Chapter 4

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Environmental Consequences

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4.0 Introduction

This chapter describes the environmental consequences we expect from implementing Great Swamp NWR management alternatives presented in chapter 3. Where detailed information is available, we present a scientific and analytic comparison between alternatives and their anticipated consequences, which we describe as "impacts" or "effects." In the absence of detailed information, we make comparisons based on our professional judgment and experience.

We focus our discussion on the beneficial and adverse impacts associated with the goals and key issues identified in chapter 1, "Purpose of, and Need for, Action." Direct, indirect, short-term, beneficial, and adverse effects likely to occur over the 15-year life span of the plan are discussed. Beyond the 15-year planning horizon, we give a more speculative description of the direct, indirect, and cumulative effects. The chapter identifies cumulative impacts, any irreversible and irretrievable commitment of resources and the relationship between short-term uses of the environment and its long-term productivity. At the end of this chapter, table 4.2 summarizes the effects predicted for each alternative and allows for a side-by-side comparison.

4.0.1 Regional, Historical, and Watershed Context

As required by CEQ and FWS regulations implementing NEPA, we assessed the importance of the effects of the alternatives presented in this draft CCP/EA based on their context and intensity. The context of the impacts ranges from site-specific to broader regional and eco-regional scales (table 4.1). Although refuge lands comprise a small percentage of these larger regional area contexts, all alternatives were developed to contribute towards conservation goals in these larger contexts.

As discussed in section 2.1.3, the refuge is located within the GSW, which is situated within the southern portion of the Upper Passaic River Watershed (figures 2-1 and 2-5). The GSW refers to a collection of adjoining subwatersheds that feed the hydrology of Great Swamp, which encompasses approximately 55 square miles (35,200 acres). The GSW is bound by a ridge of the Appalachian Mountains to the northwest, the third Watchung Mountain to the south, and the Loantaka Moraine to the northeast (Parrish and Walmsley 1997). Black Brook, Great Brook, Loantaka Brook, and Primrose Brook flow through the refuge, generally in an east to west direction, before draining to the Passaic River, located along the western refuge boundary. The Passaic River forms the western refuge boundary.

Table 4.1: Regional Context for Impacts Analyses at Great Swamp National Wildlife Refuge

Resource	Context
Air Quality	The New York-New Jersey Metropolitan Area
Water Quality	Waters that pass through or are contained by the Great Swamp National Wildlife Refuge and the reaches of rivers immediately downstream

Table 4.1: Regional Context for Impacts Analyses at Great Swamp National Wildlife Refuge	
Resource	Context
Soils	Area within the refuge boundary
Vegetation	Area within the refuge boundary
Species	Immediate impacts to migratory species while on refuge and consideration of greater populations that refuge specific individuals are a part of
Socioeconomics	Morris and Somerset Counties
Recreation	Morris and Somerset Counties

Across a more localized landscape scale, the refuge protects a variety of resources and provides a unique opportunity for education and outreach in the New York-New Jersey Metropolitan Area. Connecting children and families with nature is a high priority national program of the FWS. The suburban to urban context of the refuge provides excellent opportunities for such environmental education and conservation outreach.

Approximately 150,000 to 160,000 visitors from around the region, the country, and other countries visit the refuge each year. Because of its location within the most highly developed and densely populated area in the country, the refuge has the potential to reach out to millions of children and adults making Great Swamp NWR the ideal place to implement the Refuge System's new "Urban Refuges" initiative. Great Swamp NWR is in a position where it can foster greater understanding of natural systems, species of conservation concern, the value of the Refuge System, and the FWS mission in conserving and protecting those resources. Each of the management alternatives is consistent with state, regional, ecosystem, and watershed conservation plans identified in chapter 1. At varying levels, each of the alternatives would make positive contributions to these larger landscape-scale conservation endeavors.

Significant land use changes since European colonization have impacted the surrounding area, as well as the refuge itself, including clearing for farmland, repeated attempts at draining and stream alteration, highway construction, landfills, and residential, commercial and industrial development. As implied in the refuge vision statement, the refuge is an island of wildlife habitat in a heavily suburbanized landscape. The heavily suburbanized environment and historical disturbance of primarily wetlands of the refuge and surrounding area also present many challenges ranging from minimizing visitor impacts to minimizing or mitigating wildlife impacts due to impaired regional water and air quality, habitat fragmentation, invasive species, and other conditions associated with urban environments.

The refuge's ability to directly and beneficially impact the regional environment is somewhat limited given the extent of surrounding land uses and the large human population, but the refuge participates in regional efforts for land conservation, protection of wildlife corridors, air and water quality improvements, and early

detection and management of regional invasive species. Given this urban context, the analysis of impacts mainly focuses on how FWS actions at the refuge might affect the physical and biological environment, socioeconomics, historical, and cultural resources, as well as wildlife-dependent public uses. Where possible and information is available, we also provide discussions of how management actions would impact regional resources.

4.0.2 Evaluation of Environmental Impacts and Time Frames

In accordance with CEQ and FWS regulations implementing NEPA, we assess the importance of the effects of the alternatives based on their context and intensity. The scale of their context ranges from site-specific to local, landscape, or regional. Although the area of the refuge is only a small percent of the context in its ecosystem or region, we developed all of our management alternatives to contribute to the many conservation goals in those larger contexts. For each alternative, we based our evaluation of the intensity of the effects on the following factors:

- Expected degree or percent of change in the resource from current conditions.
- Frequency and duration of the effect during the 15-year planning horizon.
- Sensitivity of the resource to such an effect or its natural resiliency to recover from such an effect.
- Potential for implementing effective preventive or mitigating measures to lessen the effect.

Significance also encompasses the magnitude of change or of an impact. It is not a value judgment, as some impacts can be beneficial for one species and adverse for another, or have a positive impact on visitor use but a negative impact on migratory birds. The following table defines this aspect of significance by giving more detailed information about the magnitude or level of intensity for each of the impacts topics which will be discussed in more detail in this chapter.

Table 4-2: Impact Significance Criteria Threshold Definitions

Impact Topic	Significance Criteria
Socioeconomic	Effects to socioeconomic elements would be considered significant if: • Management actions would result in readily apparent changes to economic conditions. While there may be some apparent changes in social or economic conditions in nearby communities, if such effects are localized, they are considered not to be significant. Significant social or economic effects encompass measurable changes in social or economic conditions at the regional level.
Cultural and Historic Resources	Effects to cultural and historic resources would be considered significant if: • Management actions would have a substantial, noticeable, and permanent effect on a site or group of sites. The action would

Impact Topic	Significance Criteria
	severely change one or more characteristics that qualify the site(s) for inclusion in the National Register, diminishing the integrity of the site(s) to such an extent that it would no longer be eligible for listing in the National Register. For purposes of Section 106, the determination of effect would be an *adverse effect.*
Air Quality	Effects to air quality would be considered significant if: • Implementation of a proposed refuge action would result in: emissions equal to or in excess of the standards set in local implementation plans for the Clean Air Act; large areas of soil becoming routinely exposed and subject to wind erosion; or sensitive receptors being exposed to substantial pollutant concentrations, including air toxics such as diesel particulates. Significant indirect effects to air quality would occur if a proposed refuge action results in frequent heavy congestion on adjacent roadways. Significant cumulative effects would occur if the "*de minimis*" (minimum) thresholds developed by the EPA for proposed Federal actions in a nonattainment area are exceeded.
Soils	Effects to soils would be considered significant if: • Management actions would result in the permanent loss or alteration of geologic features or soils in relatively large areas, such as 1,000 acres, or there would be a strong likelihood for erosion or mass movement of large quantities of soil, sediment, or rock as a result of the action. Mitigation measures to offset adverse effects would be necessary, extensive, and their success could not be guaranteed. • Management actions would preserve or restore geologic features, geologic processes, or soil resources in relatively large areas, such as 1,000 acres.
Water Quality and Hydrology	Effects to water quality and hydrology would be considered significant if: • Actions would result in substantial increased flooding on- or off-site, accelerating flooding, or further deviation from historical hydrological patterns above reasonably anticipated levels due to climate change, or a substantial reduction in the local groundwater table. • Actions would violate any water quality standards or waste discharge requirements, substantially increase sedimentation, introduce persistent contaminants (nonpoint source pollution) into the watershed, or otherwise substantially degrade water quality.

Impact Topic	Significance Criteria
	Water quality impacts could include increased loads of sediment, debris, chemical, or toxic substances, or pathogenic organisms. The impact could be easily visible to visitors. • Restoration projects and best management practices would measurably improve water quality in most tributaries in the refuge, and overall effect would be clearly detectable.
Vegetation	Effects to vegetation would be considered significant if: • An action would result in a substantial change in the amount or quality of available habitat for a wildlife species (for wintering waterfowl, other migratory birds, or native resident wildlife, a substantial reduction in habitat resulting in a significant adverse impact would be defined as a reduction of 30 percent or more of the available acreage or 50 percent of the quality of habitat for these species within the refuge; a significant beneficial impact would be defined as a 30 percent or greater increase in the quantity or 50 percent increase in the quality of habitat for wintering waterfowl, other migratory birds, or native resident wildlife). • A substantial portion of native habitat would be removed or otherwise modified as to accommodate a proposed action. The impacts would be substantial and highly noticeable and could result in widespread change. This could include changes in the abundance, distribution, or composition of a local vegetation community or regional plant population to the extent that it would be likely to be replaced by a different vegetation community. Significant ecological processes would be altered, and changes would be expected. • A refuge action causes mortality of greater than 30 percent of a regional or State population of a species. • Management actions would restore or preserve vegetation or unfragmented forest blocks throughout much of the refuge. • Management actions to remove invasive vegetation are not considered significant even if the result substantially decreases the abundance of the invasive species, if the result is the restoration or increase in quantity or distribution of native vegetation.
Threatened and Endangered Species	Effects to threatened and endangered species would be considered significant if: • An action would result in a substantial adverse effect, either directly or through habitat modifications, on any Federal

Impact Topic	Significance Criteria
	threatened, endangered, candidate, or special concern wildlife or fish species. Also included would be species listed threatened or endangered by NJDEP. • Management actions could result in a noticeable change to a population or individuals of a listed or protected species or designated critical habitat. The change would be substantial and highly noticeable and would most likely result in a *likely to adversely affect* opinion from the FWS. • Management actions would measurably increase a population or numbers of individuals of a listed or protected species or enhance designated critical habitat.
Terrestrial Wildlife, Waterfowl, Shorebirds, Secretive Marsh and Waterbirds, Mammals, Reptiles and Amphibians, and Invertebrates	Effects to species would be considered significant if: • An action would result in a substantial change in the amount or quality of available habitat for a wildlife species (for wintering waterfowl, other migratory birds, or native resident wildlife, a substantial reduction in habitat resulting in a significant adverse impact would be defined as a reduction of 30 percent or more of the available acreage or 50 percent of the quality of habitat for these species within the refuge; a significant beneficial impact would be defined as a 30 percent or greater increase in the quantity or 50 percent increase in the quality of habitat for wintering waterfowl, other migratory birds, or native resident wildlife). • A substantial portion of native habitat would be removed or otherwise modified to accommodate a proposed action. • A refuge action causes mortality of greater than 30 percent of a regional or State population of a species. • Management actions would restore or preserve aquatic wildlife populations in large portions (1,000 acres) of the refuge. This could include changes in the abundance, distribution, or composition of local terrestrial wildlife populations.
Fisheries	Effects to fisheries would be considered significant if: • An action would substantially change the availability of habitat for fish. • An action would result in an obvious detectable effect to aquatic wildlife populations at the regional level. Extensive mitigation would be needed to offset any adverse effects, and their success would not be guaranteed. • An action would restore, improve, or preserve aquatic wildlife populations in large portions (i.e., 1,000 acres) of the refuge. This

Impact Topic	Significance Criteria
	could include changes in the abundance, distribution, or composition of local aquatic wildlife populations.
Public Use and Access	Effects to public use and access would be considered significant if: • A proposed action resulted in substantial displacement of a wildlife-dependent public use (>25 percent of existing activities or opportunities moved to a different area or terminated at the refuge); • Substantial reduction in the quality of the wildlife-dependent experience (crowding increasing by more than 50 percent or substantial anticipated losses of wildlife or habitat supporting the experience). • Proposed actions resulted in substantial increase in opportunity for or quality of a wildlife-dependent public use (>25 percent increase over existing opportunity or quality of experience). • Management actions would result in impacts that would be readily apparent and would likely be perceived as highly positive by visitors because they would obviously enhance the visitor experience by making access to most refuge resources and experiences very easy.

Some impacts are not considered major or significant, and are described as either negligible, minor, or intermediate. The magnitude of such changes is defined as follows:

Scope, scale, and intensity can be defined on a range from negligible to major.

- Negligible: Management actions would result in impacts that would not be detectable or if detected would be considered slight, localized, and short term. .

- Minor: Management actions would result in impacts that would be detectable, but localized, small, and of little consequence to a population, wildlife or plant community, public use and access opportunity, visitor experience, or cultural resource. Mitigation, if needed to offset negative effects, would be easily implemented and likely to be successful.

- Intermediate: Management actions would result in impacts that would be readily detectable and localized with consequences to a population, wildlife or plant community, public use and access opportunity, visitor experience, or cultural resource. Mitigation measures would be needed to offset negative effects and could be extensive, moderately complicated to implement, and probably successful.

- Major: Management actions would result in impacts that would be obvious and would result in substantial consequences to a local area or regional population, wildlife or plant community, public use and access opportunity, visitor experience, or cultural resource. Extensive mitigating measures may be needed to offset negative effects and would be large-scale, very complicated to implement, and may

not have any guarantee of success. In some instances, major effects would include the irretrievable loss of the resource.

In addition to the magnitude of impact (negligible, minor, moderate, or major) the impacts of the management action on some of the environmental attributes are also, at times, described as beneficial or adverse. Generally, an impact will be described as 'beneficial' if it results in a condition that improves the biological health, population size of native or naturally occurring species, or the robustness or sustainability of that characteristic. However, many times value judgments cannot be given for ecological change. A change in habitat that is beneficial for certain species of waterfowl may be adverse for others with different habitat preferences. Factors which reduce the population of a predator may be adverse for the predator and positive for the prey. Therefore, sometimes our impact assessments do not describe impacts as either positive or negative, or describe them specifically in term of what the impact applies to. The duration of identified effects and their consequences varies, from those occurring only once for a brief period in the 15-year period of this plan—for example, the effects of construction for expanding existing facilities—to those occurring more frequently during the year, like mowing. The environmental consequences analysis provided in this chapter will also furnish the level of detail necessary to assess the compatibility of all proposed uses.

Time scales are defined as either short-term or long-term.

- Short-term or temporary: An effect that generally would last less than a season or year.
- Long-term: A change in a resource or its condition that would last longer than a single season or year.

4.0.3 Management Actions Not Analyzed in Detail

The following list of management activities is included in the analysis in this document even though they are both trivial in effect and common to all alternatives. If any of these items were independently proposed they would qualify for categorical exclusion under applicable regulations:

- Operations and maintenance of existing infrastructure and facilities (unless major renovation is involved).
- Issuance of new or revised management plans when only minor changes are planned.
- Law enforcement activities.
- Environmental education and interpretative programs (unless major construction is involved, or a significant increase in visitation is expected).
- Research, resource inventories, and other resource information collection activities.
- Routine, recurring management activities and improvements, including managing invasive plants.
- Small construction projects (for example, fences, berms, small stream and wetland restoration projects, trail maintenance, interpretative kiosks, and development of access for routine management purposes).
- Minor vegetation plantings.

- Reintroducing native plants and animals.
- Minor changes in amounts or types of public use.

In addition, some of the actions that are described would fall under the "extraordinary circumstances" exceptions in 43 CFR 46.215. Further, some of the management actions described in chapter 3 are not categorically excluded from NEPA, such as emergency responses to a major disease outbreak. Where either of these conditions applies, we have conducted further NEPA analysis and included it in the following section. Where possible and information is available, we provide discussions of how the below management actions could beneficially or adversely impact refuge resources:

- Increasing management and restoration of open, spring-fed wetlands for the purpose of benefiting the bog turtle under alternatives B, C and D.
- Consolidating habitats to create large, contiguous patches and to reduce fragmentation under alternatives B, C, and D.
- Eliminating hedgerows to reduce fragmentation under alternatives B, C, and D.
- Allowing natural succession of select areas of actively managed grassland and brushland habitats to forest under alternatives B and D.
- Allowing natural succession of select areas of actively managed grassland and brushland habitat, as well as open water habitat associated with Pools 3A and 3B, to maximize natural regeneration to forest or other late successional stage, while maintaining large contiguous patches of actively managed grasslands and brushlands under alternative C. Open water habitat within Pools 3A and 3B would be reduced by performing draw-downs and removing boards from water control structures.
- Increasing open water habitat within the existing impoundments to provide additional wildlife viewing opportunities under alternative D.
- Constructing a pond near the Visitor Center for wildlife observation and environmental education opportunities under alternative D.
- Using prescribed burning to manage grasslands and brushlands under alternatives B, C, and D.
- Expanding the Visitor Center's operational hours under alternatives B, C, and D.
- Creating additional trails along the Passaic River, within the "Black Brook Acquisition Area" (south of White Bridge Road) and at the WOC, and constructing wildlife observation viewing towers at the WOC and along Pleasant Plains Road under alternatives B and D.
- Creating additional trails east of Long Hill Road (south of Pleasantville Road and south of White Bridge Road) and west of Long Hill Road connecting to an existing management road; creating a Wilderness Area connector trail; permitting seasonal use of existing management roads by public on foot; and evaluating additional trail opportunities under alternative D.

- Expanding outreach, interpretation, and education programs to increase refuge visitation and to promote awareness about the refuge, its purposes, and the Refuge System under alternatives B, C, and D.
- Constructing additional pull-offs and parking opportunities under alternative B, and to a greater extent, alternative D.
- Expanding auto tour route from the Great Brook Bridge to the new Visitors Center under alternative B.
- Adjusting the hunt program by providing additional opportunities for disabled individuals, permitting fall archery season for deer hunting, and opening spring turkey hunting under alternatives B and D.
- Keeping the refuge open to the public during the spring turkey hunting season under alternatives B and D.
- Providing limited opportunities for fishing on the refuge under alternative D.

4.0.4 Adaptive Management Actions Common to All Resources

Adaptive management strategies are proposed for all management actions to mitigate uncertainties in information upon which the proposed activities are based. We propose continued and expanded monitoring, surveying, and inventorying of resources to ensure that we have sufficient scientific data, or have consulted with sufficient subject matter experts, to support our proposed activities affecting refuge resources. Where baseline data is lacking, we have proposed additional inventories. We propose continuing ongoing research and monitoring, including, but not limited to, bat emergence surveys, to help inform proposed management actions. We propose strengthening and expanding partnerships with agencies, universities, and other designated parties to help conduct these activities to address uncertainties and improve management practices (see chapter 3).

All of the alternatives include a renewed focus on gathering baseline information on refuge resources and monitoring resources to evaluate the potential impacts of climate change. The potential impacts of monitoring, surveying, and inventorying resources to the physical and biological environment are controlled and mitigated by SUPs that specify the research activities, locations, frequency of activities and limitations, such as seasonal or temporal timing restrictions to mitigate potential impacts. Generally, these activities have short-term and localized adverse impacts to physical and biological resources.

4.0.5 Organization of Chapter 4

We have organized this chapter by major resource headings so that each section describes the impacts of all management activities proposed under each of the four alternatives that would likely have an effect on a given resource, such as an impact on water quality or on waterfowl. We begin with the physical environment (air, water, soils, etc.), then the biological and ecological resources (habitats and wildlife), and finally the socioeconomic, cultural, and historic environment. Under each heading, we discuss the resource context and the types of benefits and adverse impacts of management actions that we evaluated. We then discuss the benefits and adverse effects that would occur regardless of which alternative is selected and the benefits and adverse impacts of each of the CCP alternatives.

4.1 Impacts on Air Quality

Chapter 2, "Existing Environment," discusses the status of air quality around the refuge. Given the heavily suburbanized nature of the surrounding area, the analysis of air quality impacts considered only how FWS actions at the refuge might affect air pollutants, visibility, and climate change, focusing on the potential for localized air quality impacts or improvement.

We evaluated the potential benefits of our actions that would protect or improve air quality:

- Managing and restoring forests and wetlands to enhance carbon sequestration and reduce greenhouse gases.
- Decreasing emissions by consolidating actively managed habitats into large, contiguous patches and allowing natural regeneration of small, isolated, or difficult to manage patches, which will reduce heavy equipment use and associated emissions.
- Continuing and expanding energy efficiency practices to reduce the refuge's contribution to emissions.
- Managing and restoring forests to enhance carbon sequestration and reduce greenhouse gases.

We evaluated the potential for the proposed actions to cause increased emissions and adverse effects on air quality:

- Emissions from increases in visitors from vehicles and facilities.
- Increasing Visitor Center hours.
- Maintaining the existing impoundments and potential impacts from emissions of methane from the impounded area.
- Use of prescribed burns.

4.1.1 Impacts on Air Quality That Would Not Vary by Alternative

Due to the refuge's location within the greater New York-New Jersey Metropolitan Area, we believe that the impacts of refuge management on regional air quality would be negligible, but slightly positive overall, and would not vary significantly under any of the alternatives. Refuge land management, regardless of alternative, would be expected to have a net positive effect on air quality.

Benefits

Our management activities are not anticipated to adversely affect regional air quality. None of the alternatives would violate EPA standards and all alternatives would comply with the Clean Air Act. There would be no major stationary or mobile sources of air pollutants at the refuge created under any of the refuge management alternatives. On the contrary, the FWS limits public uses of the refuge to compatible wildlife-oriented activities, and land ownership and protection curtails human sources of emissions from vehicles and infrastructure by preventing development and consequent impacts to air quality.

Maintaining natural vegetation on approximately 98 percent (includes impoundments; excludes administrative, residential, transportation/utilities, and open water) of the refuge and promoting the growth of woody vegetation on previously managed fields would provide various benefits to air quality. Trees have been shown to reduce the concentration of the five air pollutants identified in the EPA's 1990 NAAQS (40 CFR part 50), including ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter less than 10 and 2.5 microns in diameter, primarily through direct uptake and adhesion to stems and leaves (Escobedo et al. 2007).

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As discussed in chapter 3 (see alternative C, objective 5.3), forests can store carbon in a process known as carbon sequestration in which atmospheric CO_2 is taken up by plants through photosynthesis and incorporated as carbon into the biomass (trunks, branches, foliage, and roots). Some carbon makes its way into soils when vegetation, litter, and roots decay. In forests, carbon can be sequestered over decades or even centuries until mature ecosystems reach carbon saturation. Carbon can return to the atmosphere as CO_2 when soils are disturbed or when biomass decays and burns (EPA 2010). Forests in the Northeast can sequester from 12 to 20 percent of current annual emissions from the region (Perschel et al. 2007). Approximately 6.8 billion tons of carbon is stored in the Northeast's forests. On average, forestland holds about 75 tons of carbon per acre, of which 38 percent is alive aboveground carbon, 8 percent is alive belowground carbon, 6 percent is in dead wood, 10 percent in litter, and 38 percent is in soil organic material (Perschel et al. 2007).

Managing and restoring forests would benefit air quality in a number of ways. Long-term benefits of restoration are healthier native plant communities that would perform more ecological services, support a greater number and diversity of wildlife year-round, and sustain or improve carbon sequestration capacity. Wetlands and forests both act as carbon sinks by incorporating decaying vegetation into sediment and trees, respectively. Wetlands can also produce methane, a greenhouse gas, but overall there is a net long-term benefit to air quality. Management activities in these habitats, such as removing and controlling invasive plants that suppress regeneration, will contribute to improvements in habitat quality and carbon sequestration capacity. These activities would occur no matter which alternative is selected, but the degree to which we practice them would vary, and thus, their impacts. Because of the urbanized nature of the region and the close proximity of heavily travelled roadways, we do not expect our management actions to result in measurably improved regional air quality, but they would contribute to improving local air quality.

