the relatively small total refuge acreage impacted, none of the above local (refuge-level) changes in bat species abundance are expected to be significant at the larger landscape or population levels.

Other mammals preferring more open canopy conditions and a denser understory layer such as mice and voles would also indirectly benefit from the prescribed fire regime and thinning treatments on up to 200 acres (refugewide). Denser understory often allows for better protection from predators along with providing more food resources for small mammals such as mice and voles.

With deer density currently well above the 6 to 8 deer per square mile MassWildlife target range for Wildlife Management Zone 11, and given normal fecundity rates, opening most of the Crooked Pond parcel to deer hunting will not significantly impact local deer density or achievement of state deer management goals.

Reptiles and amphibians—Reptiles, and amphibians favored by open canopy conditions with a dense shrub understory, such as American toad, Fowler's toad, and eastern hognose snake are expected to benefit to an even greater (up to fourfold) degree from prescribed burning and thinning and on up to approximately 200 acres.

Invertebrates, including pollinators—As already discussed above under alternative A, invertebrate data for the refuge are generally lacking for most species. Rare butterfly and moth species that depend on sandplain heathland community or pitch pine-oak shrubland habitats, such as the Pine Barrens

buckmoth and Gerhard's Underwing moth and others, will benefit refugewide from prescribed burning and thinning on up to 200 acres. Many caterpillars (larvae) of these species eat only pitch pine, scrub oak, or other specific plant hosts found only or mostly in pitch pine-scrub oak shrubland association or sandplain heathland communities. Prescribed burning and overstory thinning will allow more light to penetrate to the understory, favoring the host plants which attract these pollinators.

Expansion of moth and butterfly species inventory and monitoring, also gives Service staff and partners better information about lepidopteran species occurrence, allowing for more strategic, targeted, and proactive application of refuge vegetation treatments.

Collaboration with the utility company to manage for shrubland habitat along the power line would also benefit pollinators such as some moths and butterflies. Studies indicate that when managed properly, utility rights-of-way become suitable habitats for certain butterflies and moths (Wojcik and Buchmann 2012). Management strategies that increase edges, favor trees along sidelines, and increase bare ground provide better butterfly habitat (Carter and Anderson 1987). Sunlight is particularly important for basking behaviors that warm the body for flight (Smallidge et al. 1996).

Refuge Access and Public Uses — Northern red-bellied cooter — Camera monitoring indicates some trespassing on refuge property. Temporary signs establishing visual and more enforceable closures around the nesting sites during nesting and incubation seasons will afford a limited additional protection for the cooter. Illegal collection of cooter eggs and other harassment by humans will be further deterred by keeping the refuge pond shorelines which cooters use for basking and nesting closed to public use, and increased enforcement.

Migratory birds — Opening most of the Crooked Pond parcel to staff and partner-led wildlife observation and photography, interpretation and environmental education, increasing refuge outreach, as well as opening most of the Crooked Pond parcel seasonally to hunting, are unlikely to provide more than minimal (not significant) benefit to migratory birds from the increased stewardship ethic and awareness of refuge resources, including migratory birds, they will foster.

Field sparrow

Bill Thompson

Some decrease in unauthorized (illegal) use that can damage or destroy eggs and nests on or near the ground, or disturb incubating or brooding adults on nests with the greater staff presence and enforcement is expected.

Mammals — Opening the refuge to staff and partner-led to wildlife observation and photograph, interpretation and environmental education, increasing refuge outreach, as well as opening most of the Crooked Pond parcel seasonally to hunting, are unlikely to provide more than minimal (not significant) benefit to mammals from the increased stewardship ethic and awareness of refuge resources, including mammals, they will foster.

Adverse Impacts

Habitat Management — Northern red-bellied cooter — Locating and protecting existing cooter nests on the refuge and clearing 1 acre of vegetation along refuge ponds may disturb individual northern red-bellied cooters infrequently for brief periods, but no significant adverse impacts on the northern red-bellied cooter are expected. However, the increased cooter nest success, hatchling survival, earlier attainment of sexual maturity and greater breeding frequency expected from these activities will more than offset disturbance impacts from the activities. Therefore, no significant adverse impacts on the northern red-bellied cooter are expected under alternative B.

Reptiles and amphibians — Herbicide use for invasive species control could negatively impact amphibian eggs, larval stages, and tadpoles to a limited extent, but are expected to be largely mitigated by precautions during application. Herbicides and surfactants intended for terrestrial use can enter freshwater ponds and wetlands, where they can be lethal to developing amphibian eggs, larval stages, and tadpoles. Great care is exercised to mitigate potential damage by adhering strictly to label directions and approved Pesticide Use Proposals. We anticipate no significant adverse effects from herbicide application to control invasive species proposed under alternative B on amphibians or reptiles.

Fish — Herbicide use for invasive species control could adversely impact developing fish eggs and juvenile fish to a limited extent, but can be largely mitigated by precautions during application. Herbicides and surfactants intended for terrestrial use to enter freshwater ponds and wetlands, where they can be lethal to developing fish eggs and juvenile fish. Great care is exercised to mitigate potential damage by adhering strictly to label directions and approved Pesticide Use Proposals. Herbicide application for invasive species control is expected to have little to no impact on refuge fish populations given the precautions taken to avoid herbicide introduction into the wetland and pond areas.

Invertebrates, including pollinators — Herbicide use for invasive species control could adversely impact pollinators and other invertebrates to a limited extent, but can be largely mitigated by precautions during application. However, the level of review that Service policy requires before we can apply any chemical or biological methods on refuge lands (Pesticide Use Proposal process) ensures that the environmental risk is minimized and that all facets of the proposed use have been examined and justified. All products are used according to label instructions to minimize impacts to resources. There is evidence that overuse of herbicides along utility lines can harm pollinators including moths and butterflies (Wojcik and Buchmann 2012). Herbicide use along the utility right-of-way could negatively impact invertebrate species to a limited extent, but can be largely mitigated by precautions during application and collaboration with the State and utility company to minimize herbicide use along the utility line.

Hazardous Fuel Loading Reduction — Migratory birds — Under alternative B, there would be as much as 200 acres burned following the development of a HMP and the spatial FMP. Migratory birds associated with closed canopy, forest interior conditions such as breeding ovenbirds and scarlet tanagers will decline, but likely persist in lower numbers and density on up to 200 acres treated with prescribed burning and mechanical thinning. Suitable habitat will remain within the refuge, and on adjoining ownerships. Ovenbirds are found at higher populations in unthinned areas (King et al. 2011). As indicated in chapter 3 and discussed above under alternative A, adult ovenbirds are often patch-size (area) sensitive, interior forest birds (Porneluzi et al. 2011). The HMP will identify patches to be reserved for migratory birds needing a more closed canopy (interior forest) habitat. Prescribed burning on up to 200 acres over the entire

Crooked Pond in Autumn

Stephanie Koch/USFWS

refuge will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. It is also anticipated that the forest interior habitat conditions ovenbirds, scarlet tanagers and their associates require will be readily available on adjoining public and private lands through this and subsequent planning periods. Therefore potential adverse impacts to forest interior associated migratory birds such as ovenbirds and scarlet tanagers will be limited across space and time, and are not expected to be significant under alternative B.

Mammals—Because there are currently no New England cottontail on the refuge or the adjoining MSSF (MADCR 2011) no direct, short-term adverse impacts are likely under alternative B. Potential direct mortality risk to small mammals such as rabbits, mice, and voles during prescribed burns on up to 200 acres is expected to be low (rare) and not significant, but may occur. Multiple small (25 to 70 acres) burn units allows rotating the prescribed fire and thinning treatments across the 200 upland refuge acres over several years. Prescribed burning on up to 200 acres over the entire refuge will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. A slightly increased predation or winter cold exposure risk during immediate post-burn periods for mammals displaced by prescribed burn units is expected. But this increase is more than offset by improved protective cover for 5 to 7 years after burning. Rotating prescribed burn treatments as smaller patches across the refuge landscape over several years leaves ample area for rabbits and other small mammals displaced from burn units to find safe cover nearby and escape the burn area. Therefore, even with the larger area treated with prescribed fire and thinning under alternative B, no significant adverse impacts on existing mammal populations or on future potential New England cottontail habitat are expected from habitat management actions under alternative B.

Prescribed burns on up to 200 acres and fires occurring when bats are rearing young (April-July) or in deep hibernation (mid-winter) can have negative impacts

on local bat populations. To minimize losses, prescribed fires should be set during warmer days (above 50° F). This impact will most likely be minimal because refuge growing season prescribed burns are unlikely during the times when neonatal bats are still in their roost or during mid-winter deep hibernation periods. Prescribed burning over the entire refuge will however be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year.

Reptiles and amphibians—Short term impacts on amphibian species from prescribed burning and mechanical thinning up to 200 acres are expected. There is increased direct mortality risk. There is also increased indirect impact potential through increased risk of losing forest floor amphibian refugia to consumption by fire. Reptiles, and amphibians favored by more mature, closed canopy forest conditions are expected to decrease (Mitchell et al. 2006) as thinning and prescribed burning is expanded. Spotted salamander, spring peeper, wood frog, and milk snake are species that could be adversely impacted, but mitigation and adaptation may be possible. The HMP will identify areas of the refuge to be reserved for migratory birds needing a more closed canopy (interior forest) habitat that will similarly provide refugia for reptiles and amphibians such as spotted salamander, spring peeper, wood frog, and milk snake. Impacts to amphibian populations from timber harvesting can be minimized using modified even-aged silvicultural practices (aggregate retention cuts, and shelterwood retention cuts) (deMaynadier and Hunter 1995, Brooks 1999). Retaining 10 to 15 percent of the refuge uplands in late-successional forest patches as planned for state wildlife lands, according to the Massachusetts SWAP (MassWildlife 2015) will contribute to long-term persistence of less mobile, moisture sensitive amphibians such as redback salamander (DeGraaf and Yamasaki 1992 and 2002), wood frog, and mole salamanders. A shaded canopy is usually restored within 10 years, and redback salamander numbers typically recover to pre-cut levels within 30 years (DeGraaf and Yamasaki 2002), and there is generally no difference in numbers of salamanders in 60-year-old second-growth forest vs. old-growth forest (Pough et al. 1987). It is also anticipated that the forest interior habitat conditions which spotted salamander, spring peeper, wood frog, and milk snakes and their associates require, will be readily available through this next (and future) planning period on adjoining public and private lands.

Under alternative B, there would be as much as 200 acres burned following the development of a HMP and spatial FMP. Prescribed burning on up to 200 acres over the entire refuge will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Rotating prescribed burn treatments as smaller patches across the refuge landscape over several years still leaves ample area for reptiles and amphibians displaced from burn units to find safe cover nearby and escape the burn area. As with alternative A, the small burn units employed under alternative B means alternate escape cover is never more than 700 feet away for reptiles and amphibians displaced by a prescribed fire or other habitat treatment. Therefore, even with the larger area treated with prescribed fire and thinning under alternative B, no significant adverse impacts on reptiles or amphibians are expected from habitat management actions proposed. The refuge ponds and other micro-site features within and surrounding burn units may provide protective refugia from fire for refuge reptiles and amphibians, and breeding by aquatic species is expected to continue uninterrupted by fire (Russell et al. 1999).

Overall, with careful consideration of management practices and the impacts on amphibians and reptiles, we anticipate no significant adverse effects from

prescribed burning or other hazardous fuel reduction actions proposed under alternative B.

Fish—Since no fish survey has been conducted by Service staff it is unclear what fish species exist in any of the ponds. As already discussed above under alternative A, prescribed burning would have little to no impact on fish populations given the precautions taken to avoid post-burn runoff into the wetland and pond areas.

Refuge Access and Public Uses—Northern red-bellied cooter—Staff and partner-led wildlife observation, photography, interpretation and environmental education will be conducted in a manner to ensure that disturbance to northern red-bellied cooters and their habitat does not occur. Although increasing public access increases disturbance risk to northern red-bellied cooter nesting areas, all access would be managed to ensure visitation does not interfere with breeding and nesting seasons for the cooter.

Other possible threats to the northern red-bellied cooter are the collection of eggs, individual turtles, and harassment by humans or their pets. Some potential for increased disturbance or harassment of northern red-bellied cooters from unauthorized users is expected, but is not deemed significant.

Migratory birds—Increased disturbance impacts to individual migratory birds may occur from authorized wildlife-dependent puboic use. Staff and partner-led wildlife observation, photography, interpretation and environmental education are expected to increase visitor use and human disturbance impacts just slightly. Impacts will vary by species involved and the type, level, frequency, duration and the time of year the disturbance occurs.

Bill Thompson

Brown thrasher

Beale and Monaghan (2004) found adverse effects to wildlife increased as number of users increased, and that an animal's response to one visitor walking down a trail is entirely different than to a group of users walking down a trail. Miller et al. (1998) found bird abundance and nesting activities (including nest success) increased as distance from a recreational trail increased in both grassland and forested habitats. In this study, common species (e.g. American robin) were found near trails and rare species were found farther from trails. Disturbance can cause shifts in habitat use, abandonment of habitat, and increased energy demands on affected wildlife (Knight and Cole 1991). In some cases there is a clear link between the extent of disturbance and survival or reproductive success of individuals (e.g. Schulz and Stock 1993). But in many cases, disturbance acts in a more subtle way by reducing access to resources such as food supplies or nesting sites (Gill et al. 1996). Bird flight in response to disturbance can lower reproductive success by exposing individuals and nests to predators.

Evidence suggests species most likely to be adversely affected are those where available habitat is limited, constraining them to disturbed areas where they suffer reduced survival or reproductive success (Gill et al. 2001). Because of the diversity of habitats represented on the refuge directly connected to other large tracts of protected lands, any population level effects to migratory birds from refuge public use would be minimized by an abundance of habitat on the refuge and adjacent public lands.

By having refuge staff present or a partner agency guide refuge visitors, potential disturbance can be substantially reduced by keeping visitors in specific areas and minimizing noise levels. Alternative B helps deter illegal use and other potential wildlife harassment by humans by enforcing migratory bird regulations refuge-wide. Increased public use and access to the refuge as proposed and expected under alternative B is not expected to have significant adverse impacts on migratory birds.

Mammals—With no known presence of New England cottontail on the refuge the opening of the refuge to environmental education and interpretation, wildlife observation and photography, and deer and turkey hunting (no small mammal hunting) will not preclude future occupancy by the New England cottontail.

Slightly increased disturbance to individual small mammals is expected. Wildlife disturbance may be compounded by seasonal needs. For example, disturbance would cause some mammals to flee. During winter months, mammals that flee would consume stored fat reserves needed to survive the winter. Hammitt and Cole (1998) found white-tailed deer females with young are more likely to flee from disturbance than those without young. In addition, native carnivores (bobcats and coyotes) also appear to shift periods and areas of activity to avoid peak recreational use (George and Crooks 2006). With public use confined to small portions of the refuge at any given time, alternative B is not expected to have significant adverse impacts on mammals, including bats. Unauthorized use will also continue to affect refuge small mammals to a limited (not significant) extent.

Jared Green

Northern red-bellied cooter

Opening portions of the refuge to deer hunting in accordance with state regulations would result in direct mortality of individual wildlife harvested. We anticipate light hunting pressure. Nevertheless, recreational hunting at any level, including for deer and turkey, can be controversial. Before any hunting is authorized on the refuge, the Service will prepare a hunt opening package and associated NEPA documentation, including public notification, scoping, and invite public input on that hunt opening package and plan.

Reptiles and amphibians—Potential disturbance from staff and partner-led trips can be substantially reduced by keeping visitors in specific areas and minimizing noise levels. Alternative B helps deter illegal use and other potential wildlife harassment by humans by increasing patrols and enforcement refuge-wide. Unauthorized use will continue to affect reptiles and amphibians on the refuge, but to a lesser extent. Increased public use and access to the refuge as proposed and expected under alternative B is not expected to present significant adverse impacts on other reptiles and amphibians.