As discussed in section 3.2 (alternative A, introduction and objective 5.3), the refuge will continue to use, expand, and promote the benefits of green technology. Use of green technology will make the refuge more energy efficient, thereby reducing the refuge's carbon footprint and providing long-term cost savings.

Refuge greening includes:

- the refuge headquarters administrative building oil furnace and air conditioning were replaced with a heat pump, that has an electric back up system (2012)
- all interior lights were replaced with efficient lighting using sensors and timers (2012)
- the electrical system was designed to add roof solar panels (expected installation in 2013 or 2014)
- Visitor Center roof solar panel design was completed (expected installation by 2014)
- the refuge plans to convert Visitor Center furnaces from oil to natural gas (2014)
- plans to replace maintenance shop oil furnace with heat pump
- 25 percent of station vehicles are hybrids and more to be added when replacements occur (currently)
- an electric powered "Gator" UTV is used on refuge (currently)
- bio-diesel is used in refuge equipment and eco-friendly anti-freeze is used when manufacturer specifications permit (currently)
- recycling of paper, cardboard, metal, plastic, glass, electronic equipment, used oil, automotive batteries
- scrap metal is recycled (currently)
- hazardous materials are properly disposed (currently)
- purchase products made from recycled materials [e.g. paper products (copy paper, cups, towels), plastic (deck lumber, park benches)] (currently)
- approximately 1.0 mile elevated swamp boardwalk trail has been constructed with recycled material (currently)
- plan to replace asbestos shingle roofing on buildings with more durable and recyclable metal roofing when replacement occurs (unknown timing).

Adverse Impacts

The most likely sources of adverse impacts to air quality from the refuge would come from exhaust fumes produced by heavy equipment and emissions from increases in visitor vehicle traffic and increased energy consumption needed for extended facility hours. In FY 2012, an estimated 168,000 individuals visited the refuge. Approximately 91 percent of these visitors arrived using a private vehicle (USGS 2011). Assuming an average of three visitors per vehicle, an estimated 50,960 private vehicles are currently entering the refuge annually. Approximately 79 percent of refuge visitors live within a 50-mile radius of the refuge (USGS 2011). The increased numbers of visitors would be very small relative to the amount of daily traffic in the area on local roads and interstate 287; therefore the overall impacts to air quality would be negligible.

Under each alternative, the refuge would continue to use IPM methods to control invasive plants, pests, and diseases. IPM is a science-based, sustainable approach to pest management that uses a wide variety of tools including biological, mechanical, cultural, and chemical methods to achieve desired outcomes in ways that minimize health, environmental, and economic risks (569 FW 1). In certain instances, chemical control is the safest and most effective treatment option. When chemical control is warranted, the refuge typically applies general use pesticides on the “Field Station Approval List” as higher-risk pesticides are generally not necessary and require either Regional Office or Headquarters approval. We must request approval, through a Pesticide Use Proposal (PUP), for all chemical control applications on the refuge. The PUP process includes section 7 consultation for endangered species. The Refuge Manager, Regional IPM Coordinator, and National IPM Coordinator have the authority to approve pesticides and their application procedures. In addition to FWS policies, all pesticide usage must also comply with applicable Federal

(FIFRA) and state regulations. Aquatically-labeled products are used in wetland areas to protect water quality. In recent years, only glyphosate and triclopyr ester herbicides have been used.

The volatilization rate (ability to vaporize) of glyphosate is nearly non-existent (Schuette 1998). Studies indicate a high potential for volatilization of triclopyr (NPS 2010). Triclopyr dissipates quickly in the environment, however, with a mean time to 50 percent dissipation of 1.5 days and 9 days to 90 percent dissipation (Thompson et al. 1994). Aerial drift of mists of these chemicals during application has the potential to cause negative impacts to non-target plants (Schuette 1998); however the methods discussed below ensure that negative impacts from drift would be very localized, short-term and negligible to the vegetation community.

When using pesticides on the refuge, we observe best management practices (BMP) and application methods that minimize drift and non-target mortality, such as cut stem, “snip and drip,” basal bark, or low-volume foliar applications with backpacks. BMPs are effective, practical, structural, or nonstructural methods that minimize or prevent the movement of sediment, nutrients, pesticides and other pollutants from land to air or water. Examples of BMPs for pesticide application include proper calibration of application equipment, following all label restrictions including the timing of applications, and creating pesticide-free buffers around environmentally sensitive areas. Pesticides used on the refuge are typically applied by hand within a few feet of ground level and only when wind speed at application level is below the drift threshold. When applied in this way, there is little to no impact on air quality. Using the BMPs mentioned, drift and other non-target impacts have been negligible. Furthermore, proper selection of herbicides and application methods has eliminated the need for repeat treatments thereby reducing the quantity and cost of herbicide usage and the potential for cumulative effects.

Because air quality in the region is generally “good” (refer to section 2.1.8), we do not expect our management to result in measurably improved air quality; however, our management efforts should contribute to the existing satisfactory conditions. Most noticeable improvements to air quality would be localized in nature.

4.1.2 Impacts on Air Quality under Alternative A (Current Management)

Benefits

Benefits to air quality are the same as those discussed in *Impacts on Air Quality That Would Not Vary by Alternative*.

Adverse Impacts

Adverse impacts to air quality would be the same as those discussed in section 4.1.1, *Impacts on Air Quality That Would Not Vary by Alternative*.

4.1.3 Impacts on Air Quality under Alternative B (FWS-Preferred Alternative)

Benefits

Under alternative B there would be continuing benefits to air quality from maintaining the natural vegetation on the majority of refuge lands. Natural vegetation serves to filter air pollutants, and maintaining refuge lands precludes development and the introduction of attendant sources of pollutant emissions. Alternative B would provide some additional long-term benefits to the air quality by allowing 169 acres of currently managed grassland and scrub-shrub fields to succeed by natural regeneration. This alternative also

proposes to increase monitoring and removal of invasive plants in all habitat types. The management actions proposed under alternative B would contribute to improvements in habitat quality and carbon sequestration capacity.

In this alternative, we would reduce the amount of grassland and brushland management and consolidate these habitats into fewer, but larger, contiguous tracts and decrease the amount of cover that is subjected to mechanical treatment. We expect the consolidation of management units will reduce the use of heavy equipment for mechanical treatments by 5 to 10 percent annually leading to corresponding reductions in fuel consumption and exhaust emissions. This would provide negligible long-term impacts.

Adverse Impacts

Based upon our proposed increase in outreach efforts to communities in the region and proposed additional Visitor Center hours, we expect a 2 percent average increase in visitation per year over the life of the plan. Given the suburban to urban area surrounding the refuge, anticipated increase in visitation and the associated emissions from travel to and from the refuge is expected to have negligible impacts on air quality.

The refuge's Visitor Center is currently open Thursday and Friday from noon until 4 p.m. and Saturday and Sunday from 10 a.m. until 4 p.m. The refuge proposes to increase operational days to 7 days per week year round. Monday through Wednesday have traditionally not been high public use days, however, and we expect opening on these additional days will result in a slight increase in visitation of between 1 to 2 percent on average per year over the life of the plan. This change in operational hours will result in a minor increase in energy consumption and the refuge's carbon footprint; however, given the urban context of the region, the expansion of operational hours is expected to have negligible impacts on air quality. In addition, an increase in energy use may be offset by the continued and expanded use of green technology.

Under this alternative, there would be temporary, short-term impacts to air quality from equipment exhaust and particulates from soil disturbance associated with the habitat restoration and reconfiguration efforts. These are temporary in nature and would most likely be offset by reduced grassland and brushland acreage maintained by mowing or cutting.

Under alternative B, we propose to introduce prescribed burning for habitat management, when and where appropriate and compatible. Prescribed burning is a cost-effective and ecologically sound tool for forest, range, and wetland management, and is often used to reduce the potential for destructive wildfires, which maintains long-term air quality. Prescribed fires removes logging residues, controls insects and disease, improves wildlife habitat and forage production, increases water yield, maintains natural succession of plant communities, and reduces the need for pesticides. Prescribed burning may be implemented in conjunction with mowing to maintain smaller scale grasslands. Under this alternative, a maximum of 200 acres of grassland with some shrub component would be burned on a rotation of every 2 to 5 years within the refuge.

The major air pollutant of concern resulting from prescribed burning is smoke, which consists of a complex mixture of carbon, tars, liquids, and various gases. The other major pollutants from wildland burning are particulate matter (dust, ash, and unburned fuel), carbon monoxide, and volatile organic compounds, including methane. Particulate matter can reduce visibility or cause negative effects on the health of people with respiratory illnesses.

For prescribed burns on grassland in the Northeast, emission rate estimates of particulate matter (PM) are 10 grams per kilogram (g/kg) burned and 75 g/kg for CO (USEPA 1996). Nitrogen oxides are emitted at rates from one to four g/kg, depending on combustion temperatures. Emissions of sulfur oxides are negligible (USEPA 1996). These pollutant emission levels are generally less than levels expected in prescribed burns of woody vegetation habitats of the northeast (USEPA 1996).

As part of this prescribed burn, a burn plan that follows USEPA standards (1998) would be in place; the plan will evaluate emissions and potential air quality impacts in detail. These emissions would be projected for the life of the plan. Because there is no record of any historic burns in recent history, the plan would not consider past emissions or impacts from fire. The emission predictions would incorporate pre-burn fuel loading by acreage, vegetation type and consumption and all other relevant factors. The plan would also set appropriate conditions for burns (moisture levels, wind speed and direction); identify sensitive receptors within the refuge region (which would include local residences and other populated areas); evaluate short term impacts and management of smoke; and incorporate ambient air monitoring plans and air station location data (when appropriate); and address all other relevant environmental and geographical factors.

In addition to being a cost-effective and ecologically sound tool for forest, grassland, and wetland management, prescribed burning is often used to reduce the potential for destructive wildfires, which actually maintains long-term air quality. The relative small scale and type of vegetation proposed to be burned combined with careful management and planning will result in a prescribed burn that will not significantly adversely affect regional air quality. The prescribed burn we propose will not violate EPA standards, and would comply with the Clean Air Act. The USDA has determined that this type of low intensity prescribed burning would release inconsequential amounts of gases (USDA 1989).

4.1.4 Impacts on Air Quality under Alternative C

The benefits and adverse impacts of alternative C would be similar to those discussed under *Impacts on Air Quality under Alternative B* in section 4.1.3 with the exception of minor increases in carbon sequestration expected based on net forested or woody vegetation habitat increases within the refuge. All differences among alternatives in air quality due to atmospheric carbon storage would be negligible in the regional or global context.

Benefits

This alternative would provide some additional very minor or negligible long-term benefits to air quality by allowing approximately 323 acres of currently managed grasslands and scrub-shrub to succeed to forest via natural regeneration. In addition, pools 3A and 3B, encompassing approximately 129 acres, would also be allowed to succeed to naturally-occurring marsh or shrub swamp plant communities.

Current information regarding carbon storage and methane production potential of wetlands is highly uncertain and varies based on wetland location and type (Bridgham et al. 2007; USEPA 2010b). We would; however, expect some additional minor long-term net benefit to air quality based on some increased carbon sequestration capacity in our expanded forest and shrub communities. As discussed in chapter 3, objective 5.3; forests in the Northeast can sequester from 12 to 20 percent of current annual emissions from the region (Perschel et al. 2007). Each acre of forestland sequesters about 75 tons of carbon in above (woody vegetation) and below ground (organic soil) storage, and dead wood (Perschel et al. 2007).

We are uncertain if the refuge impoundments act as a net source, or sink, for greenhouse gasses in the atmosphere. If these impoundments do act as a source, restoration of forests could reduce emissions of methane, a powerful greenhouse gas. Regardless, given the relatively small size of refuge impoundments regionally and globally, it is not expected to be a significant source of methane and differences would be short-term, localized, and negligible.

4.1.5 Impacts on Air Quality under Alternative D

Benefits and adverse impacts to air quality of alternative D would be similar to those discussed in section 4.1.3, *Impacts on Air Quality under Alternative B,* except this alternative seeks to increase visitation and program participation. An increase in visitation may elevate associated emissions from travel to, from, and within the refuge; however, given the urban context of the refuge, this increase is expected to have negligible impacts on air quality.

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Benefits

Under this alternative, marketing efforts or increased outreach or programming would generally target the local (NYC metropolitan) population. The majority (currently 79 percent) of refuge visitors will continue to travel from the same 50 mile radius (see section 4.2.1). As a result, we would not expect additional adverse air quality impacts due to increased visitor traveling distances.

Adverse Impacts

Based on 2012 private vehicle numbers (see section 4.2.1), the 2 percent increase in visitation expected under alternative B equates to an estimated increase of 1,139 to1,480 private vehicles entering the refuge each year. If annual visitation increases under alternative D were to double to 4 percent, the result would be an estimated increase of 2,278 to 2,960 private vehicles per year for the duration of this CCP. Under each of these scenarios, the traffic generated by the increased numbers of visitors would be very small relative to the amount of daily traffic in the area on local roads and interstate 287. As a result, the overall impacts to regional air quality from private vehicles would remain negligible under this alternative.

There are variables that may further negate adverse impacts to air quality resulting from increased refuge visitation. Improvements to vehicle fuel efficiency and emissions may offset some of the air impact associated with the visitation increase. Under alternative D, increased outreach efforts by the refuge to promote green technologies, use of public transportation, fuel efficiency, and carbon storage, may further help to mitigate air quality impacts resulting from visitation.

Any adverse regional air quality impacts directly related to construction activities from equipment or vehicles would be negligible. The short duration of construction activities (including observation tower

construction and visitor center improvements) and the limited amount of planned construction relative to the surrounding region would make these impacts undetectable on a regional scale. Some short-term, localized impacts may result from construction vehicle use. These can be mitigated through a number of measures including increased use of green technologies and strict adherence to BMPs during construction.

4.2 Impacts on Soils

Chapter 2, "Existing Environment," discusses the geologic history of the Piedmont Province and the soils of the refuge. Soils are the structural matrix and nutrient source for plant productivity and must be protected to sustain the variety of upland and wetland habitats that would meet refuge habitat and species management goals.

We evaluated the potential benefits of our proposed actions that would conserve, restore, and improve soils:

- Limiting sources of sediment by maintaining forest and other vegetative cover thereby preventing erosion.
- Allowing natural regeneration of select grassland and brushland fields, which reduces soil disturbance caused by mowing activities, to maintain carbon sequestration in soils.
- Using prescribed burning as a management tool, which will increase soil fertility and site productivity.

We evaluated the potential for the actions proposed to cause adverse effects on soils:

- Disturbing soils during non-regular refuge maintenance activities, which promote the spread of invasive plant species.
- Impacting soils by pesticide application, mowing, and invasive plant management.
- Disturbing soils during construction projects, including trails and parking lots.
- Increasing visitation and expanding the six priority public uses.

4.2.1 Impacts on Soils That Would Not Vary by Alternative

Based on the land use history, existing conditions, and current management of the refuge, we believe that the impacts of refuge management on soil structure and productivity would be negligible and would not vary significantly under any of the alternatives. The refuge's soils consist of heavy clays and are, therefore, not greatly susceptible to soil compaction. We predict that refuge land management, regardless of which alternative is selected, would be expected to have a net positive effect on soil quality. The following management actions would benefit or impact soils under all alternatives dependent on the scale, frequency, and duration of these activities and the sensitivity of the soils to erosion and compaction.

Benefits

Promoting intact forest cover and restoring forests and natural hydrology would benefit soil quality and help restore soil structure and improve the biological productivity of soil. By restoring the natural vegetation and hydrology, we encourage the natural physical, chemical, biological weathering and other soil-formation processes. Overall, the protection, maintenance, and restoration of habitats on the refuge are expected to benefit soils. Restoration projects would consider natural landform and transitional zones with project designs in order to replicate transitional soil characteristics, soil stability, and hydrology.

Increasing public awareness of soil erosion and the ways people can reduce soil erosion would continue to be part of environmental education and interpretation programs, including the benefits of conservation landscaping.

Adverse Impacts

Under each alternative, we propose to continue to manage select grassland and brushland fields through rotational mowing and cutting, although the acreage and location of managed fields would vary under each alternative. Rotational mowing and cutting could result in soil compaction though the refuge uses low ground pressure equipment whenever possible to minimize such impacts. Timing of these management actions are also considered to minimize any adverse impacts, e.g. fields are mowed in the fall when ground conditions tend to be dry and firm (after nesting season, most herptiles are absent, fall blossoms have past and pollinators absent); brush and forest mowing is scheduled in winter when vegetation is dormant and ground likely to be frozen.

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Currently, the refuge maintains approximately 7.5 miles of gravel roads, including 1.3 miles of Pleasant Plains Road and 6.9 miles of management roads, and 1.1 mile paved section of Pleasant Plains Road to facilitate refuge management activities and recreational access for visitors (by foot, bicycle, vehicle, or special access for visitors with disabilities). Several municipal and county paved roads also traverse the refuge. Although the gravel roads are pervious to precipitation, they do cause the compaction of soils and the loss of vegetation. Gravel access roads are generally located around the impoundments or provide access to administrative grasslands (i.e., remediated landfills). Maintenance of access roads, grading to minimize storm water erosion, and repairing soil erosion are done on an as needed basis. No new roads are proposed under any alternative.

We also maintain approximately 8.5 miles of primitive trails in the Wilderness Area. Trail maintenance in the Wilderness Area is limited to non-mechanical and non-motorized techniques. Bicycles are prohibited in Wilderness Area by law as a form of mechanical transportation. Horseback riding, though not banned by law, would continue to be prohibited due to the disproportionate damage caused by horses to the soft, wet soils underlying wilderness trails.

Public use impacts to soil, including those associated with short, relatively high participation events like the deer hunt or World Series of Birding, have not been observed on the refuge. However, trampling and the resultant loss of porosity, aeration and nutrient availability through soil compaction are commonly associated with high levels of public use (Roovers et al. 2004, Bell 2002). We regularly monitor trails and

roads and have not observed any major impact areas resulting from wildlife observation, photography, environmental education, or interpretive uses. Public use trails, wildlife observation areas, parking areas, and other high use areas are designed and maintained to minimize impacts on soils. We monitor parking and other concentration areas and have not observed excessive soil impacts. Maintenance of access roads, trails, and other facilities could cause negligible short-term, localized soil compaction and erosion. These activities would occur to some degree no matter which alternative is selected. We would continue to use BMPs to minimize any potential adverse impacts.

As discussed above under section 4.1, *Impacts to Air Quality*, herbicidal applications could also be a potential source of impacts to soil; however, we follow the PUP process and use the BMPs described in the Air Quality section to select pesticides that have less mobility or persistence in soils and generally use only highly-targeted direct application methods. The typical half-life of glyphosate in soil considered to be approximately 47 days (Vencill 2002); however, the half-life may range from 2 to 197 days (Giesey et al 2000) depending on climate conditions. The chemical absorbs tightly to soil and is generally considered immobile in soils. It primarily degrades by microbial action in the soil (Roberts 1998). Glyphosate degrades into two weak acids of low toxicity, Aminomethylphosphonic acid and glyoxlic acid, both of which ultimately degrade into carbon dioxide (Roberts 1998). Regarding, triclopyr, numerous studies have shown that it dissipates rapidly in the environment (Thompson et al. 1994; Berisford et al. 2006; Johnson et al. 1995; Petty et al. 2001). Based on their relative immobility and rapid degradation in soil, as well as their limited and careful application at the refuge, it is expected that adverse impacts to soil would be negligible, short-term and localized.

Under each alternative, the refuge may construct a new Headquarters facility, Visitor Center additions, and associated parking which would cause negligible short-term, localized disturbance to soil. These activities would occur to some degree no matter which alternative is selected. During the construction of these structures and associated parking lots, some upper layers of soils would be disturbed and compacted. BMPs and sediment and soil erosion controls will be implemented to minimize the release of sediments and soil erosion into environmentally sensitive areas, such as wetlands and waterbodies. Such practices would include the scheduling of construction to avoid periods with high erosion potential; preservation of natural features, slopes, and vegetation to the greatest extent possible; use of silt fencing, sediment traps, geotextile mats, or mulch; and prompt stabilization with native vegetation. Staff and contractors would be trained in the use of these BMPs.

4.2.2 Impacts on Soils under Alternative A (Current Management)

Benefits and adverse impacts on soils under alternative A would be the same as those described under section 4.2.1, *Impacts on Soils That Would Not Vary By Alternative.*

4.2.3 Impacts on Soils under Alternative B (FWS-Preferred Alternative)

Benefits

Alternative B would potentially improve soils by allowing natural regeneration to occur on approximately 169 acres of grasslands and brushlands, which are currently managed by rotational mowing and cutting. The areas allowed to succeed would no longer be subjected to soil compaction from heavy equipment. Succession to forest would potentially and improve soil conditions by restoring organic layers and biota that were previously impacted by farming or other disturbances.

As discussed in chapter 3, forests can play an important role in mitigating climate change by naturally removing carbon out of the atmosphere, a process known as carbon sequestration (Perschel et al. 2007). Carbon sequestration or storage occurs in forests and soils primarily through photosynthesis in which atmospheric CO_2 is taken up through tiny openings in leaves and incorporated as carbon into the plant's biomass (trunks, branches, foliage, and roots). Carbon can return to the atmosphere as CO_2 when soils are disturbed or when biomass decays and burns (USEPA 2010a). On average, each acre of forestland sequesters about 75 tons of carbon per acre of which 38 percent is in soil organic material (Perschel et al. 2007). Promoting natural regeneration (increase in forest cover) and reducing soil disturbance will therefore promote carbon sequestration on the refuge.

Soils will also be improved in areas where prescribed burning is used as a management tool. Although the relationship between fire and soil nutrients is complex, some generalizations can be made. Fires typically result in a reduction of fuel and the amount of organic soil nutrients present (nutrient pool), increase soil nutrient turnover rates, and redistribute nutrients through the soil profile. Post-fire soil nutrient dynamics and site productivity is most often determined by the intensity of the fire. High intensity fires typically decrease nutrient pools and site productivity more than low intensity fires. Low intensity fires can actually increase site productivity, as well as soil fertility (Forest Encyclopedia Network 2008). In order to perform a prescribed burn, specific weather and site conditions are required to control the extent and intensity of the fire, manage smoke, and maintain the burn within "prescription." Prescribed burns are generally low intensity fires that attempt to minimize the chance of an uncontrolled, high intensity wildfire in the future and are conducted to improve wildlife habitat, vegetation structure, and soil fertility.

Adverse Impacts

Disturbance of soils will occur during the reconfiguration of habitat patches (specifically, cutting of vegetation to regress to earlier successional stages) and the removal of hedgerows. Disturbance to soils during these activities would be minimal and temporary in nature. The use of BMPs, including soil erosion controls would be implemented to minimize the release of sediment into environmentally sensitive areas, such as wetlands and waterbodies.

Alternative B also proposes construction of additional facilities, including two observation towers, parking lots and pull-offs, additional trails, and other small improvements. During the construction of these structures, trails, and parking lots, some upper layers of soil would be disturbed and compacted. BMPs and soil erosion/sediment control plans will be implemented to minimize or prevent soil erosion and sediments entering wetlands and waterbodies. Such practices would include the scheduling of construction to avoid periods with high erosion potential; preservation of natural features, slopes, and vegetation to the greatest extent possible; use of silt fencing, sediment traps, geotextile mats, or mulch; and prompt stabilization with native vegetation. Staff and contractors would be trained in the use of these BMPs.

Activities associated with providing increased hunting opportunities have the potential to adversely impact refuge soils. Soils can become compacted and eroded as a result of continued foot traffic, and soils associated with wetland habitats have been rated as either high or very high in their potential for compaction (Bell 2002). However, impacts on soils from hunters will be minimal. The use of ATVs, which can cause soil erosion, is not permitted. The increased foot traffic prior to entering off-road hunting sites should not significantly impact soils because the trails in the Wilderness Area were constructed in areas that are not subject to high levels of erosion, and the boardwalks and gravel roads in the Management Area provide low impact travel routes. Additionally, impacts from off-trail foot traffic by hunters also are expected to be minimal due to the low number of hunters allowed on the refuge and the short duration of the hunts.

Hunters tend to disperse themselves and due to the nature of hunting on the refuge, once dispersed, most hunters remain stationary in a portable tree stand or on the ground. Hunters going off-trail often follow existing deer trails, but in areas where new vegetation is trampled, effects likely will be temporary. The soils throughout the refuge (predominantly poorly drained silt loam, stratified lacustrine sand, silt, and clay) by nature allow vegetation such as grasses, legumes, wild herbaceous plants, hardwoods and coniferous trees to recover rather quickly (NRCS 1976). Additionally, the archery hunt will occur during the dormant season; in general, impacts to soils are greater during the growing season than the dormant period due to the greater soil moisture content at that time of year.

4.2.4 Impacts on Soils under Alternative C

Benefits
The benefits of alternative C would be similar to those described in section 4.2.3, *Impacts on Soils under Alternative B*. However, this alternative emphasizes maximizing natural regeneration; therefore, the biological function of soils may improve as a result of succession and restored hydrology. Succession to forest would potentially restore historic soil profiles that were previously farmed, removed or filled.

Adverse Impacts
The adverse impacts of alternative C would be the same as those described in section 4.2.3, *Impacts on Soils under Alternative B*.

4.2.5 Impacts on Soils under Alternative D

Benefits
The benefits of alternative D on soils would be similar to those described under *Impacts on Soils under Alternative B.*

Adverse Impacts
The adverse impacts of alternative D would be similar to those described under section 4.2.3, *Impacts on Soils under Alternative B*; however, this alternative proposes the construction of additional facilities, including parking lots and additional trails. During the construction of these facilities, some upper layers of soils would be disturbed and compacted. BMPs and soil erosion/sediment control plans will be implemented to minimize or prevent soil erosion and sediments entering wetlands and water bodies.

4.3 Impacts on Hydrology and Water Quality

The alternatives we propose will have a neutral or net benefit to hydrology including water quantity and quality. No alternative we propose will negatively impact the hydrological benefits of the refuge's diverse vegetation communities. These communities act as riparian buffers that slow velocity of water entering the swamp, regulate surface water temperatures, increase dissolved oxygen (DO) levels, and filter contaminants. There are no activities that would measurably disrupt groundwater discharge or recharge or lead to a net increase in runoff on the refuge property. All alternatives include proper management and mitigation of potential hydrological impacts, such as strict control of herbicide use and minimization of impervious surfaces.

Hydrology of Great Swamp has been altered over the years through repeated attempts of ditching, draining, and stream alteration. In the 1960s, after the refuge was established, refuge staff began plugging

some of the previously constructed drainage ditches to restore previously drained wetlands. Also, several low dikes with water control structures were constructed to restore and enhance wetland habitats. Five major impoundments, encompassing a total of approximately 480 acres, were constructed in the 1970s and early 1980s in order to improve wetland wildlife habitat and influence plant composition and abundance. In the past, water levels in these impoundments were actively manipulated to create short- and long-term hydrological fluctuations (i.e., flooding and drought cycles). Water levels are currently maintained and only drawn down periodically (every 7 years) to mimic a natural drought cycle, which results in significant germination of annual plants and high seed production.

Water quality and quantity entering the refuge has been impacted by development and land use changes throughout much of the GSW. For the past 30 years, Great Swamp NWR has been involved in regional efforts to improve water quality with surrounding municipalities (see section 2.1.4, Water Quality and Quantity).

We evaluated the potential benefits on hydrology and water quality as a result of potential management actions under each of the alternatives:

- Restoration, expansion and maintenance of spring-fed emergent wetlands for bog turtle.
- Consolidation and maintenance of forests, scrub-shrub, grasslands, open water, and wetlands.
- Improving aquatic wildlife habitat for priority species by restoring natural hydrologic conditions in some impoundments.
- Controlling invasive species infestations.
- Increasing public awareness through the expansion of environmental interpretation and wildlife-dependent recreation.
- Increasing visitor and public awareness through continued and expanded partnerships, environmental education, and interpretation to benefit water quality and hydrology.

We evaluated the potential for the proposed actions to cause adverse effects on hydrology and water quality:

- Impacts to water quality due to increases in visitation.
- Impacts to water quality from the six priority public uses, including the addition of fishing and expansion of other uses.
- Impacts from the expansion of open water in impoundments via raising water levels to improve wildlife viewing opportunities.
- Impacts from introduction of non-wildlife-dependent activities, such as kayaking and canoeing.
- Impacts on water quality from the construction and management of public use facilities, including observation towers, buildings and trail expansion.

- Impacts due to changes in the management of impoundments.
- Impacts resulting from invasive plant species control, including the use of pesticides.
- Larger scale routine management activities, such as rotational mowing of fields, and facilities maintenance.

4.3.1 Impacts on Hydrology and Water Quality That Would Not Vary by Alternative

The hydrology of Great Swamp NWR is complex due to the convergence of five major surface waters (Passaic River, Black Brook, Great Brook, Primrose Brook, and Loantaka Brook) and multiple groundwater inputs that feed the refuge and the surrounding area. The refuge is situated in the lower receiving end of its 55 square mile watershed. All of one and parts of nine other municipalities in Morris and Somerset Counties make up the watershed. Much of the Great Swamp NWR hydrology is fed by offsite influences over which the refuge has limited control.

The impacts of nonpoint sources from surrounding development are reflected by the moderate impairment ratings of associated streams within the vicinity of Great Swamp NWR. Much of the impact of these streams is related to suspended solids, depleted DO depletion, presence of *E. coli*, and temperature issues (see chapter 2, section 2.1.4, AMNET monitoring and 303d lists). The refuge has worked closely with the surrounding communities and conservation partners for more than two decades to preserve the ecological integrity of the refuge and its watershed; however, the refuge is still very much subject to issues of water quality and quantity due to land use changes within the watershed.

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Benefits

Much of the Great Swamp NWR's vegetated landscape provides a riparian buffer along the complex of streams that pass through the refuge. The refuge's expansive forests, scrub-shrub, and emergent wetlands and riparian buffers slow velocity of water entering the swamp via stream systems and sheet flow occurs when streams overflow. As discussed in chapter 3, wetlands, in general, are critical natural resources because they perform a variety of important functions, including improvement of water quality through nutrient cycling, prevention of shoreline erosion, flood attenuation, and groundwater recharge, among various other functions (Balzano et al. 2002). The refuge's native aquatic and wetland vegetation helps mitigate the impacts of temperature, DO, total suspended solids (TSS), and *E. coli* by providing a filter of vegetation. Riparian buffers and wetlands trap and hold suspended solids and increase DO levels in refuge waters. A lack of consolidation of grassland and scrub-shrub habitats under alternative A may result in less soil and vegetation disturbances associated with hedgerow removal and other management activities and therefore, less hydrological impacts in the short term.

The refuge's vegetation communities help maintain lower water temperatures by providing shade and filtering contaminants and sediment from the waterbodies that pass through it. The refuge's role in this capacity is particularly important given its urban regional setting. Great Swamp NWR contains more than 5,000 acres of bottomland forest, which provides the greatest ecological benefit to the region in the form of shallow groundwater recharge, water quality, flood control and storage, nutrient and pollutant uptake, and soil stabilization. There is little, if any, groundwater recharge to deep aquifers due to the predominate thick clay layers present at the refuge; however, groundwater recharge to shallow aquifers does occur. Riparian forest also helps prevents bank erosion and increases the water's capacity to retain DO.

Refuge impoundments provide a variety of habitats suitable for feeding, nesting, brooding, and resting habitats for migratory birds and resident wildlife. Periodic drawdowns will continue to be performed to mimic a natural drought cycle and allow replenishment of vegetation and foraging opportunities for wildlife, such as migratory waterfowl, shorebirds, wading birds, and turtles. The five impoundments are connected through a series of low-level dikes and water control structures for varying the water levels. Vegetation, including oak spp., buttonbush, smartweed, cattail, bulrush, arrow arum, and pickerel weed is interspersed throughout the impoundments and provides excellent waterfowl habitat, especially for wood ducks. In the past, summer partial drawdowns were carried out on all five impoundments. For example, for Pool 1, the purpose of one of the drawdowns was to increase vegetative diversity and abundance through the rejuvenation of buttonbush, live timber, and emergent aquatics; in Pools 2, 3A, and 3B, drawdowns were to initiated to rejuvenate live timber and accelerate the partial drawdown of Pool 1; and in Middle Brook, drawdowns were initiated to enhance the growth of smartweed. In general, periodic drawdowns provide maximum feeding potential for migratory waterfowl in the spring and fall; lower water levels encourage growth of preferred waterfowl food, while normal operating levels provide suitable feeding areas for spring and fall migrating waterfowl. Additionally, drawdowns create quality breeding and brood habitat for waterfowl by enhancing the growth of emergent aquatics, which provide both food and cover.

Many of the existing outreach, education and interpretive programs and partnerships that are in place focus on watershed and water quality improvement. Great Swamp NWR and its watershed partners have been instrumental in promoting local ordinances which helped preserve the ecological integrity of the refuge and its watershed (see chapter 2, section 2.1.4 for details). These established partnerships and programs will continue in varying degrees under all alternatives.

Monitoring, maintenance, and restoration of spring-fed emergent wetlands for bog turtle will help improve water quality and hydrologic stability. The continued identification and management of invasive species at the refuge is also important as they pose a direct threat to refuge habitats, wildlife populations, and ecological functions. Invasive plant infestations, such as *Phragmites australis* for example, can quickly transform healthy, biodiverse communities into monotypic stands with reduced value for wildlife (Auclair et al. 1973; Hansen et al. 1998; Benoit and Askins 1999). Invasive aquatic plant infestations can negatively impact aquatic ecosystems by reducing DO levels (Caraco et al. 2006), altering water temperature, and reducing light availability (Angeloni et al. 2006). Some invasive species, when left uncontrolled, can rapidly change the hydrology of wetlands. For example, purple loosestrife is capable of altering hydrological and biochemical processes in wetlands, and may result in increased sedimentation and alteration of flow within wetlands (Lythrum salicaria Working Group, 2004).

Adverse Impacts

Although this will vary under alternatives, all alternatives include the continued mowing and cutting of managed patches. The maintenance of these habitats, particularly wet habitats, will result in some short-term, localized, and minor impacts to soils and water from the use of machines in soft, wet substrates for the purposes of cutting vegetation. Reduced impacts to these wet managed areas would occur under alternatives B, C, and D, since these alternatives propose to reconfigure and consolidate managed habitats. Small, difficult to manage units, especially wetter fields, would be eliminated from this management program.

Although reestablishing natural hydrology in Pools 3A and 3B is considered under alternative C, fully restoring the natural hydrology of the refuge is not achievable within the management areas. As soil was permanently altered by agricultural land practices, including ditching and tilling, so was hydrology of the refuge. Works Progress Administration projects in the 1930s resulted in the creation of deep drainage ditches within Black Brook to control flooding for agricultural purposes, which were ultimately unsuccessful. In the 1960s and 1970s, refuge staff plugged many ditches to restore the previously drained wetlands and constructed several impoundments with water control structures to manipulate shallow water levels and aquatic vegetation. Native vegetation growth may be suppressed by the use of water control structures that keep wetland areas inundated for prolonged periods of time. Physically removing water control structures would aid in restoring the natural hydrology in Pools 3A and 3B, but growth of historic native vegetation may still be suppressed from past land management activities. Thus, these areas may require additional habitat modifications for full restoration

Several historic sources of contamination prior to the establishment of Great Swamp NWR, including Rolling Knolls landfill, several asbestos dump areas and a former Harding Township landfill, have impacted local water quality (see chapter 2, section 2.1.4). All of these contaminated areas have been remediated, are considered “stable” due to depth of contamination, or are in some stage of remedial action or investigation. These sites will continue to be maintained and monitored in the future in accordance with O&M Plans that include quarterly inspections and annual monitoring of groundwater, surface water and sediment. These plans require that failure of the remedy to be protective, as indicated by physical problems with the landfill cap or analytical results that exceed the appropriate screening criteria, be immediately addressed. In the case of Rolling Knolls landfill, the site will be remediated and an O&M plan implemented by the responsible parties under the oversight of EPA, pursuant to CERCLA requirements. Therefore, it is expected that these sites will not affect water quality in the future if all O&M plans are followed. Remediation of all contaminated sites includes establishment and maintenance of a native grassland vegetative cover.

The development of new facilities may have temporary impacts on water quality due to the disturbance of soils during construction; however, we would implement BMPs to minimize impacts to adjacent habitats and waterways. Certain facilities, such as observation towers and new trails, are not proposed under alternative A. As a result, we would expect slightly less short-term impacts associated with facility construction and less long term impacts associated with expanded public access under this alternative. Any increase in visitation may also have impact on water quality through the increased use trails and vehicles on refuge roads. The most intense direct impacts to water quality could occur from construction of new facilities, maintenance of access roads and trails, and other maintenance activities (e.g., mowing of grasslands, brush and forested areas and pesticide application for invasive species control), which would cause negligible short-term, localized sedimentation or spills that could impact water quality. These

activities would occur to some degree no matter which alternative is selected. These impacts would be minimized by using BMPs. In general, variations in the amount of public use would result in negligible differences in impacts to water quality, especially in the context of the highly developed watershed.

Road maintenance activities, such as gravel spreading and the limited use of de-icing agents, have a relatively minor impact on water quality. The refuge limits the use of de-icing agents for public safety purposes only at locations that experience high visitation. De-icers are only used in parking lots at the refuge headquarters and the Visitor Center, on pedestrian walkways in those areas, and along the paved stretches of Pleasant Plains Road within the refuge. Environmentally friendly calcium magnesium acetate (CMA) is utilized whenever possible and in all environmentally sensitive areas. CMA is used to minimize runoff contaminants and possible environmental impacts. Standard rock salt is used in larger, less environmentally sensitive areas due to the high cost of CMA.

Under all alternatives, standard maintenance, including the mowing of managed grasslands and cutting of brushlands, would have some minor and seasonal impacts associated with the use of machinery and soil disturbance.

Though much of its effects are not fully understood at this time, the refuge will need to consider hydrologic impacts associated with climate change. Climate change could result in destabilized hydrologic cycles, including periods of flood and drought caused by changes in weather patterns or increased temperatures or precipitation (see chapter 2, section 2.1.7). More frequent and severe flooding could lead to increased erosion and sedimentation in waterbodies. All of the alternatives will monitor and develop strategies for mitigating climate change impacts on open water and refuge hydrology.

As discussed above under section 4.1, *Impacts to Air Quality*, herbicidal applications could also be a potential source of impacts to water quality; however, we follow the PUP process and use the BMPs described in the Air Quality section to select pesticides that have less mobility or persistence in water and generally use only highly-targeted direct application methods. The use of pesticides to control invasive species would have a negligible impact on water quality under all alternatives. Managing invasive plant species at current levels has not included widespread application of pesticides adjacent to or directly in hydrologic resources. Currently, glyphosate and triclopyr are the primary active ingredients used by the refuge to treat invasive plants. Both glyphosate and triclopyr are systemic herbicides that operate only on enzymes located in certain plant tissues within roots or vascular system structures. Glyphosate is a herbicide commonly used in crop production and as a management tool for invasive species. It quickly degrades making it biologically unavailable. The chemical has been found to persist in soils for approximately 47 days (Vincill 2002); however the half-life may range from 2 to 197 days (Giesey et al 2000) depending on climate conditions. Glyphosate has a low toxicity to wild birds and studies have shown bioaccumulation factor in birds was as low as 1/10,000 (USFS 1984). Glyphosate is nearly non-toxic to fish and mammals, which generally excrete the chemical in an unchanged form (USEPA 1987). Glyphosate does have a high solubility rate in water (Schuette 1998). However, the potential for glyphosate to accumulate in the tissues of aquatic invertebrates or other aquatic organisms is considered low (PIP 1984). Triclopyr is not labelled for aquatic applications and is toxic to fish at high concentrations. Residues are not persistent (Berisford et al. 2006), however, and dissipate rapidly in the environment (Johnson et al. 1995; Woodburn et al. 1993; Petty et al. 2001; Kreutzweiser et al. 1995). As a result of application restrictions and low persistence, the potential for contamination of surface and groundwater is minor. Berisford et al. (2006) found that triclopyr had the lowest potential to move into groundwater of five common herbicides tested. Woodburn et al. (1993) found no accumulation of triclopyr in sediment, no bioconcentration in fish,

and no decline in water quality. Kreutzweiser et al. (1998) found no significant mortality of detritivorous aquatic insects at typical environmental concentrations. Petty (2001) found no adverse effects on water quality or on the non-target biotic community following triclopyr applications.

We would minimize potential adverse effects to aquatic organisms by properly training all personnel performing pesticide application, applying all pesticides according to label instructions, state, and Federal laws, and FWS policy, and only using pesticides approved for aquatic use in and around waters and wetlands. Through its careful and limited application, the refuge would ensure that use of glyphosate remains well under the EPA enforceable contaminant level (MCL) of 0.7 mg/L or 700 ppb.

4.3.2 Impacts on Hydrology and Water Quality under Alternative A (Current Management)

The adverse impacts of alternative A would be the same as those described under section 4.3.1, *Impacts on Hydrology and Water Quality That Would Not Vary by Alternative.*

4.3.3 Impacts on Hydrology and Water Quality under Alternative B (FWS-Preferred Alternative)

Benefits

Within 5 years, the impoundments would be evaluated to determine the ecological costs and benefits of maintaining, enhancing, or altering succession in each of these impoundments. Depending on the findings of these evaluations and the future management of these areas, hydrology and vegetation composition within these impoundments may change. Adverse impacts and benefits to impoundments may eventually be similar to alternative A or alternative C, depending upon results of the impoundment study and conclusions. The study results will enable us to minimize negative impacts to ecological communities under the chosen management scenario.

The consolidation of habitats, including the conversion of brushland and grassland fragments to later successional stages, will have a modest benefit on water quality by maximizing absorption levels in the forested areas. As previously mentioned, the consolidation of habitats will result in less seasonal disturbance associated with maintaining small fragments of grassland or brushland fields, particularly those that are difficult to manage due to wet or inundated conditions.

The expansion of educational and interpretive programs would provide additional emphasis on regional issues, including water quality and watershed protections. As it has in the past, a sustained outreach program focusing on the issue of water quality and quantity, particularly in the context of climate change, may improve practices and ordinances within the surrounding communities. Maintaining and expanding this network of partnerships and communication may have the greatest positive impact on improving refuge water quality under this alternative.

Alternative B seeks to aggressively expand refuge efforts to manage for and promote understanding of climate change. The refuge would monitor changes in hydrological cycles and when necessary, follow the approach outlined in the FWS Strategic Plan (USFWS 2010a). This plan utilizes the approach of adaptation, mitigation and engagement (see chapter 2, section 2.1.7). The adaptive management approach allows the refuge to utilize management strategies that reduce hydrological impacts as they are observed or anticipated.

Adverse Impacts

As previously mentioned, any increases in program participation and visitation may result in increases in vehicle use and foot traffic near water bodies; therefore, these increases in public uses may result in negligible impacts to water quality due to increased sediment load from trail erosion, litter, or chemicals from leaking cars and exhaust. Public outreach and education on littering and importance of proper waste disposal will help reduce impacts associated with increased visitation. In addition, increased hunting under this alternative would be expected to have negligible impacts on water quality as these activities would not result in substantial increases of foot traffic or vehicle use.

In general, the refuge minimizes adverse effects on water resources in a variety of ways. Trails are placed in areas that are not subject to high levels of erosion or adjacent to sensitive areas, to minimize erosion and adverse impacts to hydrology and water quality. Additionally the refuge has constructed boardwalks on some of the heavily visited areas to prevent impacts to hydrology. Further, the Wildlife Observation Center and wilderness trail parking lots are graveled and are therefore more porous than impervious surfaces such as asphalt or concrete. This allows precipitation to absorb into the ground, preventing storm runnoff into the brooks and streams. The refuge also does not permit the public to drive off designated roads or to use ATVs, which can cause depressions in the soil and divert water from original drainage patterns.

Activities associated with increased hunting have the potential to adversely impact refuge water resources. For example, because hunters are not restricted to using only trails designed for other public use activities, they may travel through areas that are susceptible to erosion and subsequent sedimentation. In such areas, concentrated off-trail foot traffic can affect the hydrology of an area by removing vegetation, compacting the soil, and causing water to channel and pool. Long-term, this can result in some drainages becoming dry while others accelerating erosion by being forced to carry more water. However, impacts of additional hunters on the hydrology and water quality should be negligible. Hunter numbers will be limited and hunters will be dispersed across the refuge, which will reduce repeated erosive actions of soils. Additionally, the soils may be frozen during the fall hunting seasons, further reducing the potential for erosion and downstream sedimentation.

This alternative also proposes the construction of additional trails and new wildlife viewing facilities, such as observation towers. The use of BMPs, including soil erosion controls, would be implemented to minimize the release of sediment into environmentally sensitive areas, such as wetlands and waterbodies. Post-construction, the long-term effects to hydrology and water quality are anticipated to be minimal. We would monitor and periodically inspect roads, trails and facilities for evidence of erosion. If any public use causes evident and unacceptable adverse impacts, the refuge would limit or discontinue the use. Additional environmental education and interpretation programs will raise public awareness on water quality issues, as well as support for wildlife protection and habitat conservation.

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This alternative considers the use of livestock to manage for woody growth and invasive species in the emergent and shrub wetland habitats of bog turtles to mimic the natural function of native ruminants. There are potential hydrological impacts associated with the use of livestock in wetlands, including nutrient input from fecal matter, overgrazing, trampling of vegetation, and soil destabilization within the vicinity of rivulets or other waters.

The introduction of manure and subsequent agricultural runoff into these systems may denude native vegetation and promote the development of invasive species (Tesauro and Ehrenfeld 2007); however this is observed when livestock are utilized at very high densities and not for the primary purpose of habitat management (Tesauro 2013). It has been observed that formerly heavily pastured sites that have been left fallow over many seasons may develop dense mats of invasive vegetation. It therefore becomes essential to utilize only low densities of livestock that mimic natural grazing conditions to control woody and invasive vegetation on sites (Tesauro and Ehrenfeld 2007; Tesauro 2013).

There is also the potential of direct impacts to bog turtles or eggs from trampling. Injuries or deaths to bog turtles as a result of livestock trampling on pastured sites have been observed; however, these observations are extremely uncommon. Variables such as density and type of livestock and substrate type and depth play a role in these impacts (Tesauro 2013).

Careful long term planning that determines the correct type and density of livestock would be required to avoid major, long-term impacts to the vegetation community and potential direct negative impacts to bog turtles. Keeping livestock at estimated levels of one or two animals per acre may be required (Tesauro 2013) to result in net positive long-term impact to bog turtle populations.

4.3.4 Impacts on Hydrology and Water Quality under Alternative C

Benefits

Benefits to water quality are similar to those discussed under section 4.3.3, *Impacts on Hydrology and Water Quality under Alternative B (FWS-Preferred Alternative).*

While partnerships to protect watershed conditions would be expected under all alternatives, alternative C has greatest focus on partnerships that expand unifying ordinances and legislation to protect the GSW.

When compared to alternative B, there are slight increases in acreages of natural regeneration for grasslands and brushlands to later successional stages. This difference would potentially result in a slight improvement to water quality due to the increase of woody vegetation and decrease in rotational mowing or cutting activities. However, these improvements to water quality would be minimal and localized in the context of the entire GSW.

Adverse Impacts

Adverse impacts under alternative C are similar to those discussed under section 4.3.3, *Impacts on Hydrology and Water Quality under Alternative B (FWS-Preferred Alternative).*

4.3.5 Impacts on Hydrology and Water Quality under Alternative D

Benefits

Impacts to hydrology and water quality under alternative D are similar to those discussed in section 4.3.3, alternative B. Alternative D will provide the maximum number of environmental education and interpretation programs, which will raise public awareness and support for wildlife protection and habitat conservation. Any increase in outreach to the local communities under alternative D may have a greater benefit for improving water quality on the refuge.