Fish—Unauthorized (illegal) use will likely continue to affect fish in refuge ponds to a limited (not significant) but lesser extent, due to increased presence by Service personnel, including law enforcement.

Effects on Climate Change

A summary of general climate change data and analyses, as well as information specific to Massachusetts was provided in chapter 2. In this section, we evaluated the alternative management actions for their potential to help mitigate or potential for increased atmospheric carbon emissions from refuge management activities to contribute to the impacts of climate change locally, in the region, and globally, including:

- The potential for enhancing habitat resiliency utilizing prescribed fires to manage pitch pine-oak forests.
- The potential for enhancing resiliency in habitats by controlling invasive species.
- Maintaining continuous vegetative cover, surface litter, and duff layers on refuge lands that sequester carbon, through area closures and applying BMPs.
- Atmospheric carbon emissions from vehicles, equipment, and prescribed burning efforts.

Climate Change Impacts Common to Both Alternatives

Unlike southern cooter populations, northern red-bellied cooter populations hibernate during winter in pond bottom substrates under the ice. With the potential for increased temperatures due to climate change, warmer conditions may shorten this hibernation period and lengthen the non-hibernation period, thereby increasing survival rates among these northern populations.

With respect to greenhouse gases responsible for climate change, plants absorb carbon dioxide and as a result, vegetated areas can act as important carbon sinks (Heath and Smith 2004; USEPA 2012). Carbon "sequestration" is essentially the process by which plants take up carbon dioxide through photosynthesis, and then store (sequester) it in plant biomass (wood, roots) and in the soil. Succession to forest stores the most carbon although the sequestration rate declines as trees mature (Heath and Smith 2004). Decomposition, functionally the inverse of photosynthesis, releases sequestered carbon back to the atmosphere, and decomposition rates increase in mature forests. Some carbon sequestered on or above the soil surface is however released back to the atmosphere whenever vegetation burns during wildfire or prescribed burn surface fire spread, partially reversing vegetation and soil carbon sequestering as with forest decomposition.

A 2012 assessment by Manomet Center for Conservation Sciences and the National Wildlife Federation looked at regional climate change vulnerability. Pine barren (pitch pine—scrub oak shrubland, pitch pine—oak woodland or forest associations, or sandplain heathland community) habitats are the least vulnerable (most resistant) to climate change forest types in the region. These naturally resilient forest types can withstand wildfire (with proper fuel load management), pest and invasive species outbreaks, often associated with climate change. Although these forests are vulnerable to non-climate stressors, with the reduction of fuel hazards, the risk of severe wildfires brought on by alternating cycles of increased precipitation and drought is reduced.

Climate Change Impacts of Alternative A

Beneficial Impacts

Hazardous Fuel Loading Reduction — Continued use of prescribed burns to manage fuel loads on 50 acres combined with expected climate change induced drought and other weather extremes, may create more favorable conditions for pitch pine-scrub oak persistence and expansion (Manomet Center for Conservation Sciences and the National Wildlife Federation 2012). Continuing hazardous fuel reduction will also reduce the high intensity wildfire threat, often

exacerbated by the alternating cycles of extremes in precipitation and severe drought expected with changing climate.

Adverse Impacts

Hazardous Fuel Loading Reduction — There is the potential for slight, short-term increases in atmospheric carbon emissions during prescribed burning and from motorized equipment use during mechanized thinning. Prescribed burning will be performed on a (5-7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. The level of carbon emissions from habitat management will be insignificant compared to the emissions from a single large, high severity wildfire due to high fuel load accumulations without fuel treatments.

Refuge Administration — Atmospheric carbon emissions will result from round-trip motor vehicle travel by complex headquarters staff to work on the refuge. The staff increasingly utilizes lower emission vehicles to reduce atmospheric carbon emission contributions to global climate change. Because of the limited level of management, the carbon emissions from administrative activity expected are minimal, and not significant.

Climate Change Impacts of Alternative B

Beneficial Impacts

Habitat Management — Coastal ponds have a medium vulnerability to climate change as a result of the potential increase in invasive plants associated with climate change (Manomet Center for Conservation Sciences and MassWildlife 2010). Surveys of aquatic invasive plants with an evaluation of the need for management would potentially benefit refuge pond climate change resilience if control efforts were implemented sooner.

Hazardous Fuel Loading Reduction — Expanding prescribed burning and mechanical thinning for hazardous fuel reduction and habitat management to as much as 200 acres should increase resiliency of the refuge forests to climate change. Episodic greenhouse gas emissions from high intensity wildfires are less likely with fuel reduction on up to 200 acres. Invasive species monitoring and control would also increase, to maintain less than 10 percent cover in invasive species refuge-wide. Resiliency to climate change impacts of the natural plant communities and the restored habitats would increase the most under alternative B.

Carbon sequestration would differ based on the change in vegetation type, structure, and forest canopy closure by extending mechanical thinning and prescribed burning to as much as 150 additional acres of what is now relatively mature, closed-canopy eastern white pine dominated forest, a less climate change resilient type. The net offset effect of carbon sequestration from forest succession to the periodic carbon release back into the atmosphere during prescribed burning is however uncertain.

Adverse Impacts

Hazardous Fuel Loading Reduction — Increasing prescribed burning by up to 150 additional acres is expected to increase atmospheric carbon emissions by up to four times over the planning period. Prescribed burning up to 200 acres will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Rapid post-burn vegetative recovery and resumption of biological carbon sequestration of atmospheric carbon following low to moderate intensity, small scale prescribed fires is expected. This increased level of atmospheric carbon emissions would still be insignificant compared with those from a single large, severe wildfire fueled by heavy fuel

loads, as experienced in past decades. The use of power tools and equipment on the refuge would also produce small amounts of carbon emissions.

Refuge Access and Public Uses — Additional impacts on atmospheric carbon emissions may occur from the slight potential increase in visitation on the refuge could occur under this alternative. Atmospheric carbon emissions from increases in refuge visitor use would likely be negligible (insignificant) since most visits to the refuge would come from nearby residents or visitors already using the adjacent MSSF.

Refuge Administration — Additional atmospheric carbon emissions will result from more round-trip motor vehicle travel by complex headquarters staff to the refuge. The shift toward lower emission vehicles to reduce atmospheric carbon emission contributions to global climate change will offset emissions from increased refuge staff administrative vehicle use. Atmospheric carbon emissions would still be minimal (insignificant) compared with emissions from sources originating outside the refuge.

Effects on Refuge Access and Public Uses

We evaluated the alternative management actions with the potential to affect the level of opportunity and visitor experience of those major activities listed:

- Offering guided wildlife observation and photography trips by staff or refuge partners.
- Opening a portion of the Crooked Pond parcel seasonally to hunting, including deer and turkey hunting, in accordance with State regulations.
- Offering onsite environmental education and interpretation hosted by refuge staff or by refuge partners under special use permit.
- Increased outreach and Service visibility to promote resource stewardship and outdoor ethics.
- Increased partnerships with local, regional, and state recreational interests.
- Law enforcement activity and effectiveness on and off the refuge.

Refuge Access and Public Use Impacts Common to Both Alternatives

No beneficial or adverse impacts to refuge access and public uses are common to both alternatives.

Refuge Access and Public Use Impacts of Alternative A (Current Management)

Beneficial Impacts

Refuge Access and Public Uses — With continued closure of the refuge to public use, there will be no significant beneficial impact to refuge access and public use. The Service will have capability for limited oversight of vehicular and pedestrian traffic on the refuge. A very limited ability to educate a wider audience about the refuge's ecosystem and the sensitivity of habitats and associated wildlife will continue. The Service would continue providing limited programming, delivered primarily through refuge partners, as staffing, funding, and the interest and availability of Service partners allow.

Adverse Impacts

Refuge Access and Public Uses — Continued closure of the refuge effectively precludes most refuge public use and access opportunities throughout the planning period. Limited outreach, interpretation, and enforcement by the Service will not ensure compliance with Federal, State, and local endangered species or wetland protection laws on the refuge. A lack of awareness of the

Sign to protect northern red-bellied cooter nesting habitat

Libby Herland/USFWS

refuge boundaries and refuge policies, and improper and unauthorized use and access to sensitive areas of the refuge is expected to remain unchanged, and continue through the planning period.

Refuge Administration — The distance of the refuge from the Refuge Complex headquarters and current levels of staffing and funding limit the Service's ability to develop and deliver the programming content and messaging that fulfills the Service's educational goals and priority use mandates. The minimal level of interpretation that has occurred off the refuge related to the refuge's natural resources has been delivered principally through refuge partners. The Service would remain entirely dependent on the interest and availability of Service partners to deliver limited interpretive programming and outreach.

Refuge Access and Public Use Impacts of Alternative B (Service-preferred Alternative)

Beneficial Impacts

Refuge Access and Public Uses — Providing staff and partner-led guided visits to the Crooked Pond parcel and opening most of the Crooked Pond parcel seasonally to hunting will increase public access and public use. Wildlife observation, photography, interpretation, environmental education, and recreational hunting are all priority wildlife-dependent recreational activities that are not available under alternative A. Alternative B somewhat increases the Service's emphasis on interpretation provided through a more coordinated public use program. Staff and partner-led interpretive programs, partner-led environmental education programming and the development of more interpretive materials should increase public awareness of the refuge.

We expect increased public awareness of the presence of a refuge in the Plymouth region, about the importance of natural resources, human impacts on wildlife, and refuge policies.

Adverse Impacts

Refuge Access and Public Uses — Continued closure to public access of ecologically sensitive areas such as refuge pond shoreline nesting sites of the northern red-bellied cooter does limit public accessibility to pond shorelines. Even with the presence of wildlife observation and photography, environmental

education and interpretation, and hunting, refuge staff would continue to limit activities that may impact the cooter. Onsite and offsite programs require expenditures and committing resources that could be available for other refuge programs. Additional authorized access to the refuge and its resources may also draw increased unauthorized use. It is unknown to what extent unauthorized use would occur with improved outreach efforts.

Effects on Refuge Archaeological, Historical, or Cultural Resources

We evaluated the alternative management actions that have the potential to protect or damage archaeological, historic, or other cultural resources located on the refuge, including:

- Using of prescribed burning for habitat management.
- Using mechanized equipment and power tools including tree-cutting, tree-girdling, mowing for habitat management.
- Invasive species management.
- Refuge public use activities including environmental education, and interpretation, a public use trail connection, and opening most of the Crooked Pond parcel seasonally to deer and turkey hunting.
- Wildland fire suppression policies and methods.
- Limited outreach, interpretation, and law enforcement on and off the refuge.
- Offering onsite environmental education and interpretation hosted by refuge staff or by refuge partners under a SUP.

Archaeological, Historical, or Cultural Impacts Common to Both Alternatives.

In protecting cultural and historical resources we are guided by specific Executive Orders, policies, laws, regulations, standards, and guidelines. Chapter 2, Refuge Archaeological, Historical, and Cultural Resources, described in more detail the refuge's resources. We will comply with all appropriate legal mandates to protect and manage refuge cultural resources. Any management actions with the potential to affect cultural resources require refuge manager review, as well as review by the Service's Regional Historic Preservation Officer, in consultation with the Commonwealth of Massachusetts SHPO and THPO as appropriate. Determining if particular actions within an alternative have the potential to affect cultural resources is an ongoing, well-established, and closely regulated process that will continue during the planning stages of any proposed projects under either alternative.

It is probable that unrecorded archaeological or cultural sites exist on current refuge lands. Many of these are likely to include Native American artifacts. The likelihood of locating other prehistoric or historic sites on the refuge is also high given the human settlement and land use history in the refuge vicinity. Regardless of alternative, the Service is responsible for managing and protecting archaeological and historic sites found on national wildlife refuges.

Archaeological, Historical, or Cultural Impacts of Alternative A

Minimal beneficial or adverse impacts to any archaeological, historical, or national resources are expected given precautions taken to protect any cultural, historical, or archaeological resources. The refuge will remain largely closed to public use. Northern red-bellied cooter management actions along the shoreline of Crooked Pond will be limited. Thinning and prescribed burning will be limited to 25 percent (or 50 acres) of the refuge within the northeastern corner of the Crooked Pond parcel. The limited law enforcement staff is not expected to prevent or detect many violations resulting from unauthorized public uses.

Archaeological, Historical, or Cultural Impacts of Alternative B

Beneficial Impact

Habitat Management and Hazardous Fuel Loading Reduction — There may be an increased opportunity to discover and protect sites and artifacts and further evaluate the cultural significance of the discovery site during project planning or implementation.

Refuge Access and Public Uses — There would be little or no beneficial impact to cultural resources from public use under this alternative. The slight increase in emphasis on environmental education and interpretation on and off the refuge would focus on the biological resources of the refuge as well as the Refuge System with little emphasis on cultural resources planned in the near-term in the absence of new cultural site/artifact discoveries.

Adverse

Habitat Management and Hazardous Fuel Loading Reduction — Minimal impact to cultural resources on the refuge from disturbance related to habitat management is expected. Although mechanical thinning and prescribed burning would potentially increase across the refuge under a HMP, the Service makes every effort to minimize new soil disturbance, identify and protect any sites or artifacts beforehand, or discovered during habitat management. Disturbance can occur through disturbing the top layer of soil that may serve as a protective layer for undiscovered artifacts. These areas would be limited to those small, localized areas disturbed through fire break creation, thinning and tree removal, or invasive species removal.

Refuge Access and Public Uses — A slight increase for potential disturbance to as yet undiscovered artifacts could result from a general increase in visitation. Hunting does not typically result in soil disturbance that might unearth buried artifacts. However, all visitation (except for hunting) would only occur when guided by refuge staff or partners. The likelihood of any destructive impacts from increased refuge public use will be minimal.

Effects on Refuge Socioeconomic Resources

We evaluated the alternative management actions that have the potential to contribute to or adversely impact the local and regional economies and quality of life, including:

- Refuge revenue sharing (in-lieu of tax revenue) to the town of Plymouth.
- Refuge visitor expenditures in the local economy.
- Refuge staff and work-related expenditures in the local economy.

Socioeconomic Impacts Common to Both Alternatives

Property ownership by the Federal Government effectively removes the property from the local, town of Plymouth tax base. Under both alternatives, the Service would continue somewhat offsetting tax revenue losses by making annual "revenue sharing" payments to the town in lieu of taxes, as provided by Congress. Under Refuge Revenue Sharing Act (16 U.S.C. 715s, as amended) local towns receive an annual payment for lands that have been purchased in full (fee simple acquisition) by the Service. In Massachusetts, payments are based on three-quarters of one percent (0.0075) of the appraised market value. In 2014, the payment to the town of Plymouth was $4,811 (see chapter 2 Revenue Sharing Payments). No major changes in the level of revenue sharing payments are expected unless Congress changes its annual revenue sharing appropriation.

The Congressional appropriation in recent years has tended to be less than the amount required to fully fund the authorized level of payments. Recent payments to local governments across many refuges have not equaled losses in tax revenue,

but we expect these annual $4,000-$5,000 payments have negligible effect on the $32.89 million (2015) town of Plymouth annual operating budget. Some literature indicates that market values of homes adjacent to protected open space are frequently higher than properties elsewhere (Trust for Public Lands 2007). An increase in home values also increases property taxes for those homes and this increase in property values then leads to higher tax revenues. In addition, people may be more likely to move to an area that values the protection of natural resources for both wildlife and public enjoyment (Trust for Public Lands 2007).

Socioeconomic Effects of Alternative A (Current Management)

Beneficial Impacts

Refuge Access and Public Uses and Refuge Administration — The refuge will remain largely closed to the public. No additional beneficial impacts to the socioeconomic resources from visitors and staff expenditures are anticipated.

Refuge Administration — No staff are stationed permanently at the refuge. Refuge Complex biological and law enforcement staff conduct site visits frequently. The slight (not significant) benefit to the local economy from small purchases of goods and services in the local area during staff visits should remain little changed under alternative A.

Adverse Impacts

None.