Adverse Impacts

Alternative D would have a greater impact to hydrology than other proposed alternatives, primarily due to the expansion of open water habitat and increased visitation. Open water could be expanded in these habitats by elevating water levels as opposed to dredging sediment or removing vegetation, which would cause significant disturbance to the underlying sediment.

An increase in water level elevations would lead to a dieback of aquatic and wetland vegetation, which would likely change hydrological patterns and potentially increase the potential for flooding. These changes could have intermediate, long-term impacts to some of the refuge's local vegetation communities that are adjacent to these open water habitats. As mentioned in section 4.4.1, lower water levels allow for the increased vegetative diversity and abundance. Tussock sedge and other *Carex* spp. , rushes ,grasses , and forbs such as smartweeds, are all examples of early wetland successional species that may be impacted by water level increase as these impoundment edge communities are increasingly flooded. Other woody species such as buttonbush may also be impacted by increased water levels that are not periodically drawn down (see section 4.4.1). We would expect that the adverse impacts of open water expansion adjacent or successional wetland communities to be long-term and intermediate in nature. Overall these impacts on the vegetation community on a refuge wide or regional population level would be negligible as these communities are common throughout the refuge relative to losses that would be experienced under this alternative.

Conversely, without open water manipulation, open water communities which are popular with refuge visitors and utilized by waterfowl will be lost over time as aquatic vegetation such as pickerel weed, arrow arum and many marsh species succeed on these open water areas.

Any changes in open water would need to be closely monitored to ensure hydrological changes do not impact sensitive wildlife species or their habitats.

Alternative D anticipates the greatest increase in refuge visitation over the next 15 years. This alternative emphasizes, to a greater extent than alternative B, the expansion of infrastructure, including the creation of new trails, observation towers, and parking lots. The potential for hydrologic impacts due to increased visitation (described under section 4.4.1, *Impacts that Would Not Vary by Alternative*) would be slightly higher than other alternatives. In addition, seasonal pedestrian access would be provided on existing service roads around Pools 3A and 3B; however, these areas would be closed to the public during migration and other time periods when wildlife may be sensitive to disturbance. If any public use or new infrastructure results in evident and unacceptable adverse impacts to water quality due to erosion or pollution, the refuge would rotate the activities to secondary sites, curtail, or discontinue the use altogether.

The introduction of fishing at the refuge may result in some water quality impacts near open water including bank erosion from foot traffic and increased amounts of litter or waste. Lead weights may be discouraged or not permitted to be used; however it is likely that lead and other waste, such as excess fishing line, lures, and miscellaneous litter, would increase within fishing access areas.

There is also greater potential for the introduction of exotic species to the refuge from other locations and sources. There are multiple examples of invasive species being transferred throughout Northeastern aquatic ecosystems by fishing and other aquatic activities. A few of the many prominent examples include the diatom known as "rock snot" (*Didymosphenia geminata*), invertebrates such as *Dreissena* spp. mussels and Asian clam (*Corbicula fluminea*), and vascular plants such as Eurasian watermilfoil (*Myriophyllum spicatum*). These organisms, including their eggs or seeds, larvae, etc. may be transferred through bait, bait bucket water, on wading boots or other equipment (NANSP 2013). Introduction of one or more invasive species could result in a long-term, major adverse impact to refuge aquatic systems. This may include a degradation of habitat and direct loss or displacement of native populations of aquatic species.

Because of limited access and other more popular freshwater fishing options within the region, it is expected that fishing would be a relatively minor and very localized activity at the refuge. In addition, much of the streams associated with the refuge are heavily utilized by anglers and canoers at nearby off-site locations. It would be expected that allowing fishing at the refuge would result in a relatively minor increase in the probability of invasive species introductions in the watershed. Other non-wildlife dependent uses, such as the introduction of canoeing and kayaking, also increases impacts to water quality through bank erosion and increased potential for invasive species introductions.

The probability of invasive species introduction may be reduced through the inclusion of informational signage at refuge fishing locations. Signage would instruct anglers on ways to decontaminate boots and other equipment before utilizing a waterbody. Other measures including restrictions on certain baits, felt boots, or other potential vectors for invasive species may also be considered.

Under this alternative, we would consider the creation of an observation pond near the Visitor Center, which would result in temporary impacts associated with soil disturbance and machine use during construction. To minimize permanent hydrological impacts to wetlands and groundwater associated with its construction, we would carefully consider and evaluate the location of the pond to avoid unnecessary impacts. Impacts to wetlands and transition areas (i.e. buffers) would be avoided to the greatest extent possible.

In addition, we would consider the creation of a paved bike trail along a gravel section of Pleasant Plains Road; however, this would result in an increase in impervious surface (i.e., increased sheet flow or stormwater runoff).

4.4 Impacts on Vegetation

As discussed in chapter 2, refuge lands include a variety of habitat types, including bottomland, upland, riparian, and floodplain forests; naturally-occurring scrub-shrub wetlands and actively managed brushlands; non-forested wetlands; open water; and managed grasslands. The Management Area of the refuge had undergone intense post-colonial agricultural disturbances that impacted vegetation patterns to the present day (Momsen 2007). The dichotomy of vegetation patterns in the eastern (i.e., Wilderness Area) and

western portions (i.e., Management Area) of the refuge reflect the differences in historic land use and land cover. The eastern portion of the present day refuge, while disturbed through logging, was not subject to the intensive soil and hydrologic alteration from farming practices though extensive ditching for flood and mosquito control was conducted in the 1930s and 1940s. As a result, the present day Wilderness Area vegetation patterns are consistent with the influence of post-glacial deposits that characterize the geologic history of the region. The pin-oak swamps and other vegetation communities of the western portion of the refuge reflect post-colonization agricultural use (Momsen 2007). Some habitats are the result of alteration, such as impoundments. Despite these alterations, many of these impacted habitats have the potential to be restored through various management actions, natural succession, and specific projects. Some habitats support rare plant communities or species of concern.

We evaluated the following benefits to vegetation as a result of potential management actions under each of the alternatives:

- Conserving and protecting refuge lands to prevent future development, thereby limiting impacts on vegetation and losses of ecosystem integrity.
- Protecting, conserving, and monitoring habitats that contain rare or endangered plants, unique habitats, and habitats that support species of special concern.
- Conversion or restoration of certain impoundments, brushlands, and grassland areas of the refuge to forest or a later stage of vegetation succession.
- Maintaining wildlife habitat and supporting wildlife in some impoundments by restoring certain impoundments to natural marsh and scrub-shrub wetlands or by maintaining static water levels in other impoundments.
- Controlling invasive species, pests, and diseases that impact vegetation on the refuge and monitoring for those that are known to be present in the region.
- Supporting regional restoration projects and scientific studies that improve habitat management, knowledge of species of concern, or provide learning opportunities for students.
- Increasing public awareness and developing partnerships to address important environmental issues, such as the spread of invasive plant species and the availability of native plant alternatives.
- Emphasizing the use of native species wherever plantings or vegetation restoration are conducted, striving for species and structural diversity, and considering for overwinter survival or future native plant recruitment objectives.

We evaluated the potential for the proposed actions to cause adverse effects on vegetation and losses of ecosystem integrity:

- Direct or indirect actions causing soil, hydrology, and water quality impacts that could adversely impact vegetation, and habitat productivity and integrity.
- Managing and restoring bottomland, upland, riparian, and floodplain forest communities.

- Invasive species control.
- Larger scale routine management activities, such as mowing fields and maintaining or controlling water levels in impoundments, and less regular activities, such as prescribed burning.
- Constructing, updating, expanding, or managing public use facilities, wildlife viewing infrastructure, trails and parking lots, and administrative offices.
- Increasing visitation and expanding the six priority public uses.

4.4.1 Impacts on Vegetation That Would Not Vary by Alternative

We expect that refuge land management, regardless of alternative, would have a net positive effect on vegetation abundance, diversity, and quality.

Benefits

Under all alternatives, the refuge would continue to protect areas of bottomland, upland, floodplain, and riparian forest, non-forested wetlands, grasslands, and brushlands. Habitats supporting rare wildlife or plant species would also be maintained and restored, when necessary. For example, we would continue to maintain and control invasive species within spring-fed emergent wetlands for bog turtle and woodland vernal pools for blue-spotted salamander. We would continue to protect existing lands adjacent to rivers and stream segments within refuge boundaries that influence aquatic life and vegetation. Overall, the protection, maintenance, and restoration of habitats are expected to benefit vegetation.

Under all alternatives we would continue to employ early detection and rapid response (EDRR) techniques, in collaboration with other conservation partners, to prevent the establishment of newly emerging invasive plants. We would continue to reduce the footprint of habitats degraded by stand-replacing, near-monocultures of non-native plant species, such as common reed and reed canary grass. For example, beginning in 1995, one-half million *Galerucella* beetles were released, resulting in a significant reduction in purple loosestrife by 2005. Invasive species control efforts would continue under all alternatives. These efforts are expected to result in a net benefit to native vegetation across all habitat types on the refuge.

Public use can benefit vegetation through our education and interpretive actions proposed under all alternatives. By educating visitors on the importance and identification of native vegetation and intact plant communities, we help individuals to recognize the prevalence of invasive species and the benefits of native species. We would also continue to encourage nearby nurseries to sell and promote native alternatives to common non-native landscaping plants. Under all alternatives, we would continue to encourage volunteer-based efforts to help control invasive species and restore native plant communities.

The refuge would also continue to support deer hunting under all alternatives. Deer hunting benefits a variety of vegetative communities by keeping deer populations within the carrying capacity of the habitat, thus reducing excessive damage to vegetation caused by over-browsing and maintaining understory habitat for other species (Rawinsky 2008).

Adverse Impacts

Maintaining and protecting a diversity of high quality vegetation habitats are consistent themes within the refuge's goals and are common to all of the alternatives. However, creating large, contiguous patches of

managed vegetative communities, particularly managed brushlands and grassland fields, are consistent themes among alternatives B, C, and D to varying degrees. Reconfiguration of habitats, including cutting, burning, or removal of vegetation to create an earlier stage of succession, would result in short term, localized, minor impacts to vegetation. The impacted areas would regenerate and develop into the desired habiat conditions with a year or two of treatment. Temporary and/or permanent loss of vegetation would also occur during construction or repair of facilities, roads, or other infrastructure; however, the refuge would promote revegetation of disturbed areas with native species typical of this part of northern New Jersey.

Short-term adverse effects from public use activities consist of the deterioration of plant material, whereas long-term effects of trampling include direct and indirect effects on vegetation and soils like diminishing soil porosity, aeration and nutrient availability through soil compaction (Roovers et al. 2004). Compaction of soils thus limits the ability of plants, particularly rare and sensitive species, to re-vegetate affected areas (Hammitt and Cole 1998). Where adverse impacts to vegetation are observed, the refuge will take necessary measures, such as remediation and trail closures, to restore plant communities.

We anticipate that allowing use on designated routes will cause some vegetation loss. Foot travel may increase root exposure and trampling effects; however, we anticipate that under current and projected use the incidence of these problems will be minor. Routes for pedestrian travel consist of existing trails and boardwalks that have been used for many years. Designated routes do not have any known occurrences of rare plant species on their surface or soils subject to compaction that will be impacted by this use. Users leaving designated trails could have impacts to adjacent vegetation. Trails will be monitored, problem areas will be identified, and appropriate restoration and protection efforts will be made.

Highly traveled trails such as the ones at the Wildlife Observation Center have had boardwalks built to lessen the impacts on vegetation and wildlife disturbance. This allows visitors to quietly walk through these areas with minimal disturbance to the surrounding wildlife. Boardwalks have also been observed to be used as cover by some of the common species of turtles, fox, frogs, snakes and salamanders present in this area.

Direct adverse impacts on vegetation may occur as a result of hunting activities. Short-term, trampling of vegetation by hunters will occur to some degree throughout the refuge during the firearm and bow deer hunting season. Additionally, vegetation in designated grass hunter parking lots temporarily will be compressed from vehicles. Plant species vary in their resistance to trampling, which can lead to changes in plant communities over time. In general, plant diversity has been shown to increase with slight use and to decrease as use intensifies (Liddle 1997). Regardless, the overall physical effects of deer hunting on refuge plant communities are expected to be minimal and short-term. The number of hunters (maximum 450 permits) and duration of the hunt (5 days) are limited by the refuge. Additionally, use of all-terrain vehicles (ATVs), off-road vehicle travel, permanent tree stands and blinds, camping, and fires, which are most likely to damage vegetation, are prohibited. Hunter trampling of vegetation is likely to be further minimized as a result of the high acreage to hunter ratio (one hunter per 32 acres for deer, less dense for turkey) and the time of year most hunting occurs (dormant season). Finally, potential impacts to vegetation from an overabundant deer population far outweigh the limited impacts on vegetation that could occur from trampling by deer hunters. In fact, positive, indirect effects on the vegetation (i.e., increased ecological diversity) will result from continued management of the refuge's white-tailed deer population.

The most intense direct impacts to vegetation would occur from construction of new facilities, maintenance of access roads and trails, and other maintenance activities (e.g., mowing, mechanical grassland and brushland treatments, pesticide application for invasive species control), which would cause negligible short-term, localized disturbance to vegetation. These activities would occur to some degree no matter which alternative is selected. These impacts would be minimized by using the BMPs described under Section 4.3.1, *Impacts on Hydrology and Water Quality.*

4.4.2 Impacts on Vegetation under Alternative A (Current Management)

Impacts from refuge management under alternative A would be the same as those described under section 4.4.1, *Impacts on Vegetation That Would Not Vary by Alternative*.

4.4.3 Impacts on Vegetation under Alternative B (FWS-Preferred Alternative)

Benefits

As described under section 4.4.1, *Impacts on Vegetation That Would Not Vary by Alternative,* alternative B would reconfigure and maintain habitats to create large (greater than 50 acres), contiguous patches to promote wildlife use, increase connectivity, decrease fragmentation, and increase maintenance efficiency and reduce associated costs. This would shift the plant community structure and species composition within affected units over time. Within 5 years, open water habitat would also be evaluated to determine the ecological costs and benefits of maintaining, enhancing, or altering succession in each of the impoundments. Depending on the findings of these evaluations and future management of these areas, vegetation structure and composition within the impoundments may change.

Managed brushlands and grasslands would be enhanced to improve vegetative structure and species composition. The quality of brushlands and grasslands would be improved by evaluating and implementing ways to manage the flora, such as prescribed burning, grazing, or plantings, to maximize their native ecological diversity and productivity. Smaller brushland and grassland field areas that do not currently support obligate grassland bird species or other priority species, such as American woodcock, would be allowed to undergo natural succession. Based upon their limited patch size and location, allowing natural forest succession within these disjunct units would improve adjacent core forest health.

Prescribed burns will occur on a maximum of 200 acres of grassland under this alternative. Prescribed burns have multiple benefits to vegetation communities and their associated wildlife. Benefits to vegetation include increases water yield, maintenance of natural succession of plant communities, suppression of invasive species, and reduction of the need for pesticides. Prescribed fire increases the production of seed in legumes and grasses in frequently burned areas. Grassland fires cause early green up of warm season grasses, improved seed-germination, and greater production of grasses and forbs. It also increases the production of berries, drupes, and pomes for 2 to 4 years after burning (Lyon et al. 2000).

The actions proposed under this alternative will allow the refuge to make the most significant ecological contribution possible at the local and landscape levels within the GSW, Northern Piedmont Region, and the Refuge System.

Adverse Impacts

Adverse impacts on vegetation would be similar to those described under 4.4.1, *Impacts on Vegetation That Would Not Vary by Alternative,* however, there would be minor, temporary impacts on vegetation due

to the removal of hedgerows within existing grassland and brushland fields that create predator perches, fragment management units, and reduce the availability of suitable nesting areas for grassland birds. In addition, this alternative would expand the successful management practices that have been developed for the bog turtle on the refuge and elsewhere. This includes the maintenance of herbaceous dominant, spring-fed wetlands through control of woody plant succession and invasive species. This would result in direct impacts to woody vegetation; however, there would be an overall benefit to the federally threatened bog turtle, as well as other reptiles and amphibians that utilize these areas.

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The regular prescribed burns proposed under this alternative would reduce the amount of successional woody vegetation growth (brushland or secondary forest) in some grassland areas. Areas proposed to be managed with fire would be limited to approximately 200 acres of grassland that is largely currently managed with rotational mowing. As a result, the addition of prescribed burning would not by itself substantially change the ratios of grassland to forested and brushland communities within the refuge.

While it is likely that certain exotic species of shrubs such as Autumn olive may be suppressed through burning, other native shrub species such as *Cornus* spp. dogwoods, and tree seedlings such as *Quercus* spp. oaks and red maple may be regularly suppressed by regular burns.

Although grassland communities are particularly resilient to burning (Knapp et al 2009), we would expect very short-term, negligible adverse impacts to herbaceous species to occur from burning through direct injury or mortality. Burns during vulnerable phonological periods (e.g early growing season) increases the chance of woody or herbaceous species mortality (Knapp et al 2009). However, if properly implemented, the long-term net benefits (stated in 4.4.5 under benefits) to native herbaceous communities would far outweigh the short-term impacts of direct mortality or injury.

The inclusion of a prescribed burn on existing grassland habitats has the ability to shift the dominance ratios and composition of herbaceous vegetation. The frequency, intensity and the timing of burns can play a significant role in manipulating composition. For example, late winter or early spring burns may more effectively kill or suppress actively growing cool-season grasses over dormant warm season grasses. As a result of this timing, managers may shift a community from a cold-season to a warm-season dominant community (Knapp et al 2009; Howe 1994). With this in mind, any prescribed burn program will undergo careful evaluation prior to implementation to avoid long-term or major adverse impacts to refuge grassland communities. This would include a careful ecological analysis of communities to be burned and evaluation of specific desired goals and potential impacts. All of this information would be included in a fire management plan for the refuge burns. The plan will incorporate appropriate methods and practices from the FWS Fire Management Handbook (USFWS 2013), Guidance for Implementation of Federal Wildland Fire Management Policy (FEC 2009), Interagency Standards for Fire and Fire Aviation (NIFC 2013), and other appropriate guidance.

Under this and all alternatives, the potential for introduction of invasive species through public use of the refuge is a constant concern. People, vehicles, and dogs can be vectors for invasive plants when seeds or

other propagules are accidentally, or deliberately, introduced into the refuge. Once established, invasive species can out-compete native plants, thereby altering habitats and indirectly impacting wildlife. The threat of invasive plant establishment is an issue requiring continual monitoring and, when necessary, treatment. Staff and dedicated volunteers will continue to work to eradicate invasive species through an increasingly proactive EDRR strategy and educate the visiting public.

Alternative B proposes construction of additional facilities, which includes two wildlife observation towers, parking lots, and new trails. During the construction of these structures and trails, some areas of vegetation would be disturbed. Most, if not all, small project construction would be located where vegetation is already degraded, so a minor permanent loss of vegetated cover would result in a negligible impact. All temporary impacts would be restored and planted with native vegetation typical of northern New Jersey and the refuge. BMPs would be used to prevent unnecessary impacts to adjacent habitats and waterways.

Activities associated with providing increased hunting opportunities have the potential to adversely impact refuge soils.

4.4.4 Impacts on Vegetation under Alternative C

Benefits

The benefits of alternative C are similar to those discussed under section 4.4.3, alternative B, except we would further emphasize converting brushlands and grassland habitat to forested habitat or other late successional stages over the life of the plan. This would shift the plant community structure and species composition over time to more mature successional stages.

A benefit under this alternative would be the increase in forest acreage. The increased acreage will aid in forest resiliency and redundancy, factors important in weathering the effects of future climate change anticipated for this area, such as increased storm events, increased temperatures, more or less rainfall, new diseases and pests, and new invasive plant species. Additional forest acreage would also increase “core” forest habitat, which would directly benefit various forest interior bird species.

Under this alternative, we would consider the use of deer exclusion devices to promote succession and forest regeneration. This would also provide opportunities to study and document browsing impacts by deer.

Another benefit to this alternative is the reduced mowing and cutting associated with grassland and brushland habitat maintenance.

Adverse Impacts

The adverse impacts of alternative C are similar to those discussed under section 4.4.3 in alternative B. This would include impacts resulting from prescribed fire and other standard management activities (see discussion in section 4.4.3). One exception would be the minor, temporary, adverse effects on vegetation associated with impoundment restoration due to changes resulting from the removal of boards from water control structures. The vegetation communities would change with a loss of open water and an initial increase in natural marsh. Eventually these communities would be expected to succeed into a scrub-shrub, and possibly floodplain forest community associated species.

There will be less available habitat to support native plants and pollinators associated with grasslands and other species in the food web that use open habitats.

As in alternative B, alternative C also anticipates an increase in refuge visitation, although most of this increase is anticipated to be from environmental education and interpretation program participation. Effects of increased visitation under alternative C are expected to be similar to those described under alternative B.

4.4.5 Impacts on Vegetation under Alternative D

Benefits
The benefits of alternative D are similar to those discussed under section 4.4.3, alternative B.

Adverse Impacts
The adverse impacts of alternative D are similar to those discussed under section 4.4.3, alternative B; however, alternative D proposes to increase open water habitat to enhance wildlife viewing opportunities. Vegetation loss would result from increasing water levels in the impoundments, not through the removal of sediment or root mass. There will be less available habitat to support waterfowl, shorebirds, and other species in the food web that use an interspersion of emergent marsh and open water habitat.

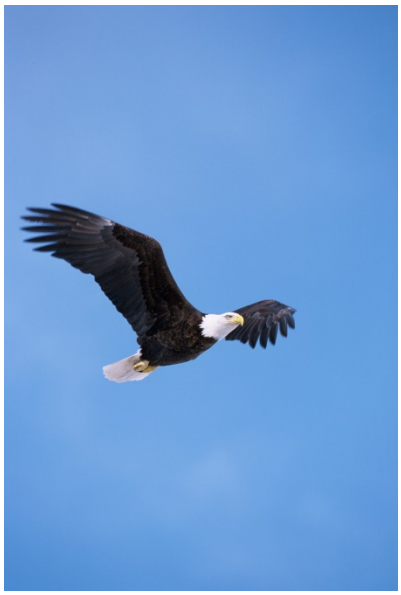
Alternative D anticipates the greatest increase in refuge visitation. Effects of increased visitation under alternative D are expected to be similar to or slightly more than those described under alternative B.

Fishing opportunities, which are not authorized under any other alternative, would be provided in select areas of the refuge. Trampling of vegetation may occur during the fishing season when visitors walk to, from, and along fishable waters. In addition, as previously mentioned, people, vehicles, dogs, and horses can be vectors for invasive plants when seeds are accidentally or deliberately introduced into the refuge. Fishing may pose additional concerns for invasive species since waders and fishing equipment can also serve as vectors for aquatic invasive plants. Once established, invasive species can out-compete native plants or create thick monocultures in water bodies, thereby altering habitats, water quality, and indirectly impacting wildlife. The threat of invasive plant establishment will always be an issue requiring annual monitoring and, when necessary, treatment. Staff and dedicated volunteers will work to eradicate invasive species and educate the visiting public.

4.5 Impacts on Federally Listed and Recently Delisted Species

There are currently two federally listed species that have established populations at Great Swamp NWR, the federally listed threatened bog turtle and the federally listed endangered Indiana bat. Both of these species utilize specific habitats at Great Swamp NWR. As part of the Refuge System, one of our highest priorities is the conservation and management of federally listed or recently de-listed species. We evaluated each of the alternatives for its potential to beneficially or adversely affect habitats where breeding, wintering, hibernating, or foraging occurs. State-endangered species or species of greatest conservation need (including amphibians, reptiles, birds, and plants) also occur on the refuge and are addressed under their individual taxonomic sections.

Indiana Bat
The Indiana bat was listed as endangered by the Federal government in 1967 due to population declines documented in their seven major hibernacula in the Midwest. This species was automatically added to the New Jersey endangered species list following the passage of the State's Endangered and Nongame Species Act in 1973 (Beans and Niles 2003). Reproductively active female and juvenile Indiana bats were first identified on the refuge in 2005. The Indiana bat uses refuge swamp forests and riparian corridors for maternal roosts and as foraging habitat during warmer months.