Socioeconomic Effects of Alternative B (Service-preferred Alternative)

Beneficial Impacts

Refuge Access and Public Uses — Research has shown that by offering places where visitors can enjoy watching birds and other wildlife local economies benefit from increased sales at local businesses for food, lodging, fuel, and supplies, and associated tax revenues (USFWS 2006). Improved visitor access to the Crooked Pond parcel for interpretation, environmental education, wildlife observation and photography, and deer and turkey hunting will result. New interpretive and environmental education programs would include a more coordinated environmental education program with partners, occasional interpretive programs, and more interpretive materials. A slight increase in refuge visitation is expected, resulting in a corresponding slight increase in expenditures in the local community by refuge visitors. New net increases in expenditures by refuge visitors captured by the local economy will not be significant, since many of these new refuge visitors are expected to be local residents or already visiting MSSF.

Cumulative Effects

According to CEQ regulations on implementing the NEPA, a cumulative impact is an impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes the other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time, including the actions of other agencies or organizations, if they are interrelated and influence the same environment. Potential cumulative impacts for the two alternatives described below considers the interaction of activities at the refuge with other actions occurring over a larger spatial and temporal frame of reference.

Under alternative B, refuge staff will increase participation with the North Atlantic LCC partners to identify focal areas for landscape conservation design, with land protection through a partnership effort likely to include Massasoit NWR, and the adjoining MSSF, and Mashpee Refuge. Because the geographic scope of this collaborative process greatly exceeds the boundaries of Massasoit NWR, and implementation of specific land protection measures remain several years off, analysis of the impacts from this future landscape

scale plan are considered beyond the scope of this analysis and plan. Results from this landscape scale conservation design initiative will however inform future Massasoit NWR CCP revisions, refuge stepdown plans and related NEPA analysis, and other Service and conservation partner land protection and stewardship initiatives.

Air Quality

Although some areas in Massachusetts periodically experience high ozone levels, the location of the refuge ensures relatively good air quality. Neither of the proposed alternatives is expected to have significant cumulative adverse impacts on air quality in the Plymouth area or elsewhere in the region. Some short-term, local impact on air quality is expected from prescribed burns and from refuge visitors' automobile emissions. However, prescribed burns would only occur under FMP stipulations (see appendix D) specifically designed to minimize air quality impacts. We expect none of the activities on the refuge to contribute to any measurable incremental increase in ground ozone levels or other air quality parameters, by the air quality monitoring network.

Although the refuge would continue to use prescribed fires to manage pitch pine-oak shrubland, woodland, or forest habitats we anticipate that air quality impacts associated with those actions would be temporary and localized. The cumulative impacts of prescribed burning throughout a region may be short term and moderate (Zeng et al. 2008); the temporary and periodic nature of the proposed fire regime on Massasoit minimizes any contribution to potential cumulative effects in the region.

Prescribed fire smoke can combine with multiple other emission sources to create "regional haze" capable of transport over long distances before impairing visibility within federally designated mandatory Class 1 areas such as national parks, monuments, or units of the NWPS. For example, Massachusetts has been cited for impairing visibility in the Class 1 airshed over Acadia National Park in Maine (D. Walker 2013 personal communication). With no more than 50 acres of prescribed burning in on any single day or in any one year under either alternative, Massasoit NWR prescribed burning will not contribute significantly to regional haze over the planning period. Regional Haze Regulations are in place to address Class 1 area visibility impairment, and both alternatives will fully comply with these regulations.

Similarly, occasional herbicidal applications to refuge habitats will for the most part be applied using backpack sprayers and are very target specific. This means of application is not anticipated to have any impacts to air quality.

We expect neither alternative to contribute to significant adverse cumulative air quality impacts locally or regionally. Along with our partners, both alternatives will continue to contribute to improving air quality through cooperative land conservation and management of natural vegetated habitats.

Any increased landscape level, partnership-based conservation efforts by the Service would help maintain regional air quality by potentially preventing residential, agricultural, or commercial development. These kinds of developments can potentially increase ground level ozone, and other pollutants from buildings, automobiles, agriculture practices such as pesticide and fertilizer use, and industrial practices and regional haze episodes. Conservation and ecosystem restoration measures through management agreements with private, other public, and non-governmental (non-profit) landowners provide means for contributing to reduced emissions compared to those occurring if the landscape were to become more developed.

Water Quality

Changes in climate and local weather patterns will likely affect aquatic systems by exacerbating or accelerating habitat degradation due to other identified threats (MassWildlife 2015). Warmer temperatures will warm surface and groundwater entering coastal plain ponds faster than normal, creating conditions favoring invasive species, and longer growing seasons for harmful algal blooms (MassWildlife 2015). Additionally, increases in severe rain and snowfall events will increase runoff of pollutants from agricultural and urban areas into waterbodies. Recent research indicates that the last two decades have been the wettest years in the Northeast in 500 years (Pederson et al. 2013, Newby et al. 2014, Weider and Boutt 2010). Increases in rain will also increase atmospheric deposition of pollutants, including nitrogen deposition. The Sustainable Water Management Initiative, administered by the MADEP, with input from multiple state agencies, is supporting research by the USGS into the hydrological alterations induced by water supply withdrawals and climate change (MassWildlife 2015).

There would be no significant adverse cumulative effects to water quality under either alternative. We would continue using best management practices and measures to control erosion sediments in habitat management and any other ground-disturbing operations to ensure impacts are minimal. Because visitation would be minimal and new public use is directed away from surface waters, there no additional cumulative impacts to water quality through authorized refuge public use are expected under either alternative.

Any additional landscape level conservation potentially provides added water quality benefits for any ponds or waterways that are near but lie beyond the refuge boundaries. Landscape level design and land protection projects would prevent further degradation of refuge pond water quality ongoing off-refuge public use, cranberry or other agricultural production, or future commercial or residential development.

Any potential negative impact from invasive species management near water bodies, prescribed burning or mechanical thinning would also be very limited and localized under either alternative.

Soils

The greatest potential adverse impacts on refuge soils occur from prescribed burns and invasive plant control. Continued best management practices use for fostering forested-shrubland habitats, prescribed burning, trail maintenance, turtle nesting habitat improvement or when selecting various chemical, biological, or mechanical methods avoids significant adverse cumulative impacts on area soils. Under alternative B, removal of invasive plant species as needed and restoration of native plant communities will improve soil nutrient recycling, restore native soil biota, and restore soil fertility. We expect neither alternative to have a significant cumulative adverse impact on the soils within the refuge or the surrounding region.

Any future landscape conservation projects or management agreements with landowners would benefit soils by preventing other detrimental uses as stated above under the impacts to water quality sections.

Natural Community Types and Vegetation

As previously discussed in chapters 2 and 3, a number of potential impacts to refuge coastal pond water quality, hydrology and to habitat and vegetation structure from land uses that are external to the refuge are possible. Shrub and tree encroachment may threaten pond shorelines in areas with excessive groundwater withdrawal. Seasonally high water levels may prevent tree and shrub encroachment, while seasonal low water is necessary to expose the pond shorelines for plant rare germination and growth. Excessive drawdown from

pumping for water consumption or cranberry bog irrigation may reduce natural fluctuations and allows woody species to advance down the shores. Use of coastal plain ponds as recipients of irrigation runoff from cranberry bogs can introduces nutrients and pesticides into the water, altering which species can survive, and encourage excessive growth of algae and vascular plants. Changes in climate and local weather patterns will likely affect aquatic systems by exacerbating or accelerating habitat degradation due to other identified threats (MassWildlife 2015) as previously discussed.

We expect neither alternative will have significant adverse cumulative impacts on the vegetation within the refuge. Prescribed burning would beneficially impact the fire-dependent natural community types and vegetation associations on the refuge and increase its resilience to climate change. Because pitch pine-scrub oak, pitch pine-oak woodland or forest, and sandplain heathland community habitat is unique and regionally important, efforts to restore the habitat through thinning and prescribed burning will contribute to landscape scale efforts to restore this habitat on a regional level. A majority of the refuge is surrounded by MSSF and any collaborative management efforts with MSSF are likely to benefit these important natural community and vegetation associations cumulatively. If increased landscape conservation efforts were to occur then the potential for managing and enhancing forested and shrubland habitat would occur over a much broader geographic scale than Massasoit NWR types.

Biological Resources

As previously discussed in chapters 2 and 3, and earlier in this chapter, sudden alterations to natural hydrologic regimes pose the greatest threats to coastal pond systems and the biological resources that depend upon them for habitat. Changes in climate and local weather patterns may exacerbate or accelerate habitat degradation due to other identified threats (MassWildlife 2015). Extended periods of drought with warmer water temperatures and lowered water levels may cause the loss of littoral habitat used for foraging, rearing, reproduction, and refuge by northern red-bellied cooters plus other species including mussel, odonate, fish, and invertebrates. Dragonfly and damselfly eggs and larvae may survive localized, short-term pond drawdowns for a time either in the stalks of vegetation (where many species lay their eggs) or in the mud of drying ponds. If all ponds in an area are drawn down too often, for too long or over too large an area, restocking by odonates, reptiles and amphibians is less likely.

Recent research indicates that the last two decades have been the wettest years in the Northeast in 500 years (Pederson et al. 2013, Newby et al. 2014, Weider and Boutt 2010). Seasonally high water levels may prevent the pond shoreline exposure for rare plant germination and growth. The nutrients and pesticides entering coastal ponds due through increased surface runoff and groundwater inflow events can alter which species can survive, and encourage excessive growth of algae and vascular plants.

Both alternatives considered in this CCP/EA maintain or improve refuge biological resources. The combination of our management actions with other partnering organizations such as MADCR, MassWildlife, and TNC through landscape scale conservation design efforts of the North Atlantic LCC could result in some, beneficial cumulative effects by:

- Increasing conservation and management of Federal and State-listed threatened and endangered species (i.e. northern red-bellied cooter, and candidate species New England cottontail) and other species of conservation concern including surrogate species.

- Increasing understanding of species and habitat relationships and limiting factors to conservation recovery.

- Using adaptive management and the best science available to manage and promote regionally important habitats and natural communities including the pitch pine-scrub oak shrubland association (sandplain heathland community) and coastal pond habitats.

- Preventing spread or reducing invasive species.

Additional monitoring and inventory information will facilitate decision-making with potentially wide-ranging, cumulative benefits for regional bird and wildlife populations. Collecting additional data about the northern red-bellied cooter on—and off-refuge, and monitoring the response to conservation and management actions of this and other wildlife and plant populations would help close existing knowledge gaps, thereby reducing uncertainty currently inherent is Service and partner stewardship decision-making. Sharing that knowledge among conservation partners would influence and improve natural resource decision-making across the entire region, with cumulative benefits on the biological environment over a broader landscape. In general, management actions would have a cumulative beneficial impact on the biological integrity, diversity, and environmental health of the pitch pine-scrub oak shrubland association (sandplain heathland community), and coastal pond community types in the region.

Native plant management, which includes restoring a more natural fire regime (historic range of variation), cumulatively benefits the biological environment by increasing and enhancing healthy soil biota, restoring and enhancing native plant resources, increasing resident wildlife populations of mammals, fish, reptiles, and amphibians, and enhancing invertebrate reproduction that sustains migratory birds, bats, reptiles and amphibians. Reducing invasive plants through management is not considered an adverse loss because these species are not components native biodiversity for the Massasoit NWR ecosystem.

Libby Herland/USFWS

Unauthorized trail behind homes at Massasoit National Wildlife Refuge

Refuge uses create local impacts individually, and as the number of uses increases over increasingly large areas have the potential create cumulative impacts on biota. Refuge uses are therefore limited to those which are formally determined to be compatible with the purposes for which the refuge was established and the National Wildlife Refuge System mission. No significant

adverse cumulative impacts are expected under alternative B because the refuge would remain essentially closed to public use year-round except for staff or partner-led wildlife walks and educational activities and possibly hunting. We anticipate a low to moderate level of participation in hunting that could be offered if we proceed with developing a hunt program (which involves more analysis and public comment). There would also be no significant cumulative adverse effects to biological resources under either alternative because the changes in habitat components that we would manage for directly, or expect to realize through natural succession offset any harmful impacts incurred by human disturbance or trail use. When we review the Massasoit NWR compatibility determinations (at least every 10 to 15 years, see appendix B), we will consider new possible cumulative effects that may have accrued over intervening years, and will address them as necessary.

With increased Service involvement and support of offsite recovery efforts, the northern red-bellied cooter population has a greater chance for persistence and recovery under alternative B (Service-preferred alternative). Collaboration in research and landscape scale, strategic conservation design efforts increases the opportunity for increasing genetic variation within the cooter population by enhancing connectivity between occupied but currently isolated ponds that may be creating genetic bottlenecks due to inbreeding (USFWS 2007). Therefore, the increased off-refuge efforts for northern red-bellied cooter recovery that occur under alternative B would benefit the endangered northern red-bellied cooter population to a greater extent than current management (alternative A).

Only 10 percent of potential northern red-bellied cooter habitat is protected through permanent conservation. The remaining habitats are under private ownership. As much as 50 percent of the northern red-bellied cooter population occurs in Federal Pond, a single private pond owned by Federal Furnace Cranberry Company (USFWS 2007). Successful recovery of the northern red-bellied cooter requires the Service, the State, and other conservation organizations to engage more fully with private landowners to complete and implement landscape scale conservation design for northern red-bellied cooters. Alternative B affords more opportunities to work with private landowners such as the nearby cranberry growers, residents along the shorelines of refuge and off-refuge ponds, and other private and public landowners in the region interested in entering management agreements. Alternative B also allows for more law enforcement outreach with private landowners, further benefiting northern red-bellied cooter populations that may exist on private lands. In addition, increased research effort under alternative B will better inform refuge decisions on refuge-level management and protection impacting existing and potential northern red-bellied cooter populations both on and off the refuge.

Under alternative B (Service-preferred alternative), increased refuge staff participation in ongoing landscape scale partnership conservation design and land protection efforts will likely benefit shrubland dependent migratory birds, New England cottontail and other mammals (including some bats), some moth, butterfly, and other pine barren or shrubland specialist pollinators.

Climate Change

Our review of proposed actions in this CCP suggests that some activities may contribute negligibly, although incrementally, to stressors affecting regional climate change, specifically our prescribed burn program, the increased visitor access, and increased use of vehicles and equipment for refuge management. We discuss the direct and indirect impacts of these activities elsewhere in chapter 4, including measures to minimize the impacts of both. With respect to our equipment and facilities, we are trying to reduce our carbon footprint wherever

possible and specifically on or surrounding the refuge by driving hybrid vehicles, along with reduced travel and other conservation measures.

Any increased landscape level, collaborative conservation efforts will help maintain regional air quality by potentially preventing residential, agricultural, or commercial development. These kinds of developments could potentially increase atmospheric carbon emissions from buildings, automobiles, agriculture, and industrial practices. The long-term growth of vegetation and interaction with the soils can sequester atmospheric carbon, thereby reducing atmospheric greenhouse gas concentrations. Conservation and ecosystem restoration measures through management agreements with private, other public, and non-governmental (non-profit) landowners provide means to increased carbon sequestration and curb atmospheric carbon emissions which would occur if the landscape is developed.

Climate change poses great challenges for migratory species management. National wildlife refuges have played a critical role in protecting migratory birds. Climate change is likely to impact habitats within refuges, underscoring the importance of climate change adaptation as part of refuge management. However, climate change is also likely to pose considerable risks to many migratory species throughout their ranges (Glick 2012). As Robinson et al. (2009) highlight, the life cycle of most migrants is tied to seasonal events such as availability of key food resources which may be altered under climate change. Under alternative B, we would monitor the impact of climate change on the refuge and detect impacts, especially on surrogate migratory birds.