USFWS

Bog Turtle
The bog turtle was listed as an endangered species in New Jersey in 1974 due to severe population declines, restricted habitat preferences, habitat loss, and collecting. In 1997, the bog turtle was listed as threatened by the FWS. The New Jersey NHP considers the bog turtle "globally, either very rare and local throughout its range or found locally in a restricted range or because of other factors making it vulnerable to extinction throughout its range" and "imperiled in New Jersey because of rarity" (Beans and Niles 2003). The bog turtle is a year-round resident that utilizes certain open wetlands at the refuge.

Bald Eagle
Although the bald eagle was removed from the Federal list of endangered and threatened species on August 12, 2007, it is still a federally protected species under the Bald and Golden Eagle Protection Act and the State continues to list it as threatened during the non-breeding season and endangered during the breeding season. A transient bald eagle may be seen occasionally throughout the year on the refuge.

Peregrine Falcon
The peregrine falcon was classified as a federally endangered species in 1970 and as a New Jersey endangered species in 1974. The peregrine falcon was removed from the Federal list of endangered and threatened species in August 1999. Although the species was removed from the Federal list, the peregrine falcon remains listed in the State of New Jersey. Peregrine falcons are rarely seen on the refuge, primarily during the fall and winter months.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of federally listed and recently de-listed species.

4.5.1 Impacts on Endangered and Threatened Species That Would Not Vary by Alternative

We do not anticipate any impacts to any endangered or threatened species under any of the alternatives. No public use trails are open on lands which are occupied by threatened Bog Turtle. The endangered Indiana bat is nocturnal and therefore these uses will not affect their foraging activities.

Based on the research done on the refuge using radio-telemetry tracking and bat acoustic surveys, the refuge provides foraging and roosting habitat for Indiana bats. We are planning to continue mist net surveys

to assess the status of Indiana bats within the refuge. Currently roost sites are in closed areas of the refuge or off trails. Indiana bat will continue to be monitored with cooperation of many of our partners and with New Jersey USFWS Ecological Field Office throughout the State and if they are found to use public areas or trail corridors on the refuge public use in those areas will be re-evaluated. We anticipate that these uses are not likely to adversely affect Indiana bats because these activities do not coincide with the area where this species is known to occur.

Based on radio-telemetry tracking the refuge provides foraging, nesting, and hibernation habitat for the bog turtle. The bog turtles will continue to be tracked and trapping will continue in areas that have historically had bog turtles to find all areas this species occurs on the refuge. All known and historical bog turtle sites are closed to the public and not located near trails. We anticipate that these uses are not likely to adversely affect bog turtles.

Disturbance by deer hunting to Indiana bats is unlikely because bats are gone from the refuge during the time of the hunt. The refuge also provides foraging, nesting, and hibernation habitat for the bog turtle. A small population occurs in a few acres of emergent wetland habitat in a refuge Safety Zone area. Additionally, several wetlands associated with seeps that historically have supported bog turtles are scattered throughout the refuge; in the recent past, single occurrences of the species have been documented in two of these areas. In general, activity of bog turtles during fall is limited as the animals reduce their movements and enter hibernacula (e.g., ground water-washed root systems of woody plants). Also, it is very unlikely that a hunter will encounter a bog turtle, as the primary population falls within a Safety Zone and much of the area is protected by fencing.

Disturbance by turkey hunting to Indiana bats is unlikely because bats are rare, they roost during the day under the exfoliating bark of trees, and are they most active at night. Also, it is very unlikely that a hunter will encounter a bog turtle, as the primary population falls within a Safety Zone and much of the area is protected by fencing. Additionally, because turkeys are an upland species, hunters are less likely to enter or remain in wetland habitats, where turtles are found. In fact, the type of habitat that bog turtles use (characterized by shallow water and deep “mucky” soils USFWS 2012) likely will be avoided by hunters as they travel to their desired turkey hunting areas.

4.6 Impacts on Landbirds

The conservation and management of forested habitats are a priority of the refuge and one of our CCP goals. We evaluated each of the alternatives for its potential to benefit or adversely affect early successional and forested habitats and associated landbirds.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of landbirds and identified focal species in chapter 2 and in our biological objectives:

- Improving and restoring bottomland, upland, riparian, and floodplain forests.
- Increasing monitoring, early detection, and control of invasive species, pests, and diseases.
- Promoting public awareness through environmental education, environmental interpretation, and wildlife-dependent recreation.

- Increasing patch size, reducing fragmentation, and improving vegetation structure and composition of forest, scrub-shrub, and grassland habitats.
- Continuing to maintain and restore vernal habitats.

We evaluated the potential for the proposed actions to cause adverse effects on habitats of landbird focal species:

- Disturbance from public use.
- Impacts to wild turkeys, as well as other land birds, from opening a spring wild turkey hunt for gobblers (males) in select areas of the refuge.
- Potential impacts from spraying of invasive species, forest restoration, removal of hedgerows, and impoundment water level manipulation.
- Construction of additional wildlife observation infrastructure, such as an observation towers.
- Mechanical treatment actions, such as grassland mowing or brushland cutting.
- Construction of new facilities, trails, and parking lots.
- Operation and maintenance of facilities, buildings, and associated infrastructure.

4.6.1 Impacts on Landbirds That Would Not Vary by Alternative

Benefits

Forest Species

There are several State-listed endangered or threatened landbirds that use forest habitats of the refuge, including but not limited to barred owl, long-eared owl, red-shouldered hawk, red-headed woodpecker, and bald eagle. These species primarily use bottomland, upland, riparian, and floodplain forests for breeding, foraging, nesting, and resting habitats.

Numerous other landbirds that are not State-listed as endangered or threatened, but identified as regional conservation priorities are included in this group as well. Species such as the Acadian flycatcher, Eastern wood-pewee, black-and-white warbler, Canada warbler, Cerulean warbler, worm-eating warbler, Kentucky warbler, Louisiana waterthrush, rusty blackbird, Baltimore oriole, scarlet tanager, and wood thrush are all noted as high management priorities in plans such as BCR 28 and 29, PIF 9 and 10, the FWS Birds of Conservation Concern list, the FWS Species of Regional Conservation Concern list, and the NJWAP. These species primarily use upland, bottomland, floodplain, or riparian forests for breeding, foraging, and resting habitats.

Scrub-Shrub Species

Although no scrub-shrub dependent landbirds are currently listed as State-endangered or threatened, several species are identified as regional conservation priorities, including American woodcock, blue-winged warbler, golden-winged warbler, willow flycatcher, eastern towhee, field sparrow, and prairie warbler.

Grasslands Species

There are many State-listed endangered or threatened landbirds that use grassland habitats at the refuge, including vesper sparrow, bobolink, Northern harrier, grasshopper sparrow, and short-eared owl.

Under all alternatives, the refuge would continue to restrict access and management activities, when and where appropriate, near known nesting sites. The refuge delays its mowing program to October to avoid impacts to breeding birds, raptors, reptiles, wildflowers, and pollinators. Long-term benefits to landbirds are anticipated through the ongoing management of forests, scrub-shrub, and grasslands. Invasive species management will enhance the habitats landbirds use for nesting, foraging, and migratory stopover. Ongoing management activities, such as invasive species management, inventory, and monitoring programs, would continue to be completed in a manner that would prevent potential impacts to individual species. The refuge would continue to coordinate with NJDFW, as well as with our conservation partners, to ensure that we use the best available science in our management decisions related to State-listed species.

Adverse Impacts

Minor impacts may occur during habitat management activities, specifically mowing and cutting of grassland and brushland habitats. These activities would occur no matter which alternative is selected, but the degree to which we practice them would vary, and thus, their impacts. As discussed above under *Benefits,* mowing and cutting of fields generally occurs in October to avoid impacts to breeding birds, raptors, reptiles, wildflowers, and pollinators. As expected, mowing has a more substantial effect on bird occupancy in brushland habitats since this form of habitat management has a much more pronounced effect on vegetation structure (Vickery et al. 2005). Brushland habitat will be maintained in various stages of succession to provide wildlife species, including landbirds, foraging, resting, nesting, and cover habitat.

Regardless of the alternative, we would continue to employ a range of invasive species management tools, such as mechanical, biological, and chemical methods, to achieve our objectives in managing for the improved health and integrity of landbird habitats. We would use these tools only when and where appropriate, and only with the proper training and focused application to avoid adverse impacts. Invasive species control can be detrimental to landbirds if proper timing and application are not considered, but we tailor our treatments to protect birds during the nesting and fledgling periods and to avoid harm to amphibians, reptiles, and pollinators. A less noticeable, but long term impact would result from no action with respect to invasive species control or failing to curtail the deer population, as these have the potential to significantly alter vegetation communities upon which birds and their prey base depend.

In general, the presence of humans disturbs wildlife, which typically results in a temporary displacement without long-term effects on individuals or populations. Disturbance varies by wildlife species and the type, level, frequency, duration, and time of year the disturbance occurs. Disturbance can cause shifts in habitat use, abandonment of habitat, and increased energy demands on affected wildlife (Knight and Cole 1991). 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 robins) were found near trails and rare species (e.g., Blackburnian warblers) were found farther from trails. In some cases there was a clear link between the extent of disturbance and either the survival or reproductive success of individuals (e.g., Schulz and Stock 1993). For recreation activities that occur simultaneously, such as hiking, biking, and horseback riding, there would likely be compounding negative impacts to wildlife (Knight and Cole 1991).

Human disturbance can cause an animal to vacate an area or habitat due to the amount or frequency of disturbance. In a study done by Gill et al. 2001, the decision of whether or not to move away from disturbed areas will be determined by factors such as the quality of the site currently being occupied, the distance to and quality of other suitable habitats, the relative risk of predation or density of competitors in different sites, and the investment that an individual has made in a site (for example, in establishing a territory, gaining dominance status or acquiring information).

There is evidence to suggest that species most likely to be adversely affected are those where available habitat is limited thus constraining them to stay in disturbed areas and suffer the costs of reduced survival or reproductive success (Gill et al. 2001). Because of the diversity of habitats represented on the refuge any population level effects to wildlife species from trail use might be minimized by the abundance of habitat on the refuge and adjacent lands.

Wildlife disturbance may be compounded by seasonal needs. For example, some species, like warblers, could be negatively affected by disturbance associated with bird watching particularly during the breeding season. When visitors approach nests too closely, they often cause the adult bird to flush exposing the eggs to weather conditions or predators (Banks and Bryant 2007, Miller et al. 2001).

State-listed bird species that possibly could be present and active on the refuge during the deer hunt include the state-endangered peregrine falcon, bald eagle, red-shouldered hawk, and vesper sparrow, and the state-threatened barred owl, long-eared owl, and red-headed woodpecker. In general, fall is the season for bird migration, and hunting could cause some level of disturbance to migrating birds during this time. Hunting activity may cause birds that are feeding and roosting in upland and wetland habitats to unnecessarily take flight, expending energy resources at a time when food resources are limited. While disturbance to the daily migrating and wintering activities of birds may occur, cumulative negative impacts should be negligible, because the hunting season does not coincide with the nesting season, which would impact reproduction, and the period of disturbance is short (5 days), reducing the likelihood that disturbance associated with the hunt would deplete important fat reserves.

Impacts to birds, such as displacement, may result from lost habitat where current and proposed new construction of building and associated infrastructure takes place. Maintenance, activities, and support structures can have an impact footprint that goes beyond the walls of a given building, and can include such things as light and noise pollution, pets, traffic, lawn maintenance and the type of vegetation, power lines, and cleared areas required for parking, solar panels, septic and drain fields.

Major construction of within the refuge will tend to occur in previously disturbed or partially urbanized habitats. As a result, commonly displaced bird species at the refuge would be disturbance tolerant, generalist passerine species such as robins, jays, finches, mockingbirds, catbirds, and common sparrows. These species tend to be very common, highly adaptable and will regularly utilize common urbanized habitats within the refuge and the surrounding landscape. As a result, we expect that any impacts to landbird populations caused by planned refuge construction will be localized, short-term, and negligible.

The refuge will take all necessary precautions to avoid and minimize adverse impacts to actively nesting birds and will work in accordance with recommendations under the Migratory Bird Treaty Act. These measures include monitoring and inspecting structures or habitats for nesting birds prior to construction. Examples may be checking shrubs for nesting species such as American robin or identifying nests in buildings or structures for species such as Eastern phoebes or barn swallows. Construction near nesting/fledging birds will be avoided as needed to prevent nest disturbance or failure, and mortality of

chicks. If required, timing restrictions during the active breeding season will be utilized for clearing of trees or other activities that have the potential to impact nesting birds. By following these procedures, we would expect to avoid long-term, adverse impacts on nesting birds.

As previously discussed, the refuge is located in a highly urbanized environment with substantial baseline disturbance associated with the several major highways (Route 78, Route 287, and Route 24) and numerous houses, businesses, warehouses, manufacturing plants, and industries. Visitors are currently limited in the Management Area to existing refuge trails and infrastructure; therefore, refuge visitors are not expected to add significantly to existing disturbance levels. Visitors have the option of exploring the entire Wilderness Area on foot, whether on existing trails or beyond. Visitation, however, is much lower in the Wilderness Area due to the more primitive, back-country conditions found there. Overall, direct impacts from public use are expected to have minimal or no adverse effects on landbirds.

4.6.2 Impacts on Landbirds under Alternative A (Current Management)

Impacts to landbirds under alternative A are the same as those discussed in *Impacts on Landbirds That Would Not Vary by Alternative*.

4.6.3 Impacts on Landbirds under Alternative B (FWS-Preferred Alternative)

Benefits

Compared to alternative A, alternative B would provide additional long-term benefits to landbirds through the protection and restoration of forest habitats, and enhancements to managed grasslands and brushlands. We would reconfigure habitats to create large, contiguous patches to promote wildlife use, increase connectivity, and decrease fragmentation. Forest birds would benefit from the consolidation of forest habitats and use of feathered edges. Large tracts of contiguous forested areas are necessary to support breeding populations of migratory songbirds (Robbins et al. 1989; Robinson et al. 1997), especially forest interior species, as well as forest dwelling raptors (Bosakowski et al. 1992; Bosakowski 1994). Consolidation of habitats into larger patch sizes would also reduce fragmentation and undesirable edge effects and associated ecological impacts, such as edge-related nest predation, brood paratism, and the spread of invasive plant species. Feathered edges will reduce fragmentation effects while serving as important ecotonal travel and dispersal corridors (Arbuthnot 2008). Feathered edges also provide important nesting, foraging, and escape cover for a variety of wildlife species.

We would maintain an interspersion of habitat types produced by the management of grasslands and brushlands, which substantially increases ecotonal areas and promotes wildlife diversity. Managing large tracts of grasslands and brushlands would help improve nesting site availability and success. This alternative also benefits the insects and other invertebrates on which these birds depend. Select forest habitats will be converted to an earlier successional stage while other areas will be allowed to succeed through natural regeneration; therefore, it is anticipated that phased removal and conversion of habitats will be performed to help minimize short-term impacts or habitat loss.

Under alternative B, we would increase monitoring, EDRR, and control of invasive species, especially in areas where change in management or land use occurs or emergent infestations develop and along dispersal corridors (roads, ditches, trails, etc.). Management of invasive species will help protect and maintain a diversity and abundance of vegetation in all habitats, which would improve nesting site availability and success for land birds.

Adverse Impacts

Habitat management, consolidation and reconfiguring, and restoration of forests, brushlands, and grasslands under alternative B would likely result in short-term, infrequent, and negligible disturbances to landbirds during necessary work and maintenance of these areas. These habitats may most often support common passerine species such as bluebirds and robins, finches, mockingbirds and other mimics, chickadees and titmice, flycatchers, wrens, and various sparrows; and other landbird species such as common woodpeckers and common raptors.

These common refuge birds may experience short-term, localized, adverse impacts as they may be temporarily displaced by noise or activity from machinery or other management activities. Provided these activities occur in the non-nesting season, this displacement would be expected to result in a temporary relocation of birds that are loafing, foraging, or engaging in other non-breeding behaviors. Displaced birds would have similar habitat options elsewhere throughout the refuge and adjacent areas . As a result, we expect that temporary bird displacement caused by management activity to have a negligible adverse impact on bird populations.

The habitats that will be altered under this alternative are fragmented habitats such as hedgerows and small grassland patches. This reconfiguration will result in a permanent change of the generalist habitat of some nesting or foraging birds. Hedgerows that are removed would be expected to support some common nesting disturbance tolerant species such as robins, cardinals or catbirds. In addition, some of the small grassland patches that are currently utilized by common field foraging species such as bluebirds, mourning doves, or field sparrows will be allowed to succeed into brushland or forest. The hedgerow and small open patch habitats that will be altered under this alternative are common and readily available throughout the regional urbanized landscape. As a result, any permanent alteration of foraging or nesting landbird habitat will have only short-term, localized, and negligible impacts on common bird populations.

We would continue to monitor known nest locations and adjust our management and timing of our actions to minimize impacts on landbirds. We would minimize or restrict certain activities, such as prescribed burns and mechanical vegetation treatments, to the fall and winter (i.e., outside of the breeding season) and would scout areas for nesting birds prior to commencing work.

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Alternative B anticipates an increase in refuge visitation over the next 15 years. Much of this increase is expected in the form of school groups and recreational users. Adverse impacts to landbirds are expected to be similar to or slightly greater than those discussed in section 4.7.1, *Impacts on Landbirds That Would Not Vary by Alternative.*

We would pursue creating additional trails and the construction of new wildlife viewing facilities, such as observation towers. Construction timing would be considered where necessary to avoid potential disturbance to nesting species, as well as to minimize impacts on foraging and resting habitat during important seasonal periods such as nesting or migration. As a result, minimal adverse impacts are anticipated from proposed

construction projects. We would evaluate the sites and programs periodically to assess whether these facilities are meeting the objectives and to prevent site degradation. If the use causes evident and unacceptable adverse impacts, the refuge would rotate the activities to secondary sites, curtail, or discontinue the use.

Under this alternative, we would open a spring turkey hunt for gobblers (males) in select areas of the refuge, specifically in the Wilderness Area and areas south of White Bridge Road. There would be no fall hunt for wild turkey. The hunt would be held for recreational purposes only (not for population management) and would sustain low daily densities of hunters. We would collect data to determine the refuge's turkey population through regular winter and spring counts. Estimating the refuge's turkey population will allow us to determine appropriate bag limits, to evaluate the success of the hunt program, and to prevent negative impacts to the refuge's wild turkey population. Turkey hunting would impact individual birds; however, we would expect only negligible impacts to the overall population. Turkey hunting has the most potential to cause disturbance to landbirds, particularly ground nesting forest birds of conservation concern, such as wood thrush. If implemented, the spring hunting season would take place on select days between mid-April and early May, when female birds are likely to be laying or incubating. This timing provides additional protection to the female turkeys, which would not be disturbed by hunters, because turkey hunters stay in one place waiting for turkeys or attempting to call males to them. Hunters may temporarily disrupt feeding and resting of migrating birds. Additionally, off-trail hiking by turkey hunters could disturb low-elevation or ground nesting breeding birds as they attempt to establish and settle into nest territories, build nests, or incubate eggs. Given the low number of turkeys anticipated to be harvested from the refuge, initially likely to range between 1-5 individuals, no cumulative impacts to local, regional or Statewide populations of turkeys are anticipated. In 2012, the Statewide harvest was 2,954 male turkeys. Turkey hunters by the nature of the hunt are mostly sedentary once initial set up has occurred so impacts to landbirds are expected to be negligible.

4.6.4 Impacts on Landbirds under Alternative C

Benefits

Alternative C differs slightly from alternative B in benefits to landbirds. This alternative would provide additional forest and late successional vegetation communities by maximizing natural regeneration. Similar to alternative B, we would continue to manage large tracts of brushlands and grasslands. Shrub and early successional habitats are currently under-represented across the region, and are considered some of the rarest wildlife habitat types in the Northeast. These habitat types benefit various warbler species and other songbirds that use dense shrub cover and open grasslands.

Under this alternative, we would consider the use of deer exclusion devices to promote succession and forest regeneration. This would also provide opportunities to study and document browsing impacts by deer.

Similar to alternative B, providing additional opportunities for environmental education and interpretation would raise public awareness and support for wildlife protection and habitat conservation.

Adverse Impacts

Adverse impacts to landbirds are similar to those discussed in section 4.6.3, alternative B. Alternative C also anticipates a similar increase in refuge participation and visitation as alternative A. Impacts to

landbirds due to visitation are the same as those discussed in section 4.6.1, *Impacts on Landbirds That Would Not Vary by Alternative*.

4.6.5 Impacts on Landbirds under Alternative D

Benefits
Impacts to landbirds under alternative D are the similar to those discussed in section 4.6.3, alternative B.

Alternative D will provide the maximum number of environmental education and interpretation programs, which would likely raise public awareness and support for wildlife protection and habitat conservation.

Adverse Impacts
Alternative D anticipates the greatest increase in refuge participation and visitation over the next 15 years. Much of this increase is expected in the form of school groups and recreational users. This alternative emphasizes, to a greater extent than alternative B, the expansion of infrastructure, including the creation of new trails, observation towers, and parking lots. In addition, seasonal pedestrian access would be provided on existing service roads around Pools 3A and 3B; however, these areas would be closed to the public during migration or other time periods where wildlife may be sensitive to disturbances.

As discussed above, timing of construction would be considered where necessary to avoid potential disturbance to nesting species, as well as to minimize impacts on foraging and resting habitat during important seasonal periods, such as nesting or migration. As a result, minimal adverse impacts are anticipated from proposed construction projects. We would evaluate the sites and programs periodically to assess whether these facilities are meeting the objectives and to prevent site degradation. If any public use or new infrastructure results in evident and unacceptable adverse impacts, the refuge would move the activities to secondary sites, curtail, or discontinue the use.

Adverse impacts to landbirds are expected to be similar to or slightly greater than those discussed in section 4.6.1, *Impacts on Landbirds That Would Not Vary by Alternative,* and section 4.6.3, *Impacts on Landbirds under Alternative B.*

4.7 Impacts on Open Water and Wetland Bird Species

The refuge's wetlands and open water habitats support a number of waterfowl, waterbird and shorebird species (see chapter 2, section 2.6.3). Among the species of regional concern that utilize the refuge open waters and wetlands are American black duck, American bittern, least bittern, and great blue heron. Four rail species, including the king rail, Virginia rail, sora, and common moorhen, nest within the marsh habitats at Great Swamp NWR. Several shorebird species, including greater and lesser yellowlegs, dunlin, semipalmated, and least and solitary sandpipers, utilize the refuge wetlands during migratory periods. The American woodcock, a shorebird of the highest refuge and regional priority, utilizes emergent and scrub-shrub wetlands for nesting and is given the highest consideration in all habitat management of wetlands and waters. We evaluated the management actions for each alternative for their potential to benefit or adversely impact open waters and wetland habitats and refuge priority species that utilize these habitats.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of open water and wetland bird focal species:

- Allowing natural regeneration of vegetation and emergent wetlands in Pools 3A and 3B.
- Consolidation of scrub-shrub (brushland) and grassland habitats and natural regeneration of small, isolated, or difficult to manage habitat fragments.
- Controlling invasive species.
- Increasing public awareness through environmental education and interpretation programs and wildlife-dependent recreation.
- Improving water quality and flood protection through local and regional partnerships.

We evaluated the potential for the proposed actions to cause adverse effects on habitats of waterbird focal species:

- Disturbance of species from public use, including increases in visitation, expansion of trail systems and public access, and introduction of fishing.
- Disturbances associated with impoundment water level manipulation, including reducing open water habitat and allowing natural regeneration in Pools 3A and 3B.
- Potential impacts from treating invasive species with pesticides or other management practices.
- Construction of additional wildlife observation infrastructure, such as wildlife observation towers.