Climate change may increase opportunities for invasive species to spread because of their greater adaptability to disturbance than some endemics. If this spread occurs, biological integrity and diversity on the refuge and potentially the entire surrounding landscape would decrease. Although a warming climate may assist the northern red-bellied cooter with warmer pond conditions, those benefits to cooters may be offset by invasive aquatic plants. Invasive species control, including extensive monitoring and control measures, is essential for avoiding larger impacts to biological diversity and integrity on the refuge and for recovery of the endangered cooter. A regional vulnerability assessment of the impacts of climate change on coastal ponds would provide information needed to benefit these habitats. Reducing invasive species would increase the resilience of habitats to climatic change.

Refuge managers will stay apprised of climate change and its specific local and regional effects on wildlife and their habitats, and use this information to adapt management techniques and strategies. Given the uncertainty regarding climate change and its impacts on the environment, traditional methods of management may become less effective in the future. An effective and well-planned monitoring program, coupled with an adaptive management approach, is essential in dealing with the uncertainty surrounding future climate change, and both are built into this CCP.

In our professional judgment, most of the management actions we propose would not exacerbate climate change in the region or project area, and in fact some might incrementally prevent or slow down local impacts. Proposed habitat management actions described in chapter 3 are intended to promote healthy, functioning forests and coastal pond habitats. We will implement an adaptive management approach as new information becomes available. We will control invasive plants, and pests, restore periodic fire to pitch pine-oak habitats, and develop and implement a detailed, stepdown Inventory and Monitoring Plan

designed to test our assumptions and management effectiveness in light of on-going change and adjust future management accordingly.

Refuge Access and Public Uses

There would be no cumulative impact under alternative A from refuge access and public use because the refuge would remain largely closed. Under alternative B, public access and use of refuge lands is increased by guided wildlife-related walks and opening most of the Crooked Pond parcel for many or possibly all hunt seasons. There are other opportunities within the southeastern Massachusetts region, including the adjoining MSSF, that provide both wildlife-dependent and other recreational activities.

Refuge Archaeological, Historical, or Cultural Resources

No significant cumulative adverse impacts to archaeological, historical, and cultural resources are expected on the refuge under either alternative. Developing a cultural resource stepdown plan and overview will further alert refuge staff and the Service to the presence of any significant cultural resources on the refuge and contribute positively to both the knowledge base and protection of these resources.

Socioeconomic Environment

Neither alternative is expected to have a significant cumulative impact on the town or county economies. Neither alternative will alter demographic or economic characteristics of the local community. Neither will any actions proposed disproportionately affect any communities, or damage or undermine any businesses or community organizations. Implementing any of the alternatives would result in minor beneficial impacts on those communities nearest the refuge.

Under alternative B, increased refuge staff participation in additional landscape level conservation will potentially increase eco-tourism opportunities in the region. Additional lands protected through a regional landscape conservation design, may increase lands available for potential public use and potentially increase visitor expenditures captured by the local and regional economies. When private lands are protected for conservation purposes, there can be a loss of property tax revenues for the towns. Protection would likely occur through several methods including fee title, easements, management agreements, and collaborative efforts with other conservation organizations. Towns may consider taking land out of tax eligibility and into conservation status, a means of bypassing tax liability by property owners. This could potentially impact town budgets (Gattuso 2008).

Conventional wisdom among decision makers and taxpayers is that development is the “highest and best use” of vacant land for increasing tax revenues. The assumption is that larger tax revenues are likely to accrue for communities if they build out with homes rather than protect open space. But in most situations, this assumption proves incorrect. When open space is transformed into homes tax revenue does increase, but concurrently adds to the cost of providing services and infrastructure (i.e., streets, electric, water, and sewer lines, additional school or library services, and police and fire protection). Increased service and infrastructure costs typically exceed the tax revenues generated from residential development, a situation that may eventually lead to tax increases on residents (Crompton 2004). Increased conservation and open space protection can potentially alleviate the need for towns to provide increased public services and utilities, thereby offsetting any adverse impacts to town budgets. Revenue sharing payments would most likely continue at some level to also help to somewhat offset lost tax revenue. Crompton (2004) shows that the conservation of open space is an integral part of the health of local economies.

Landscape level land protection may also potentially adversely impact cranberry and other agricultural benefits to the local economy should land be removed from

production (Gattuso 2008). The Service, through our conservation partners would attempt to work collaboratively with existing cranberry producers for habitat and species protection through management agreements before considering fee title purchase or other methods of acquisition.

Future landscape level conservation and acquisition in the region may cumulatively benefit the overall socioeconomic environment through a change in tax base for local communities, and/or shared revenues to offset tax revenue loss. Landscape level conservation may also attract more people to the region who prefer to visit or live near areas that are protected from development, thus providing a beneficial cumulative impact through an increase in tourism and residential growth near the protected areas.

Our working relationships with private landowners and others should improve in terms of responsiveness to inquiries and speed of joint projects under alternative B with increased staffing in key areas such as biology and law enforcement. The overall coordination and communication with the public should improve under alternative B.

More emphasis on education and outreach in alternative B should foster more understanding and appreciation of resource issues and needs, and could lead to increased political support and funding benefitting fish and wildlife resources on the refuge. The increased outreach of alternative B could also positively affect land use decisions outside the refuge by local governments and private landowners, and lead to increased fish and wildlife populations over a broader area. There would be minor benefits affiliated with revenue sharing payments and refuge spending under alternative B. Fully funding the additional staff in alternative B would also make a small, incremental contribution to employment and income in the local community.

Relationship between Short-term Uses of the Human Environment and Enhancement of Long-term Productivity

NEPA section 102(C) (iv) (CEQ regulations part 1502.16) requires Federal agencies to disclose the relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity. The Service expects that the proposed alternatives would lead to long-term productivity through the life of the CCP (15 years). This discussion focuses on the tradeoffs between short-term environmental costs and long-term environmental benefits.

Under both alternatives, our primary aim is to maintain or enhance the long-term productivity and sustainability of the natural resources on the refuge and in the surrounding landscape, including trust species such as the endangered northern red-bellied cooter, other species of conservation concern such as New England cottontail, and surrogate species including neotropical migratory song birds. Outreach and environmental education are included in alternative B to encourage visitors, nearby educators and school children, and the general public to be stewards of our environment and ensure they are informed about our unique natural resources. Encouraging people to support conservation efforts can ultimately lead to long-term environmental benefits. Our management actions, including controlling invasive plant species, managing for native pitch pine-scrub oak shrubland association (sandplain heathland community) vegetation, enhancing habitats for northern red-bellied cooter, New England cottontail and other surrogate species may have short-term insignificant adverse impacts, but would enhance long-term productivity of the refuge. Habitat management practices that mimic ecological and sustainable processes optimize the maintenance and enhancement of the biological diversity, integrity, and environmental health of those habitats for the long term.

Basking trap to catch northern red-bellied cooters

Jared Green

In summary, we predict that the alternatives would contribute positively toward maintaining and enhancing the long-term productivity of the refuge's natural resources, with sustainable beneficial cumulative and long-term benefits to the environment surrounding the refuge and minimal inconvenience or loss of opportunity for the American public

Unavoidable Adverse Effects

Unavoidable adverse effects are those actions that could cause significant harm to the human environment and that cannot be avoided, even with mitigation measures. There would be some minor, localized unavoidable adverse effects under alternative B. For example, installing signs or re-routing a section of trail has negligible adverse effects which are more than offset by the benefits of protecting resources and educating the public about the sensitivity of the refuge ecosystems. Public land ownership p entails an unavoidable impact on local governments due to the loss of property tax revenues. This loss is partially offset by refuge revenue sharing payments and the benefits of increased conservation to public health and wellbeing, and potential economic growth through the attraction to areas surrounded by conservation lands. None of the unavoidable adverse effects rise to the level of significance, and all would be mitigated so there would be no significant unavoidable adverse impacts under any of the alternatives.

Potential Irreversible and Irretrievable Commitments of Resources

NEPA section 102(C) (v) (CEQ regulations part 1502.16) requires Federal agencies to consider any irreversible and irretrievable commitment of resources that would be involved in the proposed action. Irreversible commitments of resources are those that cannot be reversed, except perhaps in the extreme long term or under unpredictable circumstances. An example of an irreversible commitment is an action that contributes to a species' extinction—once extinct, it can never be replaced. No irreversible commitments of resources are expected as a result of management activities on Massasoit NWR.

In comparison, irretrievable commitments of resources are those which can be reversed, given sufficient time and resources, but represent a loss in production or use for a period of time. We could consider the construction of kiosks and educational signs built in collaboration with partners as an irretrievable commitment of resources. However, we can dismantle those interpretive resources and restore the sites if resource damage is occurring. Similarly,

prescribed burning and thinning to open forest canopies and encourage shrub understory are irretrievable resource commitments. However, we can discontinue those habitat treatments and allow natural forest succession to resume again at any point, and after several decades without such treatments most areas will return to conditions similar to those present today.

Environmental Justice

EO 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (February 11, 1994), requires that Federal Agencies consider as part of their action, any disproportionately high and adverse human health or environmental effects to minority and low income populations. Agencies are required to ensure that these potential effects are identified and addressed.

The USEPA defines environmental justice as, "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." In this context, fair treatment means that no group of people should bear a disproportionate share of negative environmental consequences resulting from the action.

Overall, we expect none of the alternatives to place disproportionately higher adverse environmental, economic, social, or health effects on minority or low-income persons or specific groups of people defined above. Wildlife observation, photography, environmental education, and interpretation are open to all who are willing to adhere to the established refuge rules and regulations or special use permit stipulations. Refuge deer and turkey hunting would be available equally to all individuals properly licensed to hunt in Massachusetts and that abide by all state hunting regulations and possessing required hunting permits.

None of the socioeconomic and environmental impacts we have identified would be localized or focused primarily or unequally on minority and low-income communities or individuals residing near the refuge. The local town and county would experience only very minor adverse effects along with some beneficial effects if the refuge is managed under either proposed alternative. Adverse impacts, such as minor increases in traffic and related emissions due to limited increased visitation at the refuge, would not disproportionately affect minority and low-income populations compared to other segments of the general population. The same is true of any negligible mobile-source air emissions from the operation of refuge equipment and vehicles. Beneficial impacts include maintaining natural vegetation that improves air and water quality, and; enhanced and free public use of the refuge.

We expect neither alternative to alter the demographic or economic characteristics of the local community. The actions we propose would neither disproportionately affect any communities nor damage or undermine any businesses or community organizations. Both alternatives maintain the existing forested landscape. Consequently, no significant adverse impacts would be expected including changes in the community character or demographic composition.

Summary of Environmental Consequences by Alternative

Table 4-1 below compares and contrasts the expected environmental consequences evaluated in detail in chapter 4, of the management actions proposed for each two management alternatives detailed in Chapter 3 of this draft CCP/EA.

Table 4-1. Summary Matrix of Environmental Consequences by Alternative.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Air Quality	**Common to Both Alternatives**	There will be minor air quality benefits from the pollutant filtering effects of maintaining 209 acres of upland and wetlands vegetation and coastal ponds. Trees (vegetation) filter some air pollutants and reduce the concentration of ambient ozone, SO_2, NO_2, CO, and fine particulate matter (PM10 and PM2.5), primarily through direct uptake and adhesion to stems and leaves. Potential air quality impacts from prescribed fire on human health and public welfare range from occupational exposure to smoke for firefighters to public health, soiling of materials (economic losses), public nuisance, and highway safety impacts from reduced visibility. The major pollutant of concern is fine particulates, both PM10 (fine: 10 micrometers or less) and PM2.5 (very fine: 2.5 micrometers or less) particles. Particulates can reduce visibility or cause negative health effects for people with respiratory or cardiovascular illnesses. Several population subgroups are more sensitive to fine particulates include asthmatics, children, the elderly, and individuals with cardiopulmonary disease. While CO overexposure causes serious health problems and can prove fatal, CO is diluted and disperses rapidly as it mixes with ambient air downrange from the combustion source. As such, CO emissions are primarily an occupational health concern for prescribed burn personnel, not for the general public. Although long-term health effects from occupational smoke exposure remain unknown, evidence suggests that brief, intense smoke exposures can exceed short-term exposure limits in peak situations, such as for firefighters holding firelines downwind of an active prescribed burn. Smoke exposure is a hazard for only short periods, is predictable, and therefore manageable. Fireline practices such as crew rotation, awareness training, and carbon monoxide monitoring can mitigate the hazard, allowing firefighters to focus on fire containment by lessening the distraction, discomfort, and health impacts of smoke exposure. When very fine (PM2.5) smoke particles infiltrate indoor environments, soiling of fabrics, painted interior walls, and works of art may occur. Individuals within 1 mile of prescribed burn operations on Massasoit NWR may experience the irritating effects of acrolein or formaldehyde with unexpected wind direction shifts. Perhaps the greatest nuisance effect of prescribed fire smoke is local, temporary visibility reduction in areas impacted by the dispersing smoke plume. Visitor enjoyment and satisfaction in the vicinity of the refuge may be diminished by reduced visibility. The potential exists for limited smoke intrusions onto the public roads from refuge prescribed fires. Burning during the summer "ozone" season has potential to cause greater impact to air quality when hot (e.g. above 90 °F), stagnant atmospheric episodes (and State issued air quality alerts) are more common. Ground-level ozone, a criteria NAAQS pollutant, has had past violations in eastern Massachusetts. Emissions from burning wildland fuels (especially NOx) subjected to sunlight and warm temperatures, mixing with the regional atmosphere, as well as nitrate and indirectly sulfate aerosols, contribute to ozone formation. Fire behavior guides Service and fire team smoke and emissions management efforts to minimize air quality impacts. Fire and fuels manipulation techniques are chosen that complement meteorological scheduling for maximum smoke dispersion and favorable plume transport. Burn plans specify no burning when poor atmospheric mixing conditions are forecast. The refuge obtains an annual air quality permit from the MADEP, and a burn day authorization from the Plymouth Fire Department, and conducts burning in accordance with those authorizations. We avoid burning when air quality alerts are forecast or issued for the region, and are unlikely to be granted a burn permit anyway. If conducted on warm summer days, there is a very low chance refuge prescribed burn emissions may contribute to down range ground level ozone formation if actual atmospheric and weather conditions depart from those forecasted. Under worst case scenarios prescribed burning efforts on Massasoit NWR over a 15 year period are not expected to adversely affect the region's air quality index given anticipated dispersion, atmospheric mixing, seasonal timing, and frequency of prescribed burning under either alternative. No more than 50 refuge acres will be prescribed burned on any given day or in any one year under either alternative. We expect prescribed burning at the refuge to produce no significant long-term adverse air quality impacts. Neither management alternative would adversely affect regional air quality, including regional haze over the long term. Neither alternative would violate NAAQS for criteria air pollutants; both would comply with the CAA.	

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Air Quality (cont.)	**Beneficial**	Applying low to moderate intensity prescribed fire every 5 to 7 years on approximately 50 acres of the Crooked Pond parcel to reduce the excess buildup of woody debris (hazard fuels) in the understory on the refuge will decrease the long-term likelihood of large emission episodes, from large uncontrolled, high intensity wildfires.	Applying low to moderate intensity prescribed fire every 5 to 7 years on up to 200 refuge acres for both habitat management and to reduce the excess buildup of woody debris (hazard fuels) in the understory will further decrease the long-term likelihood of large emission episodes, from large uncontrolled, high intensity wildfires.
	Adverse	Prescribed burning on 50 acres over the entire refuge will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. There may be some localized (generally downwind from burns, and within 10 miles or less), short duration (minutes to hours) decrease in air quality or brief, localized visibility impairment from fine particulates. Carbon monoxide, carbon dioxide, hydrocarbon, and small nitrogen oxide releases are expected. However, low intensity prescribed burning, releases inconsequential amounts of these gases. The fire team's knowledge of fire behavior and smoke management helps minimize air quality impacts and human exposure to smoke. Additional steps taken to reduce emissions include reducing fuel through mechanical means prior to burning, and keeping burn units small. Emissions (hydrocarbons) released from heavy equipment and power tools during initial firebreak and fuelbreak establishment and periodic maintenance are expected infrequently for brief periods, but are not expected to significantly impact local or regional air quality. The refuge will remain closed to the public; therefore no additional transportation-related emissions generated by refuge visitors are anticipated. A small amount of hydrocarbon emissions result from refuge activities, mostly vehicle transportation to and from the refuge, especially during the spring, summer, and fall when trips may occur weekly. Adverse air quality impacts would be very limited and temporary. The vehicle fleet at the refuge headquarters is becoming cleaner as older vehicles are replaced by low (hydrocarbon) emission hybrid vehicles. Refuge vehicle-related hydrocarbon emissions may actually decrease slightly from current levels, over the 15 year plan period.	Invasive plant treatments would incorporate mechanical, chemical, or biological control as necessary. Impacts to air quality would be localized and short-lived. Mechanical removal of invasive species would likely inject some dust and soil particles into the air, for short periods. Chemical application in accordance with labeling and approved Pesticide Use Proposals would likely involve backpack sprayers to obtain optimal target specificity. There is still some potential to impact a wider area than is targeted through spray drift to non-target sites. By not treating on windy days, and through careful calibration of spray nozzles to achieve the correct droplet size and application rate, spray drift is effectively minimized. We anticipate insignificant short-term, localized impacts to air quality from treating invasive plants. Prescribed burning on up to 200 acres over the entire refuge will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Total prescribed burn impacts to air quality over the planning period from prescribed burns may as much as four times greater than alternative A. There may be some localized (generally downwind from burns, and within 10 miles or less), short duration (minutes to hours) decrease in air quality or brief, localized visibility impairment from fine particulates. Carbon monoxide, carbon dioxide, hydrocarbon, and small nitrogen oxide releases are expected. However, low intensity prescribed burning, releases inconsequential amounts of these gases. The fire team's knowledge of fire behavior and smoke management helps minimize air quality impacts and human exposure to smoke. Additional steps taken to reduce emissions include reducing fuel through mechanical means prior to burning, and keeping burn units small. Although up to 4 times greater over the plan period than under alternative A, alternative B air quality impacts are not expected to be significant due to burn and smoke management measures, and public notification and outreach procedures the Service already has in place and is already implementing.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Air Quality (cont.)			Emissions (hydrocarbons) released from heavy equipment and power tools during initial firebreak and fuelbreak establishment and periodic maintenance are expected infrequently for brief periods, but are not expected to significantly impact local or regional air quality. New refuge visitors under alternative B are not expected to generate significant increases in transportation-related (hydrocarbon) emissions to adversely impact air quality. Increased hydrocarbon emissions from expanding refuge activities and staff site visits to provide enforcement and habitat management are expected. The vehicle fleet at the refuge headquarters is becoming cleaner as older vehicles are replaced by low (hydrocarbon) emission hybrid vehicles, offsetting hydrocarbon emissions from the increased refuge staff vehicle use. It is anticipated that the alternative B impacts on air quality would remain insignificant over the 15 year plan period.
Water Quality	**Common to Both Alternatives**	Local water quality benefits from the pollutant buffering and filtering effects of maintaining essentially continuous upland and wetlands vegetation across the 209-acre refuge landscape are expected. Trees (vegetation) filter some air pollutants that can enter ponds by atmospheric deposition. Vegetation, surface litter, and duff also slow, intercept, and filter out some pollutants from surface runoff before it can reach downslope waterbodies, or rainfall and runoff as it infiltrates the soil before it moves into the groundwater aquifer. Any drawdown or pollution to the groundwater in the Plymouth area close to the refuge would more likely have a greater impact to Crooked Pond water levels and water quality than refuge management activities. Some year-round and summer homes on refuge ponds can potentially adversely impact surface water and groundwater quality, from septic systems, landscaping activities, swimming, or boating. The Service has no direct authority over the use of ponds by residents who own shoreline and/or land abutting Gunners Exchange, Hoyt, and Island Pond or outside refuge boundaries. Under both alternatives, a network of constructed firelines (1.11 miles), shaded fuelbreaks (2.49 miles), and existing roadbeds (1.57 miles) will be maintained to facilitate wildland fire suppression and prescribed burning. Machinery will be used to mow or masticate understory vegetation every 5 to 7 years on approximately 13.6 acres (6.5 percent) of the refuge to keep the network passable for fire equipment and personnel. Litter and duff layers remain largely undisturbed and intact. Slight increases in surface runoff are expected from this fuel and firebreak network for one to two growing seasons following treatment. Protective litter and duff layers will largely prevent post treatment soil erosion and downslope sediment transport in runoff into refuge waterbodies. Refuge firelines (2.68 miles) typically have a 1.5-foot strip from which the protective litter and sometimes the duff layer are removed using leaf blowers and rakes, potentially exposing mineral soil in order to slow or halt the spread of a fire through surface fuels on up to 0.49 acres (worst case estimate). Between fires, firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically, potentially exposing mineral soil, some soil erosion from these firelines could be transported downslope in surface runoff into refuge ponds from soil exposure until the next autumn “leaf-drop” (6 to 12 months). Prescribed burns proposed in both alternatives are more frequent, smaller, less intense, and consume less vegetation, litter, and duff (fuel) than past large, high intensity wildfires. Prescribed burning water quality impacts will be less than those from past, higher intensity wildfires. Decreasing the likelihood of large high intensity wildfires through hazard fuel reduction under both alternatives also reduces the long-term likelihood of large overland pollutant transport episodes to refuge ponds. Neither management alternative will contribute to water quality degradation. Neither management alternative will violate Federal or State water pollution control regulations, and both will comply with the Clean Water Act.	

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Water Quality (cont.)	**Beneficial**	With little to no authorized public use, the generally good refuge water quality is likely to be protected.	Refuge staff would monitor for invasive aquatic plants within Crooked Pond and address any identified concerns. If aquatic invasive plants become a concern, the Service would act in accordance with the IPMP, in collaboration with refuge partners and neighbors, to remove or control such species, protecting water quality and restoring the natural ecosystem function for the long-term.
	Adverse	Mechanical clearing of brush, trees, and other vegetation to create canopy openings and improve northern red-bellied cooter nesting sites near Crooked Pond totals ¼ acre. Temporary disturbance of the sandy shoreline vegetation and soil in close proximity to the ponds could result in some small-scale instances of erosion, and small quantities of soil sediment entering Crooked Pond. Vegetation closest to the shoreline is not disturbed, and root systems of shrubs on the pond shoreline are kept intact to help hold exposed soil in place. This minimizes or completely prevents sediment runoff from entering the pond, so any impacts are very localized, temporary, and therefore not significant. Prescribed burning efforts are limited to current levels (50 acres) on the Crooked Pond parcel. Prescribed burning of two burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. These two burn perimeters combined require 0.99 miles, 0.50 miles, and 0.45 miles respectively of the refuge fireline, existing roadbed, and 100-foot wide shaded fuelbreak network. This network requires (worst case estimate) up to 0.27 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 7.68 acres for shaded fuelbreaks and access roads. In the intervals between fires, firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically, potentially exposing mineral soil, some soil erosion is possible from these firelines that could be transported downslope in surface runoff into refuge ponds from soil exposure until the next autumn "leaf-drop" (6 to 12 months). Protective vegetative and litter cover typically recovers within one growing season following mechanical cutting of shaded fuel breaks, or prescribed burning.	Using herbicides or mechanical methods to control invasive plants could incur some short-term and localized risk to water quality. Before any chemical is applied to refuge lands, Service policy and required project review ensures that water quality risk is evaluated and minimized. All products are used according to label instructions to minimize impacts on ground and surface waters. Only those herbicides specifically labeled for aquatic application are used on or near refuge waters. When used appropriately, these products pose negligible directly or indirectly impacts on water quality. Very often, herbicides are not needed. But when required for effective control, the Service selects the herbicide application that is most effective for the target species and least harmful to non-target organisms. Risk reducing measures include choosing optimal times of year to apply herbicides, reducing spray drift, and applying the minimum amounts needed to effectively control the target species. If chemical application is deemed necessary, it would likely be applied using backpack sprayers to obtain optimal target specificity from the close range of application. Mechanical clearing of brush, trees, and other vegetation to create canopy openings and improve northern red-bellied cooter nesting sites near Crooked Pond, Hoyt Pond, and Island Pond totals 1 acre. Temporary disturbance of the sandy shoreline and soil in close proximity to the ponds could result in some small scale instances of erosion, and small quantities of soil sediment entering the ponds. Vegetation closest to the shoreline is not disturbed, and root systems of shrubs on the pond shoreline are kept intact to help hold exposed soil in place. This minimizes or completely prevents sediment runoff from entering the pond, so any impacts are very localized, temporary, and therefore not significant.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Water Quality (cont.)	**Adverse (cont.)**	Due to the dense post-burn vegetative cover, intact duff and litter layers, and gentle slopes of the treated burn units, no concerns with sediment-laden runoff from prescribed burn units into local water bodies are expected. The refuge remains closed to public uses. Therefore any impacts to water quality from public use will be from unauthorized, illegal activities such as littering of pond shorelines by trespassers, oil or gas leaks from illegal ORVs near the pond edges, horseback riding, or pollution from swimming or boating.	Prescribed burning efforts would expand to most refuge upland acres (up to 200 acres) HMP and spatial FMP completion. Prescribed burning of 10 to 20 individual burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. These burn perimeters combined require up to 1.11 miles, 1.57 miles, 0.57 miles, and 1.92 miles respectively of the fireline, existing roadbed, 100 foot wide and 12 foot wide shaded fuelbreak network, with only a portion (20 to 50 percent) needed in any single year in the absence of a large wildlife. This network requires (worst case estimate) up to 0.49 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 13.6 acres for shaded fuelbreaks and access roads. In the intervals between fires, mineral soil firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically to expose mineral soil, some soil erosion from these constructed firelines that could be transported by surface runoff into downslope waterbodies is possible from soil exposure until the next autumn "leaf-drop" (6 to 12 months). Protective vegetative and litter cover typically recovers within 1 growing season following mechanical cutting of shaded fuel breaks, or prescribed burning. Due to the dense post-burn vegetative cover, intact duff and litter layers, and gentle slopes of the treated burn units, no concerns with sediment-laden runoff from prescribed burn units into local water bodies are expected. There is a low to moderate risk that nutrients released during prescribed burning may be transported overland into ponds and waterways downslope. However, this would be buffered by the duff and litter layer remaining following the prescribed burn. Visitors would be able to access the Crooked Pond parcel only when accompanied by staff or partners working under an SUP, and most of the Crooked Pond parcel could be opened seasonally for hunting. Potential water quality impacts from refuge public use are limited. New refuge visitors under alternative B are not expected to significantly impact existing water quality, with their water quality impacts similar to those they are having on the adjoining MSSF. The limited environmental education and interpretation hosted by the Service or our partners will have no detectable impact to the water quality because access to the ponds, especially Crooked Pond, would remain restricted. Greater enforcement and increased public outreach, should reduce water quality impacts from illegal, unauthorized uses, more than alternative A.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Soils	**Common to Both Alternatives**	Maintaining essentially continuous upland and wetlands vegetation across the refuge landscape as expected under both alternatives, helps protect against soil loss through erosion. Plant foliage and stems intercept rainfall that can erode exposed soil. Vegetation, living and dead, especially plant roots help hold the soil in place when subjected to surface runoff, wind, or other erosive forces and help maintain soil porosity and water holding capacity. When vegetative tissues are shed, they return organic matter and nutrients to the soil that can be recycled and used by other plants and animals. Dead plant tissues accumulate to form the litter and duff layers that help protect the soil surface from erosive forces and help retain soil water essential for plant growth. Fire elevates surface temperatures; mineralizes detritus, litter, and standing dead material; volatilizes some nutrients and organic matter; alters soil water-holding capacity; and alters soil animal species (micro- and macro-fauna) populations. Intense, long-duration fires such as those associated with past wildfires consume more organic matter than the short-duration, low intensity prescribed fires proposed for Massasoit NWR under both alternatives. Nitrogen compounds volatilize and are lost at low temperatures (212° to 392 °F); while, calcium, sodium, and magnesium usually are deposited on the soil surface and quickly recycled during post-burn vegetative recovery. At higher temperatures (392° to 572 °F), large amounts of organic substances are lost, which can reduce soil cation exchange and moisture holding capacity. Removal of litter and duff may initially facilitate water infiltration; but, the loss of all litter and blackened soils may accelerate evaporation reducing soil water available for plant growth (water-holding capacity). Moderately hot fires (349° to 399 °F) can increase water repellence, and extremely hot fires (above 399 °F) volatilize hydrophobic substances and may increase soil water repellence. After moderately intense fires, increased runoff may result in soil erosion. Fire usually reduces soil fungi but increases soil bacteria, and may also remove pathogens. Fire often destroys nitrifying bacteria, so that post-fire soil nitrogen recovery is often dependent upon regrowth of legumes and other nitrogen-fixing plants. Fire may enhance this nitrogen fixation, due to the mineralization of nutrients and elevated pH levels in soils. Prescribed fires conducted on the refuge under either alternative should benefit soils in the short term by returning nutrients bound up in above ground plant biomass prior to the burn, back into the soil. A risk of long-term soil damage (still evident on the refuge today from the catastrophic fires in the 1950's) from high intensity wildfires remains. But fuel load reduction planned under both alternatives will help minimize, but not eliminate that risk. Wildfires will be suppressed in a safe, prompt, and cost effective manner to minimize adverse impacts to resources and acreage. Under both alternatives, a network of constructed firelines (1.11 miles), constructed shaded fuelbreaks (2.49 miles), and existing roadbeds (1.57 miles) will be maintained to facilitate wildland fire suppression and prescribed burning. Machinery will be used to mow or masticate understory vegetation every 5 to 7 years on approximately 13.6 acres (6.5 percent) of the refuge to keep the network passable for fire equipment and personnel. Litter and duff layers remain largely undisturbed and intact. Slight, increases in surface runoff are expected from this fuel and firebreak network for 1-2 growing seasons following treatment. Protective litter and duff layers will largely prevent post treatment soil erosion. Refuge firelines (2.68 miles) have a 1.5 foot strip from which the protective litter and sometimes the duff layer are removed using leaf blowers and rakes, potentially exposing mineral soil in order to slow or halt the spread of a fire through surface fuels on up to 0.49 acres (worst case estimate). Between fires, firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer is removed periodically, potentially exposing mineral soil to erosion from these firelines could be transported downslope in surface runoff into refuge ponds from soil exposure until the next autumn "leaf-drop" (6 to 12 months). Refreshing firelines as preparation for pre-planned prescribed burns would occur around the perimeters of burn units totaling no more than 50 acres in any given year under both alternatives. Wildfires are not predictable as to the time and place of ignitions, but the same network of firelines and methods will be used to suppress any unplanned wildfires within the refuge. Because the protective litter layer is removed periodically potentially exposing mineral soil, some soil erosion is possible from these firelines, from soil exposure until the next autumn "leaf-drop" (6-12 months).	