4.7.1 Impacts on Open Water and Wetland Birds That Would Not Vary by Alternative

Benefits

Under all alternatives, the refuge would continue to restrict public access and management activities, when and where appropriate, including near known nesting sites and important wintering areas. We would monitor and evaluate the breeding success of American woodcock and other priority waterbird, shorebird, and waterfowl species.

The refuge will continue to provide a diversity of wetland habitats dominated by native species, including marshes, open water and mudflats for waterfowl, waterbirds, and shorebirds of regional conservation concern, such as American and least bitterns, sora, king rail, and American black duck.

Under all alternatives, an interspersion of habitats, such as emergent and scrub-shrub wetlands will be maintained to support a stable population of breeding American woodcock on the refuge.

The refuge would monitor and continue to control invasive plant species, including but not limited to common reed and purple loosestrife, that reduce native species diversity and productivity of wetlands. A variety of carefully considered invasive species management tools, such as mechanical, biological, and chemical controls, will be utilized to achieve our objectives in managing for the biological integrity, diversity and environmental health of open water and wetland habitats.

Under all alternatives, the refuge would continue to support programs that feature waterfowl, waterbirds, shorebirds, and their habitats. We would encourage the public to participate in activities, such as wildlife photography, that involve these species at the refuge. We believe that connecting people to nature through these types of activities would help encourage habitat conservation over time.

Adverse Impacts

Bennett and Zuelke (1999) summarize several studies indicating recreational activities that would have at least temporary effects on the behavior and movement of birds using shallow water habitats adjacent to trails and roads on wildlife refuges (Burger 1981, 1986; Klein 1993; Burger et al. 1995; Klein et al. 1995; Rodgers and Smith 1997; Burger and Gochfeld 1998). Some minor disturbance or displacement of shorebirds may occur near the observation pond along Pleasant Plains Road, especially during periods of migration and at peak visitation times. Disturbances or displacement of waterfowl, waterbirds, or shorebirds may also occur along other public access areas near water, such as at the WOC or near impoundments, particularly during peak visitation times of the year or when group activities or programs are occurring. These disturbances are generally limited and temporary in nature. We would evaluate areas potentially impacted by frequent visitation and programs periodically to assess whether they are meeting objectives, degrading sites, or disturbing wildlife. If the use causes evident and unacceptable adverse impacts, the refuge would move the activities to secondary sites, change their seasonal timing or frequency, curtail or discontinue them.

Overall, the effects from public use are expected to have minimal adverse effects on waterbirds utilizing open water and wetland habitats. There are few visitor facilities (e.g., trails) in these habitats due to the presence of open water, saturated soils, and their location in a closed area of the refuge; therefore, they are relatively inaccessible to the public. Large dense emergent vegetation dominant wetlands and portions of open water would be expected to provide adequate buffers to protect wetland bird species against human disturbance (Gibbs and Melvin 1992).

Invasive species control can be detrimental to open water and wetland birds if proper timing and application are not considered. Extreme caution will be used in the application of mechanical, biological and chemical invasive species control within the vicinity of wetlands and open water. Chemical treatments will require the focused application of approved wetland and open water pesticides, restricting pesticide application during sensitive breeding and fledging periods, and during periods when weather conditions exceed application thresholds. The refuge will continue to require all staff utilizing pesticides be properly trained to avoid adverse impacts.

Issues of water quality (see section 4.3), including contaminants from nonpoint source pollution, have the potential to impact refuge waterbirds, waterfowl and shorebirds feeding on aquatic flora and fauna. As previously mentioned, continued partnerships with local communities is the best method for the refuge to improve refuge water quality and ultimately protect wildlife from contamination.

4.7.2 Impacts on Open Water and Wetland Birds under Alternative A (Current Management)

Benefits and adverse impacts to open water and wetland birds are the same as those discussed in section 4.7.1, *Impacts That Would Not Vary by Alternative.*

4.7.3 Impacts on Open water and Wetland Birds under Alternative B (FWS-Preferred Alternative)

Benefits

The consolidation of managed shrubland and grassland habitats will be designed to provide habitat benefits to American woodcock. Grassland or shrubland fragments targeted for natural regeneration and ultimately reforestation are not utilized by nesting or staging woodcock. Other areas of grassland and scrub-shrub habitat proposed to be enhanced or expanded under this alternative currently provide suitable habitat for American woodcock (see chapter 3, alternative B, goal 2) and as a result, we expect direct benefits to American woodcock populations on the refuge. Populations of woodcock will need to be carefully monitored in areas of habitat expansion and management adjusted as needed to maximize the benefit to this species.

Within 5 years, Pools 3A and 3B would be evaluated to determine the ecological costs and benefits of maintaining, enhancing, or altering succession in each of the impoundments. Depending on the findings of these evaluations and the future management of these areas, hydrology and vegetation composition within these impoundments may change. Adverse impacts and benefits to impoundments may eventually be similar to alternative A or alternative C, depending on results of the impoundment study and conclusions. The study results will enable us to minimize impacts to ecological communities under the chosen management scenario.

As a result, alternative D creates more opportunities to educate a greater numbers of individuals on the benefits of wetland preservation, water quality, and the diversity of wetland and open water birds and other wildlife on the refuge. We believe that connecting people to nature through environmental interpretation and education would help encourage habitat conservation over time.

Adverse Impacts

Increases in visitation would be expected to be greater under alternative B than the no-action alternative. This may result from increases in interpretive programs and improvements to infrastructure, such as trail extensions and the development of two observation towers. Wildlife observation towers will be created in existing public access areas. Negligible differences in displacement or disturbance of waterfowl and waterbirds may occur as a result of increased visitation. New trails are not proposed in any sensitive shorebird, waterbird or waterfowl nesting habitats. Any impacts due to increases in visitation can be mitigated by careful monitoring of visitation in these areas and, if needed, the adjustment of programs accordingly to minimize impacts to wildlife. These adjustments may involve use of alternate areas or seasonal restrictions on access, if required.

The creation of infrastructure near wetlands and open water habitats, such as the wildlife observation towers may have a temporary impact on wetland or open water birds or wildlife during construction due to increased activity and noise. The assembly of observation towers at the WOC and along Pleasant Plains Road will be performed with the use of heavy machinery during times of the year that will have the least impact on breeding birds and other sensitive wildlife. We believe that connecting people to nature through wildlife observation and photography and environmental education and interpretive programs would raise public awareness and support for wildlife protection and habitat conservation over time.

The consolidation of habitats, particularly the use of machinery to remove hedgerows and other activities within the vicinity of wetlands or open water, has the potential to temporarily disturb or displace certain

wildlife species, such as American woodcock or wood duck. Timing of construction would be considered to avoid disturbance to sensitive species and impacts to these species is not anticipated.

Overall, adverse impacts to open water and wetland birds would be localized, minor, and short-term.

4.7.4 Impacts on Open Water and Wetland Birds under Alternative C

Benefits

Benefits to open water and wetland birds would be similar to those discussed under section 4.7.3, *Impacts on Open Water and Wetland Birds under Alternative B,* except Pools 3A and 3B would no longer be maintained as impoundments, and as a result, these areas would be allowed to succeed to naturally occurring marsh or shrub swamp plant communities. Allowing these areas to return to a more natural hydrologic condition and vegetative community more closely follows the Refuge System's BIDEH policy. Natural succession of these areas would reduce open water and result in greater densities and variations of native wetland vegetation that would benefit a suite of marsh, scrub-shrub, and wetland dependent species, including American and least bitterns; marsh wren; various herons, rails, and shorebirds; willow flycatcher; and blue-winged warbler. Refer to chapter 3, alternative C for further information of habitat requirements of focal species and the expected benefit from expansion of naturally occurring marsh habitat.

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Adverse Impacts

Since Pools 3A and 3B would no longer be maintained as impoundments under this alternative, there would be a decrease in the amount of open water habitat and an increase in shrub swamp plant communities due to natural regeneration and lower water levels. We would remove boards from the water control structure, which control the water levels of an impoundment, in an attempt to restore the natural hydrology of these areas. We anticipate that the wetlands would contain shallower, seasonal amounts of standing water. The conversion of impoundments (specifically Pools 3A and 3B) to a mix of natural marsh and scrub-shrub wetlands may result in some minor displacement of non-breeding waterfowl from the loss of open water; however, we do not anticipate impacts to overall populations of waterfowl. Although the primary purpose of the refuge is to provide foraging, resting and staging habitat for migratory waterfowl, the refuge's size, inland location, and the largely forested and urbanized surrounding landscape does not significantly contribute to overall waterfowl populations. Regardless, Great Swamp NWR would continue to provide an interspersion of wetland and open water habitats for waterfowl at remaining impoundments.

As with alternative A, alternative C anticipates some increases in refuge visitation. However, as less emphasis is directed toward increasing visitation under this alternative than under alternatives B and D, we would expect slightly less impact from increases in traffic, noise and other disturbances in publically accessed wetlands and open water areas. As mentioned above under section 4.7.1, *Impacts That Would Not Vary by Alternative*, existing precautionary measures would result in infrequent, localized impacts on open water or wetland birds with the anticipated increase in visitation. We would continue to monitor refuge visitation and potential impacts on open water and wetland birds and adjust our management accordingly to continue to protect these species and their habitats.

4.7.5 Impacts on Open Water and Wetland Birds under Alternative D

Benefits

Benefits to open water and wetland birds would be similar to those discussed under section 4.7.3, *Impacts on Open Water and Wetland Birds under Alternative B,* except this alternative places greater emphasis on the expansion of programs, partnerships, and visitation. As a result, alternative D creates more opportunities to educate a greater numbers of individuals on the benefits of wetland preservation, water quality, and the diversity of wetland and open water birds and other wildlife on the refuge. We believe that connecting people to nature through environmental interpretation and education would help encourage habitat conservation over time.

Adverse Impacts

Alternative D anticipates the greatest increase in refuge visitation over the next 15 years. This alternative emphasizes, to a greater extent than alternative B, the expansion of infrastructure, including the creation of new trails, observation towers, and parking lots. Some of the infrastructure proposed under alternative B is included under this alternative as well, such as the development of two observation towers and the introduction of several new trails; however, this alternative also proposes the creation of several more access trails that would increase the likelihood and frequency of disturbance to wildlife. Therefore, the potential for wildlife impacts due to increased visitation would be slightly higher than other alternatives (described under section 4.7.1, *Impacts that Would Not Vary by Alternative*). In addition, seasonal pedestrian access would be provided on existing service roads around Pools 3A and 3B. Access would be restricted to certain times of the year when sensitive wildlife are least vulnerable. Seasonal restrictions may include breeding or migratory periods for waterfowl or waterbirds. It is likely that even with seasonal restrictions, some displacement and disturbance of wildlife may occur. There is also greater potential for unauthorized access to occur as visitors become familiar with these trails. The refuge would strictly enforce and communicate the restrictions on access to these areas to minimize negative impacts. If any public use or new infrastructure results in evident and unacceptable adverse impacts to waterbirds, waterfowl, or shorebirds to public use, the refuge would move the activities to secondary sites, curtail, or discontinue the use altogether.

Other proposed non-wildlife dependent recreational activities proposed under this alternative that are near water, such as allowing canoeing or kayaking access across refuge lands along the Passaic River, also has the potential to displace nesting or wintering waterfowl, waterbirds and other wildlife. The establishment of fishing opportunities on the refuge may result in some impact to open water and wetland dependent birds. Such negative impacts to birds could occur from lost fishing gear, including entanglement in fishing line or ingestion of lead sinkers, hooks, lures, or litter. Ingested tackle may be toxic or cause damage or penetration of the mouth or other parts of the digestive tract that may result in impaired functioning or death. Lost fishing tackle such as fishing lures may harm waterfowl and waterbirds that become impaled by a hook. Fishing line may also become wrapped around body parts and hinder movement (legs, wings), impair feeding (bill), or cause a constriction with subsequent reduction of blood flow and tissue damage. Any introduction of fishing would require careful monitoring of litter and its impact on wildlife

4.8 Impacts on Fisheries

The refuge supports a relatively diverse fish community with at least 21 documented species. The refuge is primarily host to a warmwater fishery, with some cold water species existing near the refuge border (i.e.,

within Primrose Brook). Among the coldwater species identified are the non-native brown trout (*Salmo trutta*) and native brook trout (*Salvelinus fontinalis*). Although a comprehensive inventory of fish species inhabiting the refuge has not been conducted recently; studies of the Lower Passaic-Hackensack River Watershed have been conducted. Approximately 39 species of freshwater fish have been reported in or immediately adjacent to the Great Swamp NWR within the Passaic-Hackensack River Watershed.

The refuge does not support any Federal trust fish species. No anadromous (Clupeids or striped bass) species have been reported within the refuge, as there are significant migratory impediments along major downstream waters (i.e., Great Falls of the Passaic River).

Fishing is the only priority public use ("Big Six" public use) that is not currently authorized on the refuge. Although the refuge has found some evidence of unauthorized fishing, demand for the activity on the refuge has remained low. Some fishing opportunities exist adjacent to the refuge and nearby.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of fish species likely to utilize refuge habitats:

- Managing and restoring bottomland, upland, riparian, and floodplain forests; scrub-shrub; grasslands; open waters; and non-forested wetlands and emergent marsh.
- Controlling invasive species.
- Increasing public awareness through environmental interpretation and wildlife-dependent recreation.

We evaluated the potential for the proposed actions to cause adverse effects on habitats of fish:

- Opening fishing in select areas of the refuge.
- Impacts on habitat quality from the construction or expansion of facilities.
- Potential impacts from spraying of invasive species and impoundment water level manipulation.
- Construction of additional wildlife observation infrastructure, such as trails, observation towers, and viewing blinds.

4.8.1 Impacts on Fisheries That Would Not Vary by Alternative

Benefits

Many of the same management actions for protecting wetlands and other species, such as controlling non-native invasive plants and providing or improving vegetated buffers around wetland-upland interfaces and riparian edges, are actions that would take place regardless of which alternative we select, and would not only benefit wetlands, but the fish species that depend upon good water quality and a well-functioning wetland ecosystem.

Where floodplain forests are found adjacent to open water, the debris from trees and other vegetation falling into the water provides cover and food. Trees along streams and adjacent to open water also helps

lower water temperatures. Many related benefits of floodplain forests are also described under the section on hydrology and water quality.

Adverse Impacts

Overall, the effects from public use (both current and anticipated) are not likely to have an impact on fisheries utilizing open water and wetland habitats on the refuge. Other sources of environmental contamination can be created by stormwater runoff from surrounding lands and the watershed. While it has never happened on the refuge, the use of pesticides in invasive species control could potentially cause small localized and temporary contamination in the event of a spill or misapplication. Glyphosate is nearly non-toxic to fish which generally excrete the chemical in an unchanged form (USEPA 1987). Glyphosate does have a high solubility rate in water (Schuette 1998). However, the potential for glyphosate to accumulate in the tissues of aquatic invertebrates or other aquatic organisms is considered low (PIP 1984). Triclopyr is not labelled for aquatic applications and is toxic to fish at high concentrations. Residues are not persistent (Berisford et al. 2006), however, and dissipate rapidly in the environment (Johnson et al. 1995; Woodburn et al. 1993; Petty et al. 2001; Kreutzweiser et al. 1995). We would continue to employ BMPs in terms of applicator training, pesticide selection, use, spill prevention, and spill response to avoid impacts from pesticide contamination. Since glyphosate strongly adsorbs to soil and sediment and dissipates rapidly in the water column, spill cleanup would involve primarily excavation and containerization of contaminated soil or sediment. Due to its higher toxicity in aquatic systems (than glyphosate), triclopyr spills would require containment by absorbing with sand, vermiculite or other inert absorbent before placement of contaminated material in appropriate container for disposal. Large spills might require diking using absorbent or impervious material such as clay or sand and recovery of as much free liquid as possible for reuse. Absorbed material would be allowed to solidify, then scraped up for disposal.

4.8.2 Impacts on Fisheries under Alternative A (Current Management)

Benefits and adverse impacts to fisheries are the same as those discussed in *Impacts That Would Not Vary by Alternative*.

4.8.3 Impacts on Fisheries under Alternative B (FWS-Preferred Alternative)

Benefits

The consolidation and reconfiguration of habitat types will include the conversion of isolated, small, or difficult to manage brushland and grassland fields to later successional stages or forest. The consolidation of habitats will result in a long-term reduction in maintenance efforts, which will ultimately reduce the potential for water pollution due to leaks and exhausts from equipment. Additional forest cover will likely improve water quality by increasing nutrient and contaminant uptake.

This alternative would expand environmental education and interpretive opportunities. Some programs will be designed to promote awareness on regional issues, including water quality, watershed protections, and climate change. Maintaining and expanding a network of partnerships is the largest component to improving refuge water quality under this alternative.

Under alternative B, we would increase monitoring, EDRR, and control of invasive species, including aquatic invasive species. Management of aquatic invasive species will help protect and maintain the ecological health of our streams and fisheries.

Refer to section 4.3.3, *Impacts on Hydrology and Water Quality under Alternative B* above for additional information.

Adverse Impacts
Habitat management, consolidation and reconfiguring, and restoration of forests, brushlands, and grasslands may result in short-term disturbances to soil. The most disturbances will likely occur during the reconfiguration of habitat patches and removal of hedgerows. This alternative also proposes the construction of additional trails and new wildlife viewing facilities, such as observation towers. The use of BMPs, including sediment and soil erosion controls (see 4.3.1, *Impacts on Soils That Would Not Vary by Alternative*) would be implemented during any construction to minimize the release of sediment into environmentally sensitive areas, such as wetlands and waterbodies. In addition, we would not perform any activity that may introduce sediment into a stream or cause a stream to become turbid during the NJDEP's recommended timing restriction of April 1 through June 30 for warmwater fisheries. As a result, minimal adverse impacts are anticipated from proposed construction projects.

Alternative B anticipates an increase in refuge visitation over the next 15 years; however, at this time, increased public use is not likely to have an impact on fisheries utilizing open water and wetland habitats on the refuge. We would monitor and periodically assess roads, trails and facilities for evidence of erosion. If any public use causes evident and unacceptable adverse impacts, the refuge would limit or discontinue the use.

4.8.4 Impacts on Fisheries under Alternative C

Benefits
This alternative proposes to maximize natural regeneration, which would provide additional forest and late successional vegetation communities. This would likely improve water quality by lowering water temperatures, filtering out sediments and contaminants, preventing stream bank erosion, and increasing the water's capacity to retain DO.

Although all alternatives would continue to maintain relationships with partners to provide consistent watershed protection in the communities surrounding the refuge, alternative C provides the greatest emphasis on partnerships and efforts that expand unifying ordinances and legislation to protect the GSW.

Under alternative C, Pools 3A and 3B would be allowed to succeed to natural marsh and scrub shrub wetlands. Allowing natural regeneration to occur within these impoundments will likely improve water quality by increasing nutrient and contaminant uptake.

Adverse Impacts
Pools 3A and 3B are heavily vegetated and contain areas of shallow water. Some fish may reside in the impoundments; therefore, impacts to individual species may occur due to changes in hydrology from the removal of boards from water control structures. Pool 3A contains an emergency overflow that discharges to the Passaic River and Pool 3B drains directly to the river through a water control structure; therefore, the removal of boards from these water control structures has the potential to result in minor, temporary increases in turbidity in the Passaic River as water is released from the impoundments.

Removal of boards would be conducted in a controlled fashion, over an appropriate period of time, and under appropriate (non-flooding) conditions. These precautions would eliminate the possibility of a rapid

change in water levels or a rapid release of sediments into the Passaic River. This carefully controlled activity, relative to the large drainage area and surface water volume of the Passaic River, would have short-term localized and negligible impacts on the River and associated watershed.

In general, the refuge would use BMPs, including soil erosion and sedimentation controls, as part of all construction projects to minimize the impacts to fisheries.

Impacts due to programs, expansion or construction of facilities, maintenance, and visitation would be similar to those discussed under section 4.8.3, *Impacts on Fisheries under Alternative B.*

4.8.5 Impacts on Fisheries under Alternative D

Benefits

Alternative D would provide visitors with fishing opportunities in select areas of the refuge. Fishing would create isolated negative impacts for some individual fish and would increase potential for adverse impacts associated with increased public use (e.g., littering, introduction of non-native fish or aquatic invasives, etc.); however, we feel that connecting people to nature through this activity would help encourage habitat conservation over time.

Adverse Impacts

Similar to alternative B, alternative D anticipates an increase in refuge participation and visitation; however, alternative D would most likely result in slightly higher numbers of public use visitation when compared to alternative B.

By providing fishing opportunities, we would have impacts to individual fish. Anglers on the refuge would be required to comply with State fishing regulations, which are intended to protect fish populations. While we encourage catch and release because of the potential contaminants present in game fish, this also helps maintain local fish populations. We feel that the long-term protection benefits gained by connecting people to nature through this public use do not affect the health of fish populations as a whole and outweigh the adverse impacts on individual fish. Regardless of the alternative, we would continue to employ a range of management tools to achieve our objectives in managing for the improved health and integrity of open water and wetland habitats.

As mentioned above, fishing would increase the potential for adverse impacts associated with increased public use, such as littering (trash, fishing line, and other tackle) and inadvertent introduction of aquatic invasives. Several aquatic invasives are becoming problematic in New Jersey, including Eurasian watermilfoil (*Myriophyllum spicatum*), didymo or “rock snot”, water chestnut (*Trapa natans*), and Hydrilla (*Hydrilla verticillata*). In addition, accidental or deliberate introductions of non-native fish through public fishing may negatively impact native fish populations. The refuge will provide educational outreach and signage on these subjects, and minimize impacts associated with non-native species introductions or aquatic invasives, if they occur, through EDRR methods.

Providing fishing opportunities may lead to unnecessary wildlife hazards from lost fishing gear, including ingestion of lead sinkers, hooks, lures, or litter, or entanglement in fishing line or hooks. Lost fishing tackle may harm waterfowl, kingfishers, herons, and other birds by catching on and tearing skin. Fishing line may also become wrapped around body parts and hinder movement (legs, wings), impair feeding (bill), or cause

a constriction with subsequent reduction of blood flow and tissue damage. Birds may also ingest sinkers, hooks, floats, lures, and fishing line. Ingested tackle may be toxic or cause damage or penetration of the mouth or other parts of the digestive tract that may result in impaired function or death. The refuge would provide education and outreach on the hazards of fishing tackle, and encourage the use of lead-free weights and fishing tackle and biodegradable fishing line.

Effects of construction and restoration projects would be similar to those described under alternative B.

4.9 Impacts on Mammals

Mammals in the vicinity of Great Swamp NWR occupy a diverse array of habitat types and food webs. As a taxonomic group, mammals benefit from refuge land protection and management of upland, bottomland, riparian, and floodplain forests; grasslands; managed and naturally-occurring scrub-shrub fields; open water; and wetlands. Likewise, refuge habitats would benefit from careful attention to the impacts on mammals resulting from any of its activities.

With exception to a few species, mammals on the refuge consist largely of relatively common species found across the Mid-Atlantic. Most of these species are able to use a variety of wetland or terrestrial habitats, and their populations on the refuge would not be expected to change under any of the alternatives.

Great Swamp NWR is documented as having maternal roost colonies of Indiana bats, a State- and federally listed endangered species. Roosting by Indiana bat occurs within the Management and Wilderness Areas of the refuge where an interspersion of forests, shrubland, open water, and wet meadow exists (Kitchell 2008). Pregnant or lactating bats forage primarily within wooded or riparian corridors, streams, associated floodplain forests and impounded bodies of water; however, they will sometimes use hedgerows, upland forest, early successional fields and croplands (Kitchell 2008). Other bat species that have been documented at the refuge include: little brown, tri-colored, Northern long-eared, big brown, Eastern small footed, hoary, silver haired, and Eastern red bats. As discussed in previous chapters, more than 5.5 million hibernating bats have died since WNS was documented in the winter of 2006-2007 (USFWS 2012d); see chapter 1, section 1.4.14 and chapter 2, section 2.6.1 for details. The majority of bats dying in the Northeast have been little brown bats; however, WNS has also affected tri-colored bat, Northern long-eared bat, Eastern small footed bat, Indiana bat, and big brown bat (USFWS 2010c).