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Soils (cont.)	**Beneficial**	Prescribed burning would potentially return nutrients bound up in plant biomass back into the soil, and enhance soil microbial nitrogen fixation in the short term on approximately 50 acres of the Crooked Pond parcel over the planning period. Given their short-term nature and the limited acreage, these are not expected to be significant beneficial soil impacts. Reducing hazardous fuel loading reduces the likelihood of high intensity wildfires, and the soil damage they can leave behind.	Prescribed burning would potentially return nutrients bound up in plant biomass back into the soil, and enhance soil microbial nitrogen fixation in the short term on up to 200 refuge acres over the planning period. Given their short-term nature and the limited refuge acreage, these are not expected to be significant beneficial soil impacts. Reducing hazardous fuel loading reduces the likelihood of high intensity wildfires, and the soil damage they can leave behind.
	Adverse	There may be some minor soil compaction and erosion on ¼ acre managed to create northern red-bellied cooter nesting habitat along the shoreline near Crooked Pond. The soil impacts will be temporary, localized, and therefore not significant. Low to moderate intensity prescribed burning will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Prescribed burning is limited to the 50 acres (two burn units) in the northeast portion of the refuge which has little slope. Recent refuge prescribed fires consumed only part of the surface litter and duff layers, without transferring excessive heat into the underlying soils. Because a partial litter and a largely continuous surface duff layer will remain after burning, little soil erosion risk will result compared to that from a high intensity wildfire. The two burn unit perimeters combined require 0.99 miles, 0.50 miles, and 0.45 miles respectively of the fireline, existing roadbed, and 100-foot-wide shaded fuelbreak network. This network requires (worst case estimate) up to 0.27 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 7.68 acres for shaded fuelbreaks and access roadbeds. In the intervals between fires, these firelines are normally allowed to accumulate leaf litter each fall. Because the protective litter layer and sometimes the duff layer is removed periodically to expose mineral soil, some soil erosion from these firelines is possible from soil exposure until the next autumn "leaf-drop" (6 to 12 months). Using heavy equipment to create fire breaks may scarify soils in some areas or potentially compact soils. Implementing Best management Practices helps to limit the amount of soil disturbance from equipment, and using 'low ground pressure' equipment reduces soil compaction potential. Future fire break maintenance can be done with much smaller and lighter equipment that will have little to no soil impact.	Increased mechanical vegetation removal, including invasive plants, using hand or power tools, or heavy equipment can potentially increase localized soil disturbance and erosion until new plants establish. Any soil disturbed by the physical removal of plants will be tamped down and compacted. Herbicides approved by the Service would be used to control invasive plants as warranted. The best methods available at the time of application will be used. All products are used according to label instructions and approved Pesticide Use Proposals, to minimize impacts to soil. There may be some minor soil compaction and erosion on 1acre managed to create northern red-bellied cooter nesting habitat along the refuge pond shorelines. The soil impacts will be temporary, localized, and therefore not significant. We expect negligible direct or indirect impacts on upland soils from habitat work. Expected soil impacts are limited in duration, of low to moderate intensity, and confined to small project areas. None of the proposed habitat management actions will adversely impact refuge soils over the long-term. Low to moderate intensity prescribed burning of 10 to 20 individual burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Recent refuge prescribed fires consumed only part of the surface litter and duff layers, without transferring excessive heat into the underlying soils. Because a partial litter and a largely continuous surface duff layer will remain after burning, little soil erosion risk will result compared to that from a high intensity wildfire.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Soils (cont.)	**Adverse (cont.)**	We expect direct or indirect impacts on upland soils to be negligible and not significant, limited by the short duration and low to moderate intensity burns, confined to the small, designated project area. The refuge remains closed to public uses. Therefore any soil impacts from public use will be from unauthorized, illegal activities. Trespass by mountain bikes and ORVs, and to a lesser extent horseback riding, occurs on the refuge. This trespass and commensurate soil damage is expected to continue. Illegally accessed trails are deeply worn exposing the roots of trees and void of protective duff and litter in several locations and where trails are on slopes, water runoff and erosion is occurring. At times these mountain bike and ORV riders will cause soil disturbance in the turtle nesting sites adjacent to the pond shoreline.	These burn perimeters combined require up to 1.11 miles, 1.57 miles, 0.57 miles, and 1.92 miles respectively of the fireline, existing roadbed, 100-foot-wide and 12-foot-wide shaded fuelbreak network, with only a portion (20 to 50 percent) needed in any single year in the absence of a large wildfire. This network requires (worst case estimate) up to 0.49 acres of potentially exposed mineral soil for firelines, and mechanical understory vegetation cutting on 13.6 acres for shaded fuelbreaks and access roads. In the intervals between fires, these mineral soil firelines are normally allowed to accumulate leaf litter every fall. Because the protective litter layer is removed periodically to expose mineral soil, some soil erosion from soil exposure until the next autumn "leaf-drop" (6 to 12 months). Protective vegetative and litter cover typically recovers within 1 growing season following mechanical cutting of shaded fuel breaks, or prescribed burning. Using heavy equipment to create fire breaks may scarify soils in some areas or potentially compact soils. Implementing Best management Practices helps to limit the amount of soil disturbance from equipment and using 'low ground pressure' equipment reduces soil compaction potential. Future fire break maintenance can be done with much smaller and lighter equipment that will have little to no soil impact. Conducting all burns within their prescriptions will minimize soil loss, although adverse soil impacts may occur in small areas. The adverse effects from higher intensity fires are only likely to occur in the presence of a natural or human induced wildfire. Pedestrian access on the Crooked Pond parcel would be limited to guided activities, and most of the Crooked Pond parcel would be opened seasonally for some hunting, most likely including deer and turkey hunting. These uses could in time impact soils through compaction, erosion, and sedimentation if not addressed. Long-term effects of trampling include soil impacts like diminished soil porosity, aeration, and water and nutrient availability for plant growth through soil compaction. Foot travel can, over time create eroded conditions; lug soles on hiking boots can exacerbate the problem. Large group activities, such as guided interpretation or environmental education on any trail used, is more likely to impact soil to a greater extent. However, we do not anticipate many guided trips will occur annually.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Soils (cont.)	**Adverse (cont.)**		The majority of the refuge's 209 acres would however remain largely closed to public use. Additionally, Service staff would monitor trails for soil damage, minimize use if necessary, and mitigating damage with soil stabilization and erosion control measures (water bars, steps, re-routing, etc.) can be undertaken promptly as needed. This is expected to mitigate any significant long-term soil impacts from authorized public use. Trespass by mountain bikes and ORVs, and to a lesser extent horseback riding, occurs on the refuge, resulting in extensive soil compaction and erosion. This illegal trespass is expected to decline, but not be eliminated under alternative B. Illegally accessed trails are deeply worn exposing tree roots and are void of protective duff and litter in several locations and where trails are on slopes, erosion is occurring. At times unauthorized mountain bike and ORV riders will cause localized soil disturbance to refuge pond shorelines. Greater enforcement and increased public outreach should reduce soil from illegal, unauthorized uses.
Natural Community Types and Vegetation	**Common to Both Alternatives**	As the pitch pine-oak forest canopy opens, shifting to a woodland structure over time with continuing mechanical thinning and prescribed fire management, understory vegetation (scrub oak shrubland and sandplain heathland) will likely increase with more sunlight reaching the ground. Understory vegetation benefitting most are pitch pine-scrub oak shrubland association (and sandplain heathland community) plants, such as lowbush blueberry, black huckleberry, and scrub oak. Prescribed burning may over time also create more snags and downed trees that provide habitat for a variety of species, although it often takes more than one season for snags to develop after burning. White pines that tend to grow taller and create closed canopy conditions will be reduced (canopy cover and density) in white pine-oak and oak-pine forest areas managed using canopy thinning and prescribed burning. Under both alternatives, a network of firelines (1.11 miles), constructed shaded fuelbreaks (2.49 miles), and existing roadbeds (1.57 miles) will be maintained to facilitate wildland fire suppression and prescribed burning. Machinery will be used to mow or masticate understory vegetation every 5 to 7 years to keep the network passable for fire equipment and personnel on approximately 13.6 refuge acres (6.5 percent) of the refuge's 209 acres. Refuge firelines (2.68 miles) typically have a 1.5 foot strip from which all vegetation and the protective litter and sometimes duff layers are removed on up to (worst case estimate) 0.49 acres. In the intervals between fires, these firelines are normally allowed to "go fallow." Wildfires are not predictable as to the time and place of ignitions, but the same network of firelines and methods will be used to suppress any unplanned wildfires within the refuge. Unauthorized operation of ORVs occurs along the utility line right-of-way, unpaved roads, and unimproved trails on the refuge, creating problems on Massasoit NWR as on most public land in Massachusetts, and is likely continue under both alternatives. In pitch pine-oak upland forest habitats subjected to ORV traffic, the resulting disturbance of dry, nutrient-poor, sandy soils may take decades to revert to native vegetation once damaged. Such soil disturbance may also provide inroads for non-native invasive plant species. Exposed soil and an abundance of sunlight along roads and trails provide ideal conditions for the establishment of invasive plant species that may be transported into the refuge in feed hay.	

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Natural Community Types and Vegetation (cont.)	**Beneficial**	Essentially continuous forest cover will be maintained across the entire refuge (209 acre) land base throughout the plan period and in perpetuity. There will be shifts in natural community types and vegetation associations through mechanical cutting and prescribed burning efforts that will thin overstory and create canopy openings on 50 acres on the Crooked Pond parcel. Management will enhance pitch pine-oak woodland or forest association habitat on those 50 acres as periodic fire encourages restoration of fire-adapted plant species. An increase in canopy openings will result in an increased understory layer (scrub oak shrubland association, sandplain heathland community) beneath the canopy gaps across those 50 acres.	Invasive species control will benefit native plant communities and refugewide floral diversity. Invasive plants such as glossy buckthorn, hairy cat's ear, butterfly bush, Morrow's honeysuckle, oriental bittersweet, black locust, common reed, and common mullein would decrease. Surveillance monitoring of aquatic plants in Crooked Pond, including invasive species, would alert the staff to any new invasive species concerns which could then be addressed sooner. Essentially continuous forest cover will be maintained across the entire refuge (209 acre) land base throughout the plan period and in perpetuity. There will be shifts in natural community types and vegetation associations through mechanical cutting and prescribed burning efforts that will thin overstory and create canopy openings on up to 200 acres (refugewide). Management will enhance pitch pine-oak woodland or forest association habitat on up to 200 acres (refugewide), as periodic fire encourages restoration of fire-adapted plant species. An increase in canopy openings will result in an increased understory layer (scrub oak shrubland association, sandplain heathland community) beneath the canopy gaps across the entire refuge (up to 200 acres). Refuge forest lands would in time more closely approximate the range of historic conditions typical of these pitch pine-oak associations at the time of European contact. Understory density and height would vary widely across the refuge with canopy opening percentage and time since last fire. Over the long term, there would increasingly be a more uneven aged, patch-mosaic, woodland structure due to the variations in timing and intensity of prescribed burning and mechanized thinning across the refuge. Refuge staff would work closely with the utility company to manage the acreage near the utility line for early successional, shrub habitat resulting in less overall vegetation removal along and within the utility line right of way, sustaining the shrubland habitat long term. Illegal access may decrease with more visitors on the refuge to detect and report illegal activity or whose mere presence may deter trespass.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Community Types and Vegetation (cont.)	**Adverse**	Mechanical clearing of brush, trees, and other vegetation on ¼ acre near Crooked Pond to improve northern red-bellied cooter nesting sites is at a very small scale, and vegetation impacts are not deemed significant. Prescribed burning two burn units will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (two burn units) burned on any given day or in any one year. The two burn unit perimeters combined require (worst case estimate) 0.99 miles, 0.50 miles, and 0.45 miles respectively of the fireline, existing roadbed, and 100-foot-wide shaded fuelbreak network. This network requires (worst case estimate) up to 0.27 acres of unvegetated soil for firelines, and mechanical understory vegetation cutting on 7.68 acres for shaded fuelbreaks and access roadbeds. In the intervals between fires, these mineral soil firelines are normally allowed to accumulate leaf litter every fall. All vegetation, including roots and the protective litter layer is removed periodically to expose mineral soil. Opening forest overstory and creating canopy gaps, changes forest vegetation structure and composition. Periodic fire discourages fire-intolerant species so a decline in canopy dominance of white pine trees is expected on the 50 acres treated on the Crooked Pond parcel. As white pine stem canopy dominance declines over time, refuge white pine-oak and oak-pine forest association acres are expected to decrease by approximately 50 acres (35 percent).	Invasive species control would have short-term adverse, localized impacts on vegetation. These include the removal of plants, herbicide application, trampling, and other potential damage to plant structure. These short-term negative impacts would be offset by providing long term benefits to native plant diversity and health across the refuge. Prescribed burning 10 to 20 individual burn units on up to 200 acres, will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres (23.9 percent of the refuge) burned on any given day or in any one year. Mowing understory vegetation with LGP equipment with mower attachments may be used to prepare for burn or where prescribed fire cannot be used effectively. The 10 to 20 burn perimeters combined require worst case estimate) up to 1.11 miles, 1.57 miles, 0.57 miles, and 1.92 miles respectively of the fireline, existing roadbed, 100-foot-wide and 12-foot-wide shaded fuelbreak network. Only a portion (20 to 50 percent) of these is needed in any single year in the absence of a large wildlife. This network requires (worst case estimate) up to 0.49 acres of unvegetated, soil for firelines, and mechanical understory vegetation cutting on 13.6 acres for shaded fuelbreaks and access roads. In the intervals between fires, mineral soil firelines are normally allowed to accumulate leaf litter every fall. Vegetative cover typically is restored within one growing season following prescribed burning or mechanical cutting of shaded fuel breaks. Opening forest overstory and creating canopy gaps, changes forest vegetation structure and composition. Periodic fire discourages fire-intolerant species so a decline in canopy dominance of white pine trees is expected on up to 200 acres treated refugewide. As white pine stem canopy dominance declines over time, refuge white pine-oak and oak-pine forest association acres are expected to decrease by approximately 140 acres (98 percent).