As discussed in section 1.4.14, potential declines were documented at the refuge post-WNS; however, detecting WNS related impacts on the maternity colony is extremely difficult in absence of substantial baseline data and significant mist netting survey efforts. Data collected at the refuge between 2006 and 2010 indicates that peak emergence counts showed a potential decline in Indiana bat colony size. Although few bats showed evidence of wing scarring, significant changes in both the bat population and in the proportion of reproductive females were evident following the onset of WNS. Survey results also indicated substantial declines in little brown bat populations; declines in Indiana bat and Northern long-eared bat populations; and significant increases in big brown bat populations after the onset of WNS (Kitchell and Wight undated). We are concerned about the status of our cave hibernating bats given the presence of WNS and the important role bats play in the foodweb and ecosystems.

River otters and mink have also been identified in the streams and rivers on and adjacent to the refuge. The river otter was once extirpated from the Great Swamp NWR until it reappeared in the 1970s. The refuge's streams and open water habitats provide suitable habitat for these two species, as well as numerous other wildlife species, including but not limited to black bear, muskrat, beaver, and raccoon.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of mammal species likely to utilize refuge habitats:

- Managing and restoring an interspersion of bottomland, upland, riparian and floodplain forests, open water, grasslands, and brushlands.
- Controlling and monitoring invasive species.
- Increasing public awareness through environmental interpretation and wildlife-dependent recreation.

We evaluated the potential for the proposed actions to cause adverse effects on habitats of mammals:

- Management of existing and proposed changes to the hunting program (e.g., opening deer archery season).
- Disturbance to mammals from public use.
- Potential impacts from treating invasive species, forest restoration, reconfiguration and consolidation of habitats, and water level manipulation of impoundments.
- Construction of additional wildlife observation infrastructure, such as observation towers.

4.9.1 Impacts on Mammals That Would Not Vary by Alternative

Benefits

Our strategies for habitat improvement measures and controlling invasive or nuisance species hold the potential for impacts on mammals, and would continue regardless of the alternative we select. Each management action indirectly benefits mammals over the long term by ensuring the continuation of quality natural habitats on the refuge. Ongoing management activities, such as invasive species management and inventory and monitoring programs, would continue to be completed in a manner that would minimize potential impacts to individual species. We will continue to allow dead trees and snags to persist (i.e., no cutting or removal) for various wildlife species, especially bats, woodpeckers, owls, and other wildlife species.

We will continue to monitor and control white-tailed deer. This will benefit the deer herd and other wildlife species by improving the quality of habitat and reducing property damage. Other furbearers and rodents will benefit from the habitat diversity and quality, and promotion of native plants species emphasized across all alternatives. Expanded and improved forest corridors on the refuge and locally via refuge land protection partnerships will benefit bats and aquatic or wetland mammals, such as river otter and mink. Beaver, when determined to be a nuisance because of undesired flooding of adjacent private property or refuge lands, will continue to be relocated to areas of the refuge where they are less likely to be a problem.

Adverse Impacts

Regardless of the alternative, we would continue to employ a range of management tools to achieve our objectives in managing for the improved health and integrity of terrestrial and wetland habitats. We would use these tools only when and where appropriate, and only with the proper training and focused application to avoid adverse impacts.

Examples of management techniques include control of invasive species, brushland cutting, and mowing activities associated with roadsides, facilities, or habitats. Areas where invasive species control or habitat diversity objectives warrant clearing an entire monotypic stand occur on a very small scale. The timing of pesticide applications varies depending on target species, treatment method, and environmental conditions. Occasionally, eliminating large monocultures of a non-native species is necessary, but in most cases, the treatments are highly targeted and spot-specific. Treated sites soon re-grow, and mammals still have similar habitat or other areas nearby for alternate use; therefore, this activity is expected to have minimal negative impacts on some individuals that are localized and short-term.

Hunting of white-tailed deer would occur under all of the alternatives. The 2011 Annual Deer Hunting Program indicates that hunting was allowed on approximately 6,376 acres of the refuge (i.e. 82 percent of the refuge) with the remaining area designated as safety zone or no entry. The maximum hunter density is approximately one hunter per 32 acres. To maintain quality habitat within the refuge, the refuge manages for a deer population density of 18 to 20 deer per square mile (USFWS 2011e). In the event that the population density falls below desired levels, as evidenced by an annual evaluation of harvest data and pre-hunt spotlight surveys, bag limits and harvest strategies are adjusted to reduce harvest pressure on the herd. For the 2009 deer season, 113 deer were harvested, including 48 bucks and 65 antlerless animals (does and fawns). For the 2010 deer season, a total of 121 deer were harvested, including 56 bucks and 65 antlerless animals. For the 2011 deer season, a total of 42 deer were harvested, including 22 bucks and 18 antlerless animals. The significant decline in harvested deer was due to an outbreak of Epizootic hemorrhagic disease (EHD) in the summer of 2011 resulting in a significant deer die-off (refer to section 3.1.16 for information regarding EHD). Similar temporary declines were also evident in 2007 and 2008 deer harvest numbers following an EHD outbreak in 2007. In both cases, bag limits and harvest strategies were adjusted to reduce the number of adult does harvested. For example, rather than allowing an unlimited number of antlerless deer and one antlered buck per hunter as had been the case from 2002 to 2006, from 2007 to 2011, the bag limit was reduced to two deer total, with a limit of one antlered buck per hunter; to help maintain a more natural buck age-class distribution, shotgun hunters were required to shoot an antlerless deer first, before harvesting a buck. However, following the 2011 season, the bag limit was further reduced to one deer of either sex per hunter. In general, recent levels of harvest are expected to maintain deer populations within the refuge to a density that reduces impacts to the forest understory and allows for forest regeneration. Although the refuge's hunt does impact individual deer on the refuge, it is unlikely that current levels of deer harvest would negatively impact the overall deer population of New Jersey. In fact, deer populations have reached problematic levels in numerous areas of the State, including communities near the refuge, but beyond the influence of the refuge's annual harvest. New Jersey's deer

USFWS/Ronald Laubenstein

population was estimated (prior to hunting season) to be approximately 110,000 in 2010, although populations vary geographically. To elaborate, New Jersey is sub-divided into 70 Deer Management Zones. The refuge comprises Deer Management Zone 38 and the annual refuge deer hunt is administered by the FWS in cooperation with NJDFW. The refuge is surrounded by State Deer Management Zone 13, which includes portions of Morris, Somerset, and Union Counties. State regulations in Zone 13 are liberal due to the overabundance of deer. For example, in 2011-12, a total of 1,706 deer were harvested from Zone 13. The State archery season spanned 135 days over three seasons, with a bag limit of 3 bucks and an unlimited number of antlerless deer per hunter; the muzzleloader season spanned 62 days, with a bag limit of one buck and unlimited antlerless deer; and the shotgun season spanned 50 days over two seasons, with a bag limit of two bucks and unlimited antlerless deer. Additionally, there was a 1-day youth archery hunt and 1-day youth firearm hunt, with bag limits of one deer of either sex (NJDFW 2012). Having an annual, limited firearm season for deer on the refuge (currently 5 days with a bag limit of 1 deer of either sex per hunter) coupled with adding a limited fall archery season (initially 5 days with a bag limit similar to that of the firearm season) will not impact New Jersey's deer population. In fact, in the communities surrounding the refuge, while a huntable deer population exists, there are limited public hunting opportunities, as the majority of land surrounding the refuge is developed and privately owned. Because there are so few large public places open for hunting, the refuge actually is providing a large contribution of deer control, which is not only benefiting refuge lands, but also the adjacent communities.

Overall, the effects from public use are not likely to have a negative impact on mammals. There is the potential for some negative impacts from increased vehicle use associated with greater visitation. Low refuge speed limits would likely keep the number of mammals hit by vehicles very low. An expected increase in visitation may create isolated negative impacts for some individual mammals; however, we feel that connecting people to nature through appropriate wildlife-dependent recreation, such as wildlife observation and photography, would minimize potential impacts and help encourage habitat conservation over time.

4.9.2 Impacts on Mammals under Alternative A (Current Management)

Benefits and adverse impacts to mammals are the same as those discussed in section 4.9.1, *Impacts on Mammals That Would Not Vary by Alternative*.

4.9.3 Impacts on Mammals under Alternative B (FWS-Preferred Alternative)

Benefits and Adverse Impacts

Benefits and adverse impacts to mammals are the same as those discussed in section 4.9.1, *Impacts on Mammals That Would Not Vary by Alternative*. In addition, management changes proposed under alternative B would result in approximately 100 acres less of grassland fields. In the short-term, there could be slightly less feeding habitat for bats, which forage over fields adjacent to woodlands, and less food and cover for open-habitat small mammals. However, significant adverse impacts to these species are not anticipated because the refuge would continue to provide sufficient roosting and foraging habitat for bats and small mammal populations are abundant. In fact, in the long-term, more bat roosting habitat would be available as trees mature and some die becoming valuable snags for these species. Moreover, under this alternative, where feasible, hedgerows less than 25 feet wide would be removed to create larger grassland patch sizes. Hedgerows provide important travel and feeding habitat for some species of carnivores (e.g., black bear, red fox, gray fox, and coyote); removing long hedgerows that connect forest patches could temporarily displace individuals or reduce home range quality for these species.

The introduction of a fall archery hunt for white-tailed deer will result in adverse impacts to individual deer on the refuge. This hunt would precede the current shotgun and muzzleloader season, and would occur within the Wilderness Area and on refuge lands south of White Bridge Road. Populations of hunted wildlife will be closely and regularly monitored. The target goal is to maintain levels of deer at 18 to 20 per square mile. Parameters of the hunt, including seasons and limits, will be adjusted as needed to maintain healthy populations of hunted wildlife.

4.9.4 Impacts on Mammals under Alternative C

Benefits and adverse impacts to mammals are similar to those discussed in section 4.9.1, *Impacts on Mammals That Would Not Vary by Alternative.* There could be less forage habitat for bats, which forage over fields adjacent to woodlands or over impoundments, and less food and cover for open-habitat small mammals. In the long-term, more bat roosting habitat could be available as trees mature and some die becoming valuable snags. As mentioned above, pregnant or lactating bats forage primarily within wooded or riparian corridors, streams, associated floodplain forests and impounded bodies of water; however, they will sometimes use hedgerows, upland forest, early successional fields and along croplands. Although alternative C proposes to maximize natural regeneration, which includes allowing Pools 3A and 3B to succeed, the refuge would continue to provide sufficient roosting and foraging habitat for bats. In addition, in the long term, more bat roosting habitat would be available as trees mature and some die becoming valuable snags. Therefore, adverse impacts to bats are not anticipated.

4.9.5 Impacts on Mammals under Alternative D

Benefits

Benefits to mammals under alternative D are the similar to those discussed in section 4.9.3, alternative B. Alternative D will provide the maximum number of environmental education and interpretation programs, which will raise public awareness and support for wildlife protection and habitat conservation.

Adverse Impacts

Alternative D anticipates the greatest increase in refuge participation and visitation over the next 15 years. This alternative emphasizes, to a greater extent than alternative B, the expansion of infrastructure, including the creation of new trails, observation towers, and parking lots. In addition, seasonal pedestrian access would be provided on existing service roads around Pools 3A and 3B; however, these areas would be closed to the public during migration or other time periods where wildlife may be sensitive to disturbances. If any public use or new infrastructure results in evident and unacceptable adverse impacts to mammals or other wildlife species, the refuge would move the activities to secondary sites, restrict, or discontinue the use altogether.

Adverse impacts to mammals are expected to be similar to or slightly greater than those discussed in section 4.9.1, *Impacts on Mammals That Would Not Vary by Alternative,* and section 4.9.3, *Impacts on Mammals under Alternative B.*

4.10 Impacts on Amphibians and Reptiles

The habitats of Great Swamp NWR support a diversity of amphibians and reptiles common to the northeastern United States (see chapter 2, section 2.6.5). Protection and management of emergent wetlands, riparian corridors, vernal pools, forests and successional habitats will benefit these species. Refuge priorities related to the long term viability of herptile populations would include the continued protection of regional water quality, control of invasive species, genetic viability, monitoring of chytrid fungus and other disease, and attention to ecological changes associated with global climate change.

The refuge currently provides critical habitat to and supports populations of certain threatened and endangered reptiles and amphibians including the federally-threatened bog turtle, the State-listed wood turtle and the blue–spotted salamander. These species and the protection of their habitats will continue to be prioritized under all alternatives.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of amphibians and reptiles likely to utilize refuge habitats:

- Consolidation and maintenance of forests, scrub-shrub, grasslands, open water, and wetlands.
- Management and restoration of spring-fed, emergent wetlands for bog turtle.
- Controlling invasive species.
- Maintenance and restoration of vernal pool habitats.
- Increasing public awareness through environmental education and interpretive programs.
- Changes in management of impoundments, including allowing natural regeneration of Pools 3A and 3B.

We evaluated the potential for the proposed actions to cause adverse effects on habitats of amphibians and reptiles:

- Disturbance of herptile species from increased visitation, public use, and vehicles.
- Potential impacts from the application of pesticides to treat invasive species, forest restoration, or impoundment water level manipulation.
- Impacts from construction of new infrastructure, including facilities, trails, and wildlife observation towers.

4.10.1 Impacts on Amphibians and Reptiles That Would Not Vary by Alternative

Benefits

Long-term improvements in water quality would benefit amphibian and reptile species, among others. The greatest water quality improvements to Great Swamp NWR will ultimately be achieved through partnerships, which promote continued watershed protection.

Under all alternatives, there will be continued habitat management to benefit populations of threatened and endangered herptile species, particularly the bog turtle. We would continue to maintain and restore spring-fed emergent wetlands to directly benefit the bog turtle, a year-round inhabitant of the refuge. Maintenance of these spring-fed habitats would also benefit a suite of other herptiles including spotted turtle, box turtles, pickerel frogs, leopard frogs and many additional species that utilize these habitats. Maintaining and improving key forest areas, grasslands, emergent wetlands and riparian habitats will ensure the continued protection of foraging, hibernating and nesting habitat of wood turtles and other herptiles that utilize similar habitats.

Protection of floodplain and vernal pools would continue to benefit amphibians and reptiles that rely on these sites for breeding habitat, including the State-endangered blue spotted salamander and the spotted turtle. The continued management of deer and invasive species across the refuge will improve natural regeneration of native ground cover, shrub vegetation, and other microhabitat conditions utilized by salamanders, snakes, and other herptiles.

Open grasslands adjacent to woodlands and forest are beneficial to box and wood turtles, which emerge to bask in the sun and feed on vegetation and invertebrates. These grassland areas also provide basking and foraging opportunities for common snake species at the refuge.

On- and offsite efforts to improve water quality and reduce non-point source pollution through protection of riparian buffers and wetlands will benefit frogs and other aquatic herptiles. Refuge partnerships and programs that focus on herptiles, their habitats and associated issues such as water quality will have a beneficial impact on the protection of these species. We will continue to monitor the success of habitat management for all threatened and endangered herptile species on the refuge.

Adverse Impacts

Some large-scale threats to herptiles, such as spread of chytrid fungus and climate change are global in nature and require cooperation between agencies, organizations, and nation to prevent impacts to herptile populations. The refuge, particularly through education, outreach and partnerships, will work to control and mitigate these larger regional herptile impacts while continuing to protect refuge herptile populations.

Climate change related issues such as increased rainfall or drought or extreme temperatures presents a major threat to amphibians and reptiles on the refuge and elsewhere. The refuge will carefully monitor sensitive herptile populations and apply adaptive management as needed to prevent impacts to these species.

Introduced diseases from pet wildlife or other sources are a constant threat to herptiles in New Jersey's urban environments and elsewhere. An amphibian disease of major concern in New Jersey is the chytrid fungus (see chapter 2, section 2.1.5). This deadly disease infects the skin of amphibians and is found in populations of frogs and salamanders around the world. The refuge in cooperation with NJDEP will continue to monitor amphibian populations for the disease to determine its impact and methods to potentially control the fungus. The refuge is also actively monitoring for ranavirus. Ranaviruses are members of the *Iridovirus* family and may infect insects, fish, amphibians, and turtles. Ranavirus infection in amphibians typically causes death in larvae or recently metamorphosed individuals and infected individuals often have ulcers on their skin. Turtles typically show signs of skin lesions, respiratory distress,

and multiple organ failure. The impact of ranaviruses on amphibian populations has been compared to the chytrid fungus.

Amphibians and reptiles would likely continue to be impacted by environmental contaminants, unrelated to refuge activities, known to occur in waters around the refuge. These may be from non-point source pollution from surrounding development or contaminants from historic landfills, such as Rolling Knolls. As mentioned above, strong partnerships that forge protections and legislation within local communities is the most effective way to improve refuge water quality and minimize impacts to aquatic herptiles.

The general maintenance of facilities, including the mowing of grass around buildings, will potentially result in minor impacts to herptiles. The construction of new facilities would have minor or temporary impacts primarily associated with soil disturbance, temporary increases in traffic, and use of heavy machinery. During these activities, BMPs, including well maintained exclusion fencing (when appropriate) and soil erosion and sediment control measures, would be employed during construction activities to protect herptiles and their habitats.

Management activities, such as the continued maintenance of grasslands for the purpose of achieving habitat and public use goals would result in minor impacts to herptiles. We would continue to avoid mowing in early successional habitats and wet grasslands during the active season when amphibians or reptiles may be breeding or seasonally moving through transitional zones.

Some amphibians and reptiles may be present during the application of pesticides and as a result, herptiles may come into contact with spray drift. We do not expect this to occur frequently and will continue to only use aquatically-labelled products in wetland areas in ways that minimize drift and non-target impacts. Invasive species management, inventory, and monitoring programs would continue to be completed in a manner that would minimize potential impacts to herptile species. We would continue to employ BMPs in terms of applicator training, pesticide selection, use, spill prevention, and spill response to avoid impacts from pesticide misapplication or contamination. As described in Section 4.9.1, spill cleanup would consist of containment by diking, use of absorbent materials, and excavation of contaminated soil. Adverse impacts would be localized and short-term.

We would expect some negligible impacts associated with the disruption or minor displacement of some herptile species from public use of trails and outdoor facilities. These impacts would vary slightly under all alternatives and would be slightly greater under alternative D. For example, public use may result in temporary displacement of snakes that use trails, water edges, other habitat edges, or structures for shelter, thermoregulation, and foraging.

Vehicle usage on roads within the refuge results in some unavoidable mortality and impact on herptiles under all alternatives. Particular times of the day and during certain conditions and seasons, herptiles are especially vulnerable to vehicular traffic. Examples include sunning snakes during morning hours, gravid pond turtles nesting in the spring, and amphibians moving to or from breeding grounds on warm rainy nights in the spring and summer. We place “Turtle Crossing” signs along high traffic refuge roads during peak turtle breeding season to alert the public. We have also recently started participating in the “Wildlife Guardians Project” to identify and protect important herptile road crossing locations on and around the refuge. Staff, interns, and volunteers are also trained in methods to protect or move herptiles found on roads. Other road related impacts come from de-icing agents and chemicals leaking from automobiles on township roads. The refuge only uses de-icers when necessary to protect public safety. In areas adjacent

to sensitive sites such as ponds or streams, we only use CMA which is more benign to the environment than rock salt. This contamination may affect surrounding water quality and consequently herptiles, particularly amphibians, utilizing aquatic habitats.

4.10.2 Impacts on Amphibians and Reptiles under Alternative A (Current Management)

Benefits and adverse impacts to amphibians and reptiles would be the same as those discussed in section 4.10.1, *Impacts on Amphibians and Reptiles That Would Not Vary by Alternative*.

4.10.3 Impacts on Amphibians and Reptiles under Alternative B (FWS-Preferred Alternative)

Benefits

Amphibian species (e.g., red-backed salamanders, *Ambystoma* salamanders, wood frogs, chorus frogs, spring peepers) that utilize forested wetlands may benefit from regeneration of forest due to the expansion of canopy cover and additional microhabitat opportunities, such as fallen trees, that provide shelter and moist conditions suitable for these species.

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Expansion of bog turtle habitat, including the selected opening of canopy and suppression of woody and invasive species, will provide increased basking and nesting opportunities for bog turtles and a suite of other herptiles that also utilize these emergent wetland environments. Expansion and restoration of bog turtle habitat will be conducted in ways that minimize impacts to other wildlife and are known to be effective.

The use of prescribed burning under this alternative would benefit herptiles by maintaining high quality grassland areas for basking species, such as wood and box turtles, while minimizing disturbance to soil that is associated with mowing alternatives. The proper maintenance of grasslands will provide a diversity of invertebrate prey opportunities for foraging herptiles. Prescribed burning would likely occur during ability and a frequent preference (by many species) for shelter under boards and other construction refuse, reptiles and amphibians are particularly vulnerable to direct mortality on construction sites from equipment or vehicles. There is also potential for secondary impacts aquatic or wetland herptile habitats from runoff or sedimentation.

Sensitive habitats or known amphibian and reptile breeding sites would be avoided for all construction. BMPs will be employed at the refuge to reduce the probability of direct and indirect impacts to herptiles. To avoid direct impacts, herptile exclusion fence will be properly installed and maintained to keep species out of the construction site. Inspection and clearing of the site for any herptiles should be completed by a staff member or biologist before machinery is utilized and periodically during construction. Removal of potential herptile shelters such as old debris piles or logs should occur before construction. All animals within the site can be relocated to a nearby safe and appropriate location on the refuge. Periodic inspection of the fence by a biologist or qualified individual will ensure that any breaches or compromises are immediately fixed.

By practicing BMPs and avoiding sensitive habitat areas, the displacement of common herptiles by the development of additional infrastructure is expected to have only short-term, localized and negligible adverse impacts on populations.

Increased visitation resulting from the expansion of infrastructure and programs may result in increased impacts to herptiles. Increased foot traffic would likely result in more frequent displacement or disturbance of herptiles in public access areas. Any increase in vehicular traffic will result in a greater probability of road mortality than under alternative A. Impacts from traffic or other public use activities may be reduced by increasing visitor education and awareness of low mobility herptiles through signage and programs.

Changes and disturbances to vegetation resulting from habitat consolidation under alternatives B, C, and D, such as allowing natural regeneration of select brushland or grassland areas, would result in negligible impacts to herptiles. It would be expected that these changes in vegetation may displace some species, such as common refuge snakes, that use edge habitats for sunning and foraging. Because such habitats will remain common at the refuge and because natural regeneration is a slow process, we do not anticipate these activities will be a limiting factor to any population of herptiles onsite. Any removal or disturbance of rocks or woody debris during management operations may result in minor impacts to herptiles utilizing these areas as shelter.

4.10.4 Impacts on Amphibians and Reptiles under Alternative C

Benefits

The succession of the Pools 3A and 3B may result in minor changes to herptile usage, which would result in a net benefit to herptile species. The creation of increased shrub swamp or marsh habitat may benefit both wood and spotted turtles that may use vegetated wetland habitats of intermediate amounts of standing water for foraging and basking. Generalist aquatic species, including painted turtles, snapping turtles, green frogs, spring peepers and water snakes, would be expected to continue utilizing these habitats.

Adverse Impacts

With regard to grassland and forest management, adverse impacts to amphibians and reptiles would be similar to those discussed under section 4.10.2, *Impacts on Amphibians and Reptiles under Alternative B*. We would anticipate only negligible differences in some herptile behavior patterns and habitat usage based on the terrestrial vegetation variations between this alternative and alternative B.

As a result of natural regeneration in Pools 3A and 3B, some shifts in herptile habitat usage would be associated with changes in hydrology and vegetation structure, density and composition. Based on the species requirements and the amount of available open water and wetland habitat, we do not anticipate any negative impacts to populations of herptiles as a result of the proposed natural regeneration of these habitats.

Impacts related to increases in visitation would not change from alternative A as efforts under this alternative are not designed to substantially increase visitation numbers.