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Community Types and Vegetation (cont.)	**Adverse**	On the remaining untreated 150 upland acres, white pine-oak and oak-pine forest association will persist and continue to succeeding to a more mature state. Now overly abundant white pines, artifacts of decades of wildfire suppression, would continue to grow and understory density will decrease further refugewide. Further loss of remnant plants associated with pitch pine-scrub oak shrubland, woodland, or forest associations (sandplain heathland community), such as huckleberry, hillside and lowbush blueberry, or scrub oak will result. None of the habitat type shifts and or vegetation structure and composition impacts expected are deemed significant. The refuge remains closed to public use. Therefore vegetation impacts from public use will be confined to unauthorized, illegal activity. Currently trespass takes place at Massasoit NWR by mountain bikes and ORVs, and to a lesser extent horseback riding, resulting in localized vegetation destruction or damage. The current level of trespass and commensurate plant damage is expected to continue. Illegally accessed trails have exposed roots of trees, are void of above ground vegetation and compacted, and therefore deter revegetation in several locations.	With increased public access and use of the refuge and opening deer and turkey hunting on the Crooked Pond parcel, vegetative communities could experience localized trampling and possibly crushing of individual plants in high traffic areas. Short-term effects consist of the deterioration of plant material itself. Long-term effects of trampling include direct vegetation damage, and indirect vegetation effects from soil compaction like diminished soil porosity, aeration, and water and nutrient availability for plant growth. Compacted soils inhibit plants, particularly sensitive species', ability to revegetate affected areas. Plant damage can include height and biomass reduction, species composition shifts, and the spread of weeds and plant pathogens. Plants adapted to wet or moist habitats are the most sensitive. Direct vegetation effects and indirect impacts from soil compaction would likely be localized, and not significant on a larger scale, because most of the refuge remains largely closed to public access, especially sensitive wetland and pond shoreline areas. Unauthorized, illegal activities may increase in terms of damage to refuge vegetation as more people "discover" Massasoit NWR. Damage from activity that currently exists on the refuge includes vegetation trampling and breakage, and trail widening. Individuals engaging in unauthorized activities or trail use may find the openings created by additional fire breaks within the refuge forests particularly attractive. Opening portions of the refuge for public use creates the potential for spread and/or introduction of invasive species. Visitors could carry seeds in footwear, and unauthorized users could transport invasive plant seeds on tires, horses can excrete seeds in their waste, and illegal paddlers can spread invasive plants transported on contaminated canoes or kayaks. While any introduction or spread of invasive plants is a great concern, allowing limited public access is unlikely to result in any significant biological impact to the refuge natural community types and vegetation. Law enforcement will continue to patrol and monitor to deter unauthorized uses thereby reducing the risk for spreading or introducing invasive species. Removing downed brush and blocking unauthorized trails can effectively reduce vegetation impacts of illegal uses. We will post and enforce refuge regulations and area closures as refuge resources permit. Increased education and awareness about refuge natural resources and reasons for refuge regulations may also decrease illegal activities.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources	**Common to Both Alternatives**	A number of impacts to refuge coastal pond hydrology and to habitat and vegetation structure from changing climate and land uses that are external to the refuge will in turn impact refuge biological resources the same under both alternatives are discussed under Cumulative Effects. For purposes of this impact analysis, it was assumed that invertebrate pollinator species found in similar habitats located within MSSF likely also occur on the refuge.	
	Beneficial ***Northern red-bellied cooter***	Clearing woody and herbaceous vegetation and allowing sunlight to penetrate to and warm the soil surface on ¼ acre along the Crooked Pond shoreline, will enhance cooter nesting and egg incubation, benefitting hatching success and early hatchling survival. This can potentially shorten the incubation period, increase hatching success and early hatchling survival, and shift the current male-biased sex ratio of hatchlings toward more females. Using predator exclosures to prevent egg destruction and increase hatching success will improve first year survival rates of northern red-bellied cooter hatchlings. Camera monitoring indicates some trespassing on the property. Temporary signs establishing visual and enforceable closures around the nesting sites during nesting and incubation seasons will help protect the cooter. Illegal collection of cooter eggs and other harassment by humans will be deterred by keeping the refuge pond shorelines which cooters use for basking and nesting closed to public use, and by enforcing current regulations.	Surveillance monitoring, including invasive aquatic plants in refuge ponds, will alert refuge staff sooner, allowing control measures to be taken before invasive plants can dominate the native milfoil and other native aquatic plants that northern red-bellied cooters rely on for food. Clearing woody and herbaceous vegetation and allowing sunlight to penetrate to and warm the soil surface on 1 acre along the Crooked Pond shoreline, will enhance cooter nesting and egg incubation, benefitting hatching success and early hatchling survival. This can potentially shorten the incubation period, increase hatching success and early hatchling survival, and shift the current male-biased sex ratio of hatchlings toward more females. The addition of basking sites created by large downed trees anchored in shallow waters during mechanical thinning treatments along refuge pond shorelines will also benefit potential breeding cooters. With increased sunlight, refuge cooters can attain sexual maturity and enter the breeding population sooner, and breed more frequently. Locating and protecting nests with predator exclosures will expand somewhat, increasing hatching success and survival probabilities for first year northern red-bellied cooter hatchlings. Increased inventory and monitoring will assist in better understanding the impact of predators on northern red-bellied cooter nests and potential nest habitats created on refuge pond shorelines. With increased research effort, Service conservation partners and refuge staff will become better informed to more strategically manage and protect the existing and potential cooter population rangewide, both on and off the refuge. Prescribed burning and mechanical thinning on up to 200 upland acres further benefit the northern red-bellied cooter, by extending increased sunlight reaching the forest floor beyond the immediate refuge pond shorelines. Most lands surrounding refuge ponds are now closed-canopy pine forests. These closed canopy forested pond shorelines, if provided with adequate sunlight, could become additional suitable cooter nesting and incubation habitat.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Beneficial** ***Northern red-bellied cooter (cont.)***		Alternative B affords more opportunity to work with private landowners such as the nearby cranberry growers, residents along the shorelines of refuge and off-refuge ponds, and other landowners in the region interested in entering into management agreements. This alternative also increases law enforcement outreach with private landowners, further benefiting northern red-bellied cooter populations existing on nearby private lands. Camera monitoring indicates some trespassing on refuge property. Temporary signs establishing visual and more enforceable closures around the nesting sites during nesting and incubation seasons will afford a limited additional protection for the cooter. Illegal collection of cooter eggs and other harassment by humans will be further deterred by keeping the refuge pond shorelines which cooters use for basking and nesting closed to public use, and increased enforcement. Some decrease in unauthorized (illegal) use, especially off-road vehicles near pond shorelines with the greater staff presence and enforcement is expected.
	Migratory birds	Prescribed burning and thinning 50 acres of mixed pine-oak forest will benefit early successional and shrub species such as prairie warbler and field sparrow, chestnut-sided warbler, black and white warbler, common yellowthroat, eastern towhee, and gray catbird. Representative species such as eastern towhee and prairie warbler, and other migratory birds preferring open canopy and dense understory, will potentially increase slightly (not significantly). Eastern wood-pewee, another surrogate species, would benefit somewhat where canopy thinning creates open park-like areas on xeric (dry) sites with low shrub density. The remaining 150 acres of untreated mixed pine-oak upland forest will continue supporting breeding wood-pewee. The remaining 150 acres of untreated mixed pine – oak upland forest will continue supporting breeding adult ovenbirds along with other surrogate bird species such as scarlet tanager that rely on closed canopy conditions.	Prescribed burning and thinning up to 200 acres of mixed pine-oak forest will benefit early successional and shrub species such as prairie warbler and field sparrow, chestnut-sided warbler, black and white warbler, common yellowthroat, eastern towhee, and gray catbird. Representative species such as eastern towhee, prairie warbler, and other migratory birds preferring more open canopy and denser understory, will potentially increase refuge-wide (locally), but is not expected to be measurable at regional or continental population scales. Eastern wood-pewee are also likely to thrive refugewide. Variability in fire intensity during individual burns, combined with rotating multiple small burn treatments across the refuge landscape over several years will provide the heterogeneity in stand structure preferred by the wood pewee. Patches of intermediate age forest with more closed canopy left where lower intensity fire spread occurs, will be in close proximity to open, park-like patches, and the entire gradient of conditions between these.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Beneficial (cont.)** ***Migratory birds (cont.)***	Juvenile ovenbirds use regenerating cleared areas that have a denser understory for foraging and predator protection near ovenbird breeding habitat, and will be able to find that on the 50 acres treated with prescribed burning and mechanical thinning. The refuge will remain largely closed to public use year-round, minimizing human disturbance of migratory birds from authorized public use.	Juvenile ovenbirds that use regenerating cleared areas with a denser understory for foraging and predator protection near adult ovenbird breeding habitat, will find that on up to 200 acres treated with prescribed burning and mechanical thinning. Also, the HMP will identify patches to be reserved for migratory birds needing a more closed canopy habitat. This ensures that dense shrub juvenile ovenbird foraging and escape habitat is provided proximally to forest interior ovenbird nesting habitat, that is expected to remain available through the planning period and beyond on adjoining public and private lands. Providing wildlife observation, photography, interpretation and environmental education through staff or partner-led activities, and opening most of the Crooked Pond parcel to hunting, with an emphasis on deer and turkey hunting, are unlikely to provide more than minimal (not significant) benefit to migratory birds from the increased stewardship ethic and awareness of refuge resources, including migratory birds, they will foster. Some decrease in unauthorized (illegal) use that can damage or destroy eggs and nests on or near the ground, or disturb incubating or brooding adults on nests with the greater staff presence and enforcement is expected.
	Mammals	Silver-haired bats that forage in fairly open habitat in mixed wood forest areas near ponds may benefit, if present, from clearing vegetation on ¼ acre near the Crooked Pond shoreline for northern red-bellied cooter nesting habitat. Prescribed burning and mechanical thinning on 50 acres will create several patches with more open canopies and dense shrub understory, potentially suitable for future occupancy by New England cottontail.	Controlling invasive plants benefits mammals by maintaining the balance of food resources and native vegetative communities to which they are adapted for cover, nesting, and quality food resources. Early detection and control of invasive plants will help prevent non-native plant monocultures displacing native plant and insect diversity which provide critical year round food resources for herbivorous and insectivorous mammals. Silver-haired bats that forage in fairly open habitat in mixed wood forests near ponds may benefit, if present, from clearing vegetation on 1 acre near refuge pond shorelines for northern red-bellied cooter nesting habitat.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Beneficial (cont.)** ***Mammals (cont)***	Bats will likely benefit somewhat from the creation of forest canopy openings on 50 acres where active vegetation management occurs. Canopy gaps created by thinning and prescribed burns may allow bats such as eastern red bat and big brown bat to forage more easily. Decreased tree density and increased openings, may also improve travel corridors for bats, as more light reaches and warms roost trees, and increases insect prey diversity and abundance through increased herbaceous and shrub growth. Fire may create new bat roost trees and snags by direct or indirect fire mortality, although it may take one or more seasons to develop after burning. Given the relatively small total and treated refuge acreage impacted, none of the above local (refuge-level) changes in bat species abundance are expected to be significant at the larger landscape or population levels. Other mammals preferring more open canopy conditions and a denser understory layer such as mice and voles would also indirectly benefit from the prescribed fire regime and thinning treatments on 50 acres. Denser understory often allows for better protection from predators along with more food resources for small mammals, such as mice and voles. The refuge will remain largely closed to public use year-round minimizing human disturbance of mammals from authorized public use.	Prescribed burning and mechanical thinning on up to 200 acres will create many patches with more open canopies and dense shrub understory, potentially suitable for future occupancy by New England cottontail. By working collaboratively with utility right-of-way managers, the future potential for additional improved habitat connectivity and conditions for New England cottontail with the larger landscape surrounding the refuge increases. Bats will likely benefit from the creation of forest canopy openings on up to 200 acres where active vegetation management occurs. Canopy gaps created by thinning and prescribed burns may allow bats such as eastern red bat and big brown bat to forage more easily. Decreased tree density and increased openings, may also improve travel corridors for bats, as more light reaches and warms roost trees, and increases insect prey diversity and abundance through increased herbaceous and shrub growth. Fire may create new bat roost trees and snags by direct or indirect fire mortality, although it may take one or more seasons to develop after burning. Given the relatively small total refuge acreage impacted, none of the above local (refuge-level) changes in bat species abundance are expected to be significant at the larger landscape or population levels. Other mammals preferring more open canopy conditions and a denser understory layer such as mice and voles would also indirectly benefit from the prescribed fire regime and thinning treatments on up to 200 acres (refugewide). Denser understory often allows for better protection from predators along with more food resources for small mammals such as mice and voles. With deer density currently well above the 6 to 8 deer per square mile MassWildlife target range for Wildlife Management Zone 11, and given normal fecundity rates, opening most of the Crooked Pond parcel to deer hunting will not significantly impact local deer density or achievement of state deer management goals. Offering refuge and partner-led wildlife observation, photography, interpretation and environmental education, as well as opening most of the Crooked Pond parcel seasonally to hunting are unlikely to provide more than minimal (not significant) benefit to mammals from the increased stewardship ethic and awareness of refuge resources, including mammals, they will foster.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Beneficial (cont.)** ***Reptiles and amphibians***	Best management practices for amphibians and reptiles in pine forests such as those on the refuge include maintaining and creating canopy gaps that allow species that need sunlight such as American toad, Fowler's toad, and eastern hognose snake to thrive. The approximately 150 acres that will maintain a more closed canopy are likely to benefit such species as spotted salamander, spring peeper, wood frog, and milk snake. The refuge will remain largely closed to public use minimizing human disturbance of amphibians and reptiles from authorized public use.	Controlling invasive species would benefit amphibians and reptiles by contributing to the restoration and propagation of native plants and associated insects that are essential food resources. Additional inventories will further inform the Service and our partners about the extent and population of various amphibians and reptiles, increasing certainty about management impacts on them. Reptiles, and amphibians favored by open canopy conditions with a dense shrub understory, such as American toad, Fowler's toad, and eastern hognose snake are expected to benefit to an even greater (up to fourfold) from prescribed burning and thinning on up to 200 acres.
	Fish	There currently is no active management for fish in Crooked Pond, and only the shorelines of the other ponds are within Service jurisdiction. Therefore no impacts to fish species on the refuge are likely. Crooked Pond will remain closed to public use minimizing human disturbance to fish from authorized public use.	If surveys proposed indicate a need for aquatic invasive plant control, fish favored by native aquatic plants would benefit indirectly from that control, but the benefit is limited and not expected to be significant.
	Invertebrates, including pollinators	Rare butterfly and moth species that depend on sandplain heathland community or pitch pine –scrub oak shrubland, woodland, or forest association habitats, such as the Pine Barrens buckmoth, Gerhard's Underwing moth, and others, would benefit slightly from prescribed burning and thinning on 50 acres. Many caterpillars (larvae) of these species eat only pitch pine, scrub oak, or other specific plant hosts found only or mostly in pitch pine –scrub oak shrubland association or sandplain heathland communities. Prescribed burning and overstory thinning will allow more light to penetrate to the understory, favoring the host plants which attract these pollinators.	Rare butterfly and moth species that depend on sandplain heathland community or pitch pine-oak shrubland habitats, such as the Pine Barrens buckmoth and Gerhard's Underwing moth and others, will benefit refugewide from prescribed burning and thinning on up to 200 acres. Many caterpillars (larvae) of these species eat only pitch pine, scrub oak, or other specific plant hosts found only or mostly in pitch pine-scrub oak shrubland association or sandplain heathland communities. Prescribed burning and overstory thinning will allow more light to penetrate to the understory, favoring the host plants which attract these pollinators. Expansion of moth and butterfly inventory and monitoring also gives Service staff and partners better information about lepidopteran species occurrence, allowing for more strategic, targeted, and proactive application of refuge vegetation treatments. Collaboration with the utility company to manage for shrubland habitat along the power line would also benefit pollinators including some moths and butterflies. Sunlight is particularly important for basking behaviors that warm the body for flight.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Adverse** ***Northern red-bellied cooter***	Locating and protecting existing cooter nests on the refuge and clearing ¼ acre of vegetation along Crooked Pond may disturb individual northern red-bellied cooters infrequently for brief periods, but no significant adverse impacts on the northern red-bellied cooter are expected.	Locating and protecting existing cooter nests on the refuge and clearing 1 acre of vegetation along refuge ponds may disturb individual northern red-bellied cooters infrequently for brief periods, but no significant adverse impacts on the northern red-bellied cooter are expected. Some potential for increased disturbance or harassment of northern red-bellied cooters from unauthorized users is expected, but is not deemed significant. It is possible that some disturbance from hunters could occur, but this is expected to be negligible as the area around Crooked Pond will be closed to hunting. Once hunters get into place, there will be no interaction with northern red-bellied cooters.
	Migratory birds	Migratory birds associated with closed canopy, forest interior conditions such as breeding ovenbirds and scarlet tanagers, will likely decline initially in the 50 acres treated with prescribed burning and mechanical thinning. Forest interior breeding birds breeding in sub-optimal conditions, may experience lower nest productivity or fledgling survival. The refuge will remain closed year round to public use, and therefore no adverse impact to migratory birds from human disturbance by refuge visitors is expected. Unauthorized use could potentially disturb and harm migratory birds if the limited enforcement capacity leads to further increases in illegal use during nesting and young rearing periods within closed areas.	Migratory birds associated with closed canopy, forest interior conditions such as breeding ovenbirds and scarlet tanagers will decline, but likely persist in lower numbers and density on up to 200 acres treated with prescribed burning and mechanical thinning. Suitable habitat will remain within the refuge, and on adjoining ownerships. Increased disturbance to individual migratory birds from authorized public uses will occur. Temporary disturbance to birds from wildlife observation and photography, environmental education and interpretation might occur. There should be no impact to migratory birds from hunting. Because of the diversity of habitats on the refuge directly connected to other large tracts of protected lands, population level effects to migratory birds from refuge public use would be minimized.
	Mammals	There will be no significant adverse impacts to mammals, including bats. The approximately 150 acres of refuge uplands remaining untreated will continue maturing to mature, degrading dense understory structure required by New England cottontails. Management activities such as prescribed burns on 50 acres naturally present a low direct mortality risk to small mammals. The impact is minor at the population level and generally of short (weeks to months) duration. Most mammals scurry out of the way, go underground or burrow under the duff and escape injury as low to moderate intensity flaming fronts move across an area. Direct mortality of some mammals, such as rabbits and raccoons, may occur during prescribed burns but is rare.	Potential direct mortality risk to small mammals such as rabbits, mice, and voles during prescribed burns on up to 200 acres is expected to be low (rare) and not significant, but may occur. A slightly increased predation or winter cold exposure risk during immediate post-burn periods for mammals displaced by prescribed burn units is expected. But this increase is more than offset by improved protective cover for 5 to 7 years after burning. Prescribed burning and mechanical thinning on up to 200 acres can have short term detrimental impacts on bats by eliminating snags and stumps.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Adverse (cont.)** ***Mammals (cont.)***	Prescribed fire removes some protective cover, potentially exposing small rodents and rabbits to predation and cold. The extent of exposure largely depends on the proximity of available cover and predator (raptors, foxes, and feral cats) in the area. Prescribed burning will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Prescribed burns on the refuge will therefore be small (50 acres or less), which means alternate escape cover is never more than 700 feet away for small mammals temporarily displaced by a prescribed fire or other habitat treatment. Prescribed burning and mechanical thinning on 50 acres can have short-term detrimental effects on bats by eliminating some snags and stumps used for roosting. Roosting bats may also be killed under intense fire conditions. Firebreaks can be raked around snags, or the bases can be sprayed with retardant to protect the snags. Prescribed burns on 50 acres and fires occurring when bats are rearing young (April-July) or in deep hibernation (mid-winter) can therefore have negative impacts on local populations. To minimize losses, prescribed fires should be set during warmer days (above 50° F). This impact will most likely be minimal because refuge growing season prescribed burns are unlikely during the times when neonatal bats are still in their roost or during mid-winter deep hibernation periods. The approximately 150 acres of refuge uplands remaining untreated will continue maturing without natural disturbance. Bats now present in these areas that prefer more open canopy conditions such as big brown bats, will likely decrease locally. Unauthorized use will continue to disturb mammals on the refuge to a limited (not significant) extent.	Prescribed burns on up to 200 acres and fires occurring when bats are rearing young (April-July) or in deep hibernation (mid-winter) can therefore have negative impacts on local populations. To minimize losses, prescribed fires should be set during warmer days (above 50° F). This impact will most likely be minimal because refuge growing season prescribed burns are unlikely during the times when neonatal bats are still in their roost or during mid-winter deep hibernation periods. Increased disturbance to individual small mammals from visitors engaged in staff and partner led wildlife observation, photography, interpretation, and environmental education and hunters will occur but will be temporary and minimal. Unauthorized use will continue to disturb mammals on the refuge to a limited (not significant) extent. Opening portions of the refuge to hunting in accordance with state regulations would result in direct mortality of the individuals harvested.
	Reptiles and amphibians	Prescribed burning will be performed on 50 acres on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. We anticipate short-term impacts on amphibian species from refuge prescribed fire activities. However, given the low-intensity and short flame-front residence time (duration), and relatively small burn area, we do not consider this to be a significant impact. The Crooked Pond and other micro-site features within and surrounding burn units may provide protective refugia from fire for refuge reptiles and amphibians, and breeding by aquatic species is expected to continue uninterrupted by fire.	Herbicide use for invasive species control could negatively impact amphibian eggs, larval stages, and tadpoles to a limited extent, but are largely expected to be mitigated by precautions during application.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Biological Resources (cont.)	**Adverse (cont.)** ***Reptiles and amphibians (cont.)***	Since the refuge will remain closed year-round to public use, so no adverse impacts from authorized public use on amphibians and reptiles are expected. Unauthorized use will continue to affect reptiles and amphibians on the refuge to a limited (not significant) extent. Utility rights-of-way, unpaved roads, and trails in pitch pine-oak upland forest systems often attract sensitive species for nesting (e.g., Eastern Box Turtle), basking (e.g., Eastern Hog-nosed Snake), or foraging where ORV traffic may result in direct mortality.	Short term impacts on amphibian species from prescribed burning and mechanical thinning up to 200 acres are expected. There is increased direct mortality risk. There is also increased indirect impact potential through increased risk of losing forest floor amphibian refugia to consumption by fire. Spotted salamander, spring peeper, wood frog, and milk snake are species that could be adversely impacted, but mitigation and adaptation may be possible. Refuge ponds and other micro-site features within and surrounding burn units may provide protective refugia from fire for refuge reptiles and amphibians, and breeding by aquatic species is expected to continue uninterrupted by fire. No adverse impacts from authorized public use on amphibians and reptiles are expected from opening the refuge to guided public use, or from hunting. Unauthorized use will continue to affect reptiles and amphibians on the refuge, but to a lesser extent
	Fish	Unauthorized use will continue to affect fish in refuge ponds to a limited (not significant) extent.	Herbicide use for invasive species control could negatively impact developing fish eggs and juvenile fish to a limited extent, but can be largely mitigated by precautions during application. Unauthorized (illegal) use will likely continue to affect fish in refuge ponds to a limited (not significant) but lesser extent, due to increased presence by Service personnel, including law enforcement.
	Invertebrates, including pollinators	Herbicide use along the utility right-of-way may negatively impact invertebrate species to a limited extent, which will largely be mitigated by precautions during application. The approximately 150 acres of refuge uplands remaining untreated will be increasingly dominated by more mature tree species such as the already common white pine. On these untreated acres, a further decline in the rarer butterfly and moth species, including Pine Barrens buckmoth and Gerhard's underwing moth is expected. Other pollinators and invertebrate species may be present or may immigrate that thrive on more closed canopy conditions that will remain largely undetected in the absence of monitoring and inventory.	Herbicide use for invasive species control could negatively impact pollinators and other invertebrates to a limited extent, but can be largely mitigated by precautions during application. Herbicide use along the utility right-of-way could negatively impact invertebrate species to a limited extent, but can be largely mitigated by precautions during application and collaboration with the State and utility company to minimize herbicide use along the utility line.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Climate Change	**Common to Both Alternatives**	With the potential for increased temperatures due to climate change, warmer conditions may shorten the hibernation period and lengthen the non-hibernation period, thereby increasing survival rates among northern red-bellied cooter populations. Carbon "sequestration" is essentially the process by which plants take up carbon dioxide through photosynthesis, and then store (sequester) it in plant biomass (wood, roots) and in the soil. Succession to forest stores the most carbon although the sequestration rate declines as trees mature. Some carbon sequestered on or above the soil surface is however released back to the atmosphere whenever vegetation burns during wildfire or prescribed burn surface fire, partially reversing vegetation and soil carbon sequestering, as with forest decomposition. Pine barren (pitch pine-scrub oak shrubland, pitch pine-oak woodland or forest associations, or sandplain heathland community) habitats are the least vulnerable (most resistant) to climate change forest types in the region. These naturally resilient forest types can withstand wildfire (with proper fuel load management), pest and invasive species outbreaks often associated with climate change. Although these forests are vulnerable to non-climate stressors, with the reduction of fuel hazards, the risk of severe wildfires brought on by alternating cycles of increased precipitation and drought is reduced.	
	Beneficial	Continued use of prescribed burns to manage fuel loads on 50 acres combined with expected climate change induced drought and other weather extremes, may create more favorable conditions for pitch pine-scrub oak persistence and expansion. Continuing hazardous fuel reduction will also reduce the high intensity wildfire threat, often exacerbated by the alternating cycles of extremes in precipitation and severe drought expected with changing climate.	Coastal ponds have a medium vulnerability to climate change as a result of the potential increase in invasive plants associated with climate change. Surveys of aquatic invasive plants with an evaluation of the need for management would potentially benefit refuge pond climate change resilience if control efforts were implemented sooner. Expanding prescribed burning and mechanical thinning for hazardous fuel reduction and habitat management to as much as 200 acres should increase resiliency of the refuge forests to climate change. Episodic greenhouse gas emissions from high intensity wildfires are less likely with fuel reduction on up to 200 acres. Invasive species monitoring and control would also increase to maintain less than 10 percent cover in invasive species refuge-wide. Carbon sequestration would differ based on the change in vegetation type, structure, and forest canopy closure, by extending mechanical thinning and prescribed burning to as much as 150 additional acres of what is now relatively mature, closed-canopy eastern white pine dominated forest, a less climate change resilient type. The net offset effect of carbon sequestration from forest succession to periodically carbon release back into the atmosphere during prescribed burning is however uncertain.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Climate Change (cont.)	**Adverse**	There is the potential for slight, short-term increases in atmospheric carbon emissions during prescribed burning and from motorized equipment use during mechanized thinning. Prescribed burning 50 acres will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. The level of carbon emissions from habitat management under alternative A will be insignificant compared to the emissions from a single large, high severity wildfire due to high fuel load accumulations without fuel treatments. Atmospheric carbon emissions will result from round-trip motor vehicle travel by complex headquarters staff to work on the refuge. The staff increasingly utilizes lower emission vehicles to reduce atmospheric carbon emission contributions to global climate change. Because of the limited level of management, the carbon emissions from administrative activity expected are minimal, and not significant.	Increasing prescribed burning by up to 150 additional acres is expected to increase atmospheric carbon emissions by up to four times over the planning period. Prescribed burning up to 200 acres will be performed on a (5 to 7 years) rotational basis, with no more than 50 acres burned on any given day or in any one year. Rapid post-burn vegetative recovery and resumption of biological carbon sequestration following low to moderate intensity, small scale prescribed fires is expected. This increased level of atmospheric carbon emissions would still be insignificant compared with those from a single large, severe wildfire fueled by heavy fuel loads, as experienced in past decades. The use of power tools and equipment on the refuge would also produce small amounts of carbon emissions. Additional impacts on atmospheric carbon emissions may occur with the slight potential increase in visitation to walk on the trail, to deer and turkey hunt, and to participate in environmental education and interpretation. Atmospheric carbon emissions from increases in refuge visitor use will be negligible (insignificant) since most visits to the refuge would come from nearby residents or visitors already using the adjacent MSSF. Additional atmospheric carbon emissions will result from more round-trip motor vehicle travel by complex headquarters staff to the refuge. The shift toward lower emission vehicles to reduce atmospheric carbon emission contributions to global climate change will offset emissions from increased refuge staff administrative vehicle use. Atmospheric carbon emissions would still be minimal (insignificant) compared with emissions from sources originating outside the refuge.
Refuge Access and Public Uses	**Common to Both Alternatives**	No beneficial or adverse impacts to refuge access and public uses are common to both alternatives.	
	Beneficial	With continued closure of the refuge to public use, there will be no significant beneficial impact to refuge access and public use. The Service will have capability for limited oversight of vehicular and pedestrian traffic. The Service would continue providing limited programming, delivered primarily through refuge partners, as staffing, funding, and the interest and availability of Service partners allow.	Allowing visitors on the refuge for staff and partner-led wildlife observation, photography, interpretation and environmental education on the Crooked Pond parcel, and opening most of the Crooked Pond parcel seasonally to hunting, increases public access and public use. Staff and partner-led programs and the development of more interpretive materials should increase public awareness of the refuge. We expect increased public awareness of the presence of a refuge in the Plymouth region, about the importance of natural resources, human impacts on wildlife, and refuge policies.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Refuge Access and Public Uses (cont.)	**Adverse**	Continued closure of the refuge effectively precludes most refuge public use and access opportunities throughout the planning period. Limited outreach, interpretation, and enforcement by the Service will not ensure compliance with Federal, State, and local endangered species or wetland protection laws on the refuge. A lack of awareness of the refuge boundaries and refuge policies, and improper and unauthorized use and access to sensitive areas of the refuge is expected to remain unchanged, and continue through the planning period. The minimal level of interpretation that has occurred off the refuge related to the refuge's natural resources has been delivered principally through refuge partners. The Service would remain entirely dependent on the interest and availability of Service partners to deliver limited interpretive programming and outreach.	Continued closure to public access of ecologically sensitive areas such as refuge pond shoreline nesting sites of the northern red-bellied cooter will limit public access to pond shorelines. Even with the presence of wildlife observation and photography, environmental education and interpretation, and hunting, refuge staff would continue to limit activities that may impact the cooter. Additional authorized access to the refuge and its resources may also draw increased unauthorized use. It is unknown to what extent unauthorized use would occur with improved outreach efforts. Onsite and offsite programs require expenditures and committing resources that could be available for other refuge programs.
Archaeological, Historical, or Cultural Resources	**Common to Both Alternatives**	We will comply with all appropriate legal mandates to protect and manage refuge cultural resources. Any management actions with the potential to affect cultural resources require refuge manager review, as well as review by the Service's Regional Historic Preservation Officer), in consultation with the Commonwealth of Massachusetts SHPO and the THPO, as appropriate. Determining if particular actions within an alternative have the potential to affect cultural resources is an ongoing, well-established, and closely regulated process that will continue during the planning stages of any proposed projects under either alternative. It is probable that unrecorded archaeological or cultural sites exist on current refuge lands. Many of these are likely to include Native American artifacts. The likelihood of locating other prehistoric or historic sites on the refuge is also high given the human settlement and land use history in the refuge vicinity. Regardless of alternative, the Service is responsible for managing and protecting archaeological and historic sites found on national wildlife refuges.	
	Beneficial	Minimal beneficial impacts to any archaeological, historical, or national resources are expected. The refuge will remain largely closed to public use.	There may be an increased opportunity to discover and protect sites and artifacts those items and further evaluate the cultural significance of the discovery site during project planning or implementation. There would be little or no beneficial impact to cultural resources from increased public access and use under this alternative.

Massasoit Refuge Resource	Type of Impact	Alternative A Current Management	Alternative B Expanded Management (Service-preferred Alternative)
Archaeological, Historical, or Cultural Resources (cont.)	**Adverse**	Minimal adverse impacts to any archaeological, historical, or national resources are expected given precautions taken to protect any cultural, historical, or archaeological resources. Northern red-bellied cooter habitat management actions along the shoreline of Crooked Pond will be limited. Thinning and prescribed burning will be limited to 25 percent (or 50 acres) of the refuge within the northeastern corner of the Crooked Pond parcel. The limited law enforcement staff is not expected to prevent or detect many violations resulting from unauthorized public uses.	Minimal impacts to cultural resources on the refuge from disturbance related to habitat management are expected. Although mechanical thinning and prescribed burning would potentially increase across the refuge, the Service makes every effort to minimize new soil disturbance, identify and protect any sites or artifacts beforehand, or discovered during habitat management. Disturbance can occur through disturbing the top layer of soil that may serve as a protective layer for undiscovered artifacts. These areas would be limited to those small, localized areas disturbed through fire break creation, thinning and tree removal, or invasive species removal. A slight increase for potential disturbance to as yet undiscovered artifacts results from periodic maintenance of the new public use trail, installation of signs and interpretive panels, and the general increase in visitation. The likelihood of any destructive impacts from guided public use and hunting is minimal.
Socioeconomic	**Common to Both Alternatives**	Under both alternatives, the Service would continue somewhat offsetting tax revenue losses from refuge lands being removed from the property tax base by making annual "revenue sharing" payments to the town in lieu of taxes, as provided by Congress. No major changes in the level of revenue sharing payments unless Congress changes its annual revenue sharing appropriation. We expect these annual $4,000-$5,000 payments will have negligible effect on the $32.89 million (2015) town of Plymouth annual operating budget. Any increase in nearby home values also increases property tax revenues for those. In addition, people may be more likely to move to an area that values the protection of natural resources for public enjoyment.	
	Beneficial	The refuge will remain largely closed to the public. No additional beneficial impacts to the socioeconomic resources from visitors and staff expenditures are anticipated. No staff are stationed are permanently stationed at the refuge. Refuge Complex biological and law enforcement staff conduct site visits several times yearly. The slight (not significant) benefit to the local economy from small purchases of goods and services in the local area during staff visits should remain little changed.	Improved visitor access to the Crooked Pond parcel for interpretation, environmental education, wildlife observation and photography, and deer and turkey hunting will result. A slight increase in refuge visitation is expected, resulting in a corresponding slight increase in expenditures in the local community by refuge visitors. New net increases in expenditures by refuge visitors captured by the local economy will not be significant, since many of these new refuge visitors are expected to be local residents.
	Adverse	None	None.