4.10.5 Impacts on Amphibians and Reptiles under Alternative D

Benefits
The primary distinguishing benefit to herptiles under alternative D is the expansion of education and interpretive programs. Programs that focus on wetlands, watershed management, and reptiles and amphibians can have a direct benefit to populations of these species. These programs, especially when conducted in partnerships with other institutions or organizations involved in herptile conservation, will benefit these species on a regional scale by raising public awareness and support for wildlife protection and habitat conservation.

Adverse Impacts
It is anticipated that the significant increase in visitation and participation under alternative D would result in greater increases to reptile and amphibian disturbance and mortality than under any other alternative. These impacts would be related to increased foot and automobile traffic, as discussed under section 4.10.1, *Impacts to Reptiles and Amphibians That Would Not Vary by Alternative.* Increased mortality during the nesting season would likely occur as a result of increased vehicles. The introduction of fishing would likely result in increased disturbance of herptiles that utilize the edges of open water habitats in fishing access areas. Species such as painted turtles, water snakes and various frog species may be displaced or disturbed by increased activity within these areas.

4.11 Impacts on Invertebrates

This broad group is the least studied within the ecosystems around the refuge. Yet, they are likely the most important contributor and modifier in the functioning of those ecosystems and related food webs. Invertebrates play key roles in those ecosystems as:

- Detritivores, returning nutrients and basic elements back to the soil and the ecosystem.
- Pollinators, without which many sexually reproducing plants would not be able to propagate.
- Prey for other species in the food web, such as the millions of mosquitoes upon which fish, frogs, birds, and bats feed.
- Predators, such as spiders, that help keep rapidly producing insects in check.
- Filters of sediment, nutrients, and other contaminants, making conditions better for fish and aquatic life.

We evaluated the benefits of our actions that would conserve, restore, improve, or increase habitats of invertebrates likely to utilize refuge habitats:

- Managing and restoring forests, brushlands, grasslands, open waters, and emergent wetlands.
- Controlling invasive species.
- Increasing public awareness through environmental interpretation and wildlife-dependent recreation on important roles invertebrates play in the ecosystems.

We evaluated the potential for the proposed actions to cause adverse effects on habitats of invertebrates:

- Disturbance from public use.
- Potential impacts from the pesticides, forest restoration, or impoundment water level manipulation
- Construction of additional infrastructure, such as facilities, trails, parking lots, and observation towers.
- Impacts of light pollution from artificial lighting.

4.11.1 Impacts on Invertebrates That Would Not Vary by Alternative

Invasive species control, grounds maintenance, rotational mowing or cutting of managed grasslands and brushlands, and forest health measures are actions common to all alternatives that may impact refuge invertebrates. Invasive species control and grounds maintenance are recurring activities done primarily during the growing season.

Benefits

The refuge's land management provides a wide array of general habitat types and microhabitats that serve as foraging, breeding, and overwintering habitat for many groups of invertebrates. Improving stream water quality will benefit aquatic insects and other invertebrates.

Removing and controlling invasive species allows native plants to reestablish and expand. This especially benefits insects that coevolved with the native plants in our area, particularly those that are host-specific, such as the monarch butterfly, which uses milkweed as the host plant for their eggs. Many species of invasive, non-native plants are not optimal hosts for native insects, and do not contribute to the health or diversity of the pollinator community. Therefore, we presume that removing these non-native plants and planting or allowing native species to regenerate would be beneficial to native invertebrates. The number of native insects that use non-native plant species as host plants is minimal and therefore, removing them would not result in unacceptable losses in the insect populations.

Adverse Impacts

Maintaining refuge grounds currently involves mowing of roadsides, parking areas, walking paths, and small lawn areas. Generally, regularly mowed areas are kept short in vegetation height (less than 6 inches); therefore, they provide very limited sources of nectar, usually clovers. Where grasses and forbs have grown tall, such as along seldom-used roads or paths where they begin to flower and set seed, pollinators and herbivorous insects would be found. Mowing in the warm months, when insects are breeding, may destroy the eggs or pupae attached to leaves, consume adults, remove food sources, or unfavorably alter microhabitat; however, the area we maintain is a very small fraction of the amount of land serving as habitat. Managed grasslands and brushlands are generally mowed in October to avoid impacts to pollinators, birds, wildflowers, and reptiles. Managed grasslands are mowed on a rotational basis on one to four year cycles; therefore, some standing cover is left each year for overwintering insects.

A variety of exotic insects have impacted forests of the Northeastern United States. The gypsy moth has impacted the oak forests of Great Swamp NWR in the past. Other insect species such as the Asian long-horned beetle and emerald ash borer may threaten the refuge tree populations. Control of these species, particularly with the use of insecticide, has the potential to have short-term and localized adverse impacts

on non-target native and beneficial insects. Although the FWS approves the pesticides we use in controlling invasive species because of their relative neutrality on animal life; soft-bodied insects, eggs, pupae, or organisms with permeable skin that come in direct contact with a pesticide or its adjuvants may experience mortality, reduced fitness, or abnormal development.

The consequences of inaction to both insect pests and invasive plants are more likely to result in major, long-term adverse impacts to substantial portions of refuge forests and other vegetated habitats; and consequently the various native invertebrate populations that utilize these habitats.

Since we treat limited portions of the refuge each year to control invasive plants, overall negative effects on invertebrates are expected to be minimal. We only use pesticides that are systemic operants on plants and approved by the EPA as having little or no impact on terrestrial insects. Very few native invertebrates use non-native plants for feeding, breeding, or pupating. We presume that any dependence on those plants is incidental and, therefore, removing them would not result in unacceptable losses in the insect populations. The refuge will continue to follow FWS guidelines and standards when applying pesticides or herbicides (see section 4.2.1). We would consult with forestry experts and FWS IPM specialists for recommendations on the least harmful products and methods to avoid impacts to non-target species.

4.11.2 Impacts on Invertebrates under Alternative A (Current Management)

Benefits and adverse impacts to invertebrates are the same as those discussed in section 4.11.1, *Impacts on Invertebrates That Would Not Vary by Alternative*.

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4.11.3 Impacts on Invertebrates under Alternative B (FWS-Preferred Alternative)

Benefits

Alternative B would provide an important, direct benefit to pollinating, herbivorous, and predatory insects by managing large tracts of diverse grasslands in the Management Area. We would perform native wildflower plantings in attempt to increase plant and invertebrate diversity. Well-established grasslands possess a diverse variety of plant species and structures that would provide food and cover year round for the annual life cycles of many species. This also benefits small mammals, reptiles, amphibians, and grassland dependent birds.

Under alternative B, we propose to introduce prescribed burning for habitat management, when and where appropriate and compatible. As previously discussed, prescribed burning is a cost-effective and ecologically sound tool for the management of forest, grassland, and wetlands that removes plant residues, controls insects and disease, improves wildlife habitat and forage production, increases water yield, maintains natural succession of plant communities, and reduces the need for pesticides. Prescribed fire increases the production of seed in legumes and grasses in frequently burned areas. Grassland fires cause early green up of warm season grasses, improved seed-germination, and greater production of grasses and forbs. It also increases the production of berries, drupes, and pomes for 2 to 4 years after fire

(Lyon et al. 2000). Fire modifies the invertebrate communities, which may continue to change a few years post burn. Different orders of invertebrates respond differently to fire depending on season and year, but prairies where fires occur in different years and seasons tend to have greater species diversity (Lyon et al. 2000.) Thus, indirect benefits may be derived to invertebrates from variable applications of a refuge fire regime. An indirect benefit is derived through increased habitat quality.

Maintenance of grasslands requires periodic disturbance. Managed grasslands and brushlands are generally mowed in October to avoid impacts to wildflowers, pollinators, birds, and reptiles. It is impossible to manage grasslands without cost to some species, especially above ground insects using plant structures for roosting, egg laying, and development; however, we would not burn or mow all the fields at once, some are left in reserve, and thus some grassland units would remain undisturbed for overwintering insects.

Under this alternative, we would also create 5 acres of habitat specifically for pollinators to promote awareness on the importance of native plants and the key roles of pollinators. Providing additional opportunities for environmental education and interpretation would raise public awareness and support for wildlife protection and habitat conservation.

Adverse Impacts
No additional adverse impacts to invertebrates are anticipated under this alternative.

4.11.4 Impacts on Invertebrates under Alternative C

Benefits and adverse impacts to invertebrates would be similar to those discussed under section 4.11.3, *Impacts on Invertebrates under Alternative B,* except there would be less grassland or grassy cover available to support the insects associated with native forbs and grasses. In addition, Pools 3A and 3B contain areas of shallow water and are heavily vegetated. Under this alternative, both impoundments would be allowed to undergo natural regeneration, which may result in changes in numbers and diversity of insects on a localized level.

4.11.5 Impacts on Invertebrates under Alternative D

Although alternative D anticipates the greatest increase in refuge visitation over the next 15 years, we anticipate that the benefits and adverse impacts to invertebrates would be similar to those discussed under section 4.11.3, *Impacts on Invertebrates under Alternative B.*

4.12 Impacts on Public Use and Access

Based on data collected from 2001 through 2011, refuge visitation ranges between approximately 140,000 and 165,000 visitors per year (Refuge Annual Performance Planning data and T. McFadden, USFWS Great Swamp NWR, pers. com. 2009). The most recent visitation information for the refuge is for FY 2011 (October 1, 2010 through September 30, 2011). During this time period, the refuge reported an estimated 165,000 visitors. Most visitors to the refuge engage in some form of wildlife-dependent recreation. Wildlife observation and photography account for the largest proportion of visits. According to the USGS Visitor Survey (Sexton et al. 2012), wildlife observation (64 percent), including bird watching (62 percent), as the most common use by visitors of the refuge during the course of a year. Hiking (57 percent) and photography (36 percent) were the next most common uses identified during the survey.

4.12.1 Impacts on Public Use and Access That Would Not Vary by Alternative

Benefits

The primary goals of the Visitor Services Program would be to continue working with volunteers and partners to promote the benefits of wildlife and habitat conservation and management, to foster an awareness and appreciation for the refuge and its role along the Atlantic Flyway and within the Refuge System, and to provide quality wildlife-dependent recreational opportunities to visitors. We would continue to provide high quality wildlife observation and photography opportunities by facilitating various forms of access. We would continue to participate in, develop, and present environmental education and interpretive programs. For many residents of the New York City Metropolitan area, refuge staff may be their one and only interaction with the FWS. Under all alternatives, refuge staff would continue to be active in outreach and partnership development, increasingly directed towards urban populations.

Adverse Impacts

We would continue to limit access to ecologically sensitive areas, such as nesting sites during breeding seasons and vulnerable wetlands. While these would result in short-term restrictions on public access and use, we would minimize these restrictions to the extent possible while ensuring proper protection of wildlife and their habitats. We do not anticipate any long-term negative impacts on public use and access.

The presence of dogs can lead to short-term and long-term adverse impacts to wildlife populations. Some wildlife species are particularly sensitive to the presence of dogs and their response to disturbance is amplified above and beyond disturbance effects from recreationists traveling without dogs. Studies have found declines in bird diversity and abundance on trails where leashed dogs were permitted exceeded declines observed from human disturbance alone (Banks and Bryant 2007). In all alternatives, the refuge permits dogs on leash as long as the activity is restricted to Pleasant Plains Road or the parking lots of the Visitor Center and Wildlife Observation Center.

During the firearm hunting season for white-tailed deer, the entire refuge would be closed to all other public use activities; however, during the 1-day youth hunt, only the western half (Management Area) of the refuge would be closed. In recent years, the firearm hunt occurred over a 5-day period in November, beginning with a 1-day youth hunt on Saturday and followed by a 4-day regular hunt the following Wednesday through Saturday. The regular hunt currently coincides with school closings associated with the annual New Jersey Teacher Convention to maximize youth hunting opportunities. Hunting hours will be from one-half hour before sunrise to one-half hour after sunset. Signs would be posted at public access points and the closure would also be publicized in local newspapers. As population surveys are conducted and biological data are collected from harvested deer or turkey and assessed annually, season dates may change and the season length may be extended or reduced.

4.12.2 Impacts on Public Use and Access under Alternative A (Current Management)

Benefits

Under alternative A, we would continue to allow currently approved public uses on currently open refuge lands. These are noted in chapter 3, alternative A. Appendix B documents the refuge manager's justification for why they are deemed appropriate and compatible. Other ownerships nearby or elsewhere sufficiently provide opportunities for other activities not determined to be compatible with the purposes of the refuge.

No major additions or changes in facilities would occur. The refuge would continue to allow already approved public uses. These include wildlife observation and photography, environmental education and interpretation, and hunting.

Adverse Impacts
Adverse impacts to public use and access are the same as those discussed in section 4.12.1, *Impacts on Public Use and Access That Would Not Vary by Alternative*.

4.12.3 Impacts on Public Use and Access under Alternative B (FWS-Preferred Alternative)

Benefits
Under alternative B, the refuge would moderately expand public uses and strive to maintain a better balance among the wildlife-dependent public uses on the refuge. For example, hiking trails would be kept open during the fall archery hunt for white-tailed deer and spring wild turkey hunt, if implemented. Wildlife observation and photography would be enhanced by creating trails, providing additional parking opportunities, expanding the Wildlife Tour Route, and constructing observation towers. We would expand Visitor Center operational hours to 7 days per week year round and increase the number of environmental education and interpretation programs on and off the refuge.

Adverse Impacts
Adverse impacts to public use and access are the same as those discussed in section 4.12.1, *Impacts on Public Use and Access That Would Not Vary by Alternative*.

4.12.4 Impacts on Public Use and Access under Alternative C

Benefits
Benefits on public use and access would be similar to those discussed under section 4.12.1, *Impacts on Public Use and Access That Would Not Vary by Alternative,* except environmental education and interpretative programs would be emphasized and expanded, as described under section 4.12.2, *Impacts on Public Use and Access under Alternative B.*

Adverse Impacts
Adverse impacts on public use and access would be the same as section 4.12.1, *Impacts on Public Use and Access That Would Not Vary by Alternative.* No additional adverse impacts would occur under this alternative.

4.12.5 Impacts on Public Use and Access under Alternative D

Benefits
Under alternative D, public use and access would be maximized to the greatest extent practical, while minimizing impacts to wildlife, through the creation of new trails, observation towers, and parking lots. We would increase open water habitat to improve public viewing opportunities. Contrary to the other alternatives, this alternative would provide public access to view currently off-limits open water areas by allowing seasonal, non-vehicular access along Pool 3A and 3B service roads. Most notably, fishing opportunities, which are not authorized under any other alternative, would be provided in select areas of the refuge. The refuge's hunting program would be expanded as described under alternative B. In addition,

this alternative would maximize public outreach, enhance and develop new environmental interpretation and education programs, aggressively expand partnerships, and increase staff presence at programs and events.

Adverse Impacts

Adverse impacts on public use and access would be the same as section 4.12.1, *Impacts on Public Use and Access That Would Not Vary by Alternative.* No additional adverse impacts would occur under this alternative.

4.13 Impacts on Cultural and Historic Resources

4.13.1 Impacts on Cultural and Historic Resources That Would Not Vary by Alternative

As discussed in section 2.8.1, John Milner Associates, Inc. (JMA) was contracted by the FWS to complete a study of known cultural resources on the refuge. The results of this study were referenced during the planning process. Building off a previous study completed in 1978 (Thomas 1978), JMA completed a document describing the current status of known cultural resources (JMA 2010). The JMA report (2010) identified 123 cultural resources within the refuge's approved acquisition boundary, 100 of which are within or intersect parcels the FWS has acquired interest in or currently owns. The remaining 23 are located within parcels that have not been acquired by the FWS at this time. Thirty-two of the identified cultural resources are considered prehistoric sites (i.e., before 1750), 57 are from the historic era (1750 to mid 1900s), 3 have prehistoric and historic components, and 31 are standing structures. To date, no sites within the acquisition boundary are listed on the National Register of Historic Places (NRHP) or the New Jersey Register of Historic Places. Two sites within the acquisition boundary have been characterized as eligible for listing on the NRHP, one pre-historic site and one standing structure. The pre-historic site was recommended for eligibility based on a single Munsee-incised ceramic shard of the Late woodland period (1300 AD to European Settlement) (Harris and Ziesing 2010). The structure, Baird Tenant House, is a rare intact example of a once locally common house type, the East Jersey cottage and was therefore recommended for eligibility (Harris and Ziesing 2010).

Benefits

Under all alternatives, we would provide appropriate and compatible opportunities for visitors of all ages to appreciate the cultural and natural resources of the refuge. We would provide interpretation of cultural and historic resources related to the refuge and conservation; however, the extent and emphasis of resource interpretation varies between alternatives. Under alternatives B and D, we would increase efforts to include information about cultural and historic resources of the refuge compared to alternatives A. For example, the refuge would promote the Heritage Trail, similar heritage resources, and the "Crossroads of the American Revolution National Heritage Area." The Heritage Trail Association offers area residents and visitors alike an opportunity to learn about the rich history of greater Somerset County while celebrating the area's unique place in our nation's history.

Under alternative D, we would expand partnerships with various interest groups, such as cultural resource and historic preservation groups, to promote use of the refuge. Under all scenarios, the refuge would continue to communicate the importance of understanding and appreciating the area's rich cultural history and how it relates to our natural history. In doing so, we would potentially provide long-term benefits to regional cultural and historic resources.

Adverse Impacts
As a Federal land management agency, we are entrusted with protecting historic structures and archaeological sites on our land, which are eligible for or listed on the National Register of Historic Places. FWS archaeologists in the Regional Office keep an inventory of known sites and structures and ensure that we consider them in planning new ground disturbing or structure altering changes to the refuge. We consult with the New Jersey State Historic Preservation Office (SHPO) concerning projects that might affect sites and structures, and conduct archaeological or architectural surveys, when needed. Projects can usually be redesigned to avoid affecting National Register eligible sites or structures.

While no adverse impacts to cultural or historic resources are anticipated at this time, we will send this draft CCP/EA to the SHPO for review in compliance with Section 106 of the National Historic Preservation Act. In all of the alternatives, we will consult with our regional archeologist and the State Historic Preservation Office as needed to ensure compliance with the Act and other applicable laws and regulations.

4.14 Impacts on the Socioeconomic Environment

The refuge management activities of economic concern in the analysis are:

- Purchasing of goods and services within the local community for refuge operations.
- Spending of salaries by refuge personnel.
- Spending in the local area by refuge visitors.
- Purchasing additional refuge land and resulting changes in local tax revenues.
- Effects of refuge management on local townships.

Tourism is an important part of New Jersey's economy. While tourism is important to the State's economy, it plays a smaller role in the region around Great Swamp NWR. A 2008 regional analysis of tourism in New Jersey shows the northwestern New Jersey Skylands region, including Great Swamp NWR, comprised the smallest share of total statewide tourism spending at 8.5 percent (IHS Global Insight 2009). Morris County itself; however, was listed as ninth out of the 21 New Jersey counties for overall tourism expenditure in 2008 at a total of $1,323,000,000.

According to the "Banking on Nature" report, prepared by the FWS Division of Economics in 2004, ecotourism is one method of deriving economic benefits from the conservation of wildlife and habitats. The report evaluates the total visitor spending, including both non-resident (visitors that live >30 miles from the refuge) and local refuge visitors, to show its significance on the local economy. For example, the report focuses on how recreational visits impact local income and employment. Daily visitor expenditures for both residents and non-residents were divided into four categories, including food, lodging, transportation, and other expenses for six activities, including freshwater fishing, saltwater fishing, migratory bird hunting, small game hunting, big game hunting, and non-consumptive activities. Non-consumptive uses are recreational activities that enjoy wildlife without consuming it, such as birding and photography (Caudill and Henderson 2004).

In FY 2004, visitors to Great Swamp NWR enjoyed both non-consumptive activities and big game hunting. Non-consumptive activities included the use of nature trails, observation platforms, other wildlife observation (i.e., observing wildlife while on the auto tour route), and other recreation (i.e., jogging, bicycling, and cross-country skiing). Eighty percent of visits were by residents. Visitor recreation expenditures totaled $1.7 million in FY 2004, 99 percent which were related to non-consumptive activities. Residents spent approximately $721,700 and non-residents spent approximately $986,100. Recreational benefits (recreation-related expenditures plus net economic value) totaled nearly $5.3 million, and budget expenditures summed to $1.1 million; therefore, comparing these two estimates shows that for every $1 of budget expenditures, $4.79 in recreational benefits are derived. The budget also contributes an additional stimulus to the local economy (Caudill and Henderson 2004).

According to the 2010-2011 Visitor Survey Results for Great Swamp NWR, most surveyed visitors (82 percent) live in the local area (i.e., within 50 miles of the refuge), while 18 percent are non-local visitors. Local visitors traveled an average of 16 miles to get to the refuge, whereas non-local visitors traveled an average of 132 miles. Non-local visitors stayed in the local area for an average of 2 days. Non-local visitors spent an average of $42 per person per day and local visitors spent an average of $31 per person per days. It should be noted that only 29 non-local visitors were surveyed (small sample size where n < 30); therefore, non-local expenditures may not provide a reliable representation of that population.

Great Swamp NWR has the potential to increase visitation, and associated economic benefits to the area, because of its proximity to highly populated areas. The Great Swamp NWR currently attracts approximately 150-165,000 visitors per a year to the area from throughout the United States and various countries. The refuge has great potential to increase visitation through partnerships and by coordinating with local cultural attractions and transportation hubs. Another important aspect of the socioeconomic setting is the number of educational institutions and environmental education centers in the New York-New Jersey Metropolitan Area. This allows the refuge partnership and recruitment opportunities from a wide range of social and cultural backgrounds.

Refer to section 2.2 of chapter 2 for additional information on the socioeconomic environment of the refuge and its context within the region.

4.14.1 Impacts on Socioeconomic Environment That Would Not Vary by Alternative

Benefits

Ongoing public uses related to wildlife-dependent recreation would continue to have a small but positive effect on the local economies surrounding the refuge. Refuge visitors, researchers, and volunteers would continue to utilize businesses around the refuge for food, fuel, supplies, and lodging. The refuge would continue to provide environmental education and interpretation programming free-of-charge to communities and schools. Great Swamp NWR has the potential to increase visitation, and associated economic benefits to the area, because of its proximity to highly populated areas. The Great Swamp NWR currently attracts

an estimated 150-165,000 visitors per a year to the area from throughout the United States and various countries.

As discussed in section 2.2.4, national wildlife refuges also contribute to local economies through shared revenue payments. Under the provisions of the *Refuge Revenue Sharing Act* (the Act of June 15, 1935; 16 U.S.C. 715s), the FWS pays an annual refuge revenue sharing payment at a rate set by Congress to municipalities that contain lands the FWS administers. Great Swamp NWR's revenue payments to Chatham, Harding, and Long Hill Townships are listed in table 2-12 for the years 1988-2012.

The economic value of the ecosystem services provided by the extensive forest, wetland, and other vegetation cover types provided by the refuge and any future land protection efforts achieved by refuge partnerships has not been quantified. The services provided by refuge forests and wetlands include groundwater recharge, flood control, nutrient filtration and uptake, improved air quality, and temperature moderation. Tools, models, or programs to measure such values, such as iTree (Nowak et al 2011), have been developed and are available to put a dollar value on those ecosystem services. Land managers can input information about the tree cover of a parcel of interest and obtain monetary value, or volume measures on the ecosystem services provided.

Adverse Impacts

The impact of protecting land is considered negligible on the economy of the region. Although some loss of tax revenue and commercial income results from protecting lands, the ecosystem services provided by natural landscapes (e.g., flood control, carbon sequestration, sediment and erosion control) offset much of the lost tax revenue. In fact, preserved lands have negligible infrastructure and emergency response requirements, while attracting visitors to the surrounding area and improving the quality of life for those who visit. In addition, as mentioned above, the FWS pays an annual refuge revenue sharing payment to counties that contain lands the FWS administers.

4.14.2 Impacts on Socioeconomic Environment under Alternative A

Benefits

In summary, implementing alternative A would continue to provide socioeconomic benefits to the community. The refuge helps to maintain the quality of life not only for local residents, but also for all refuge visitors. Alternative A would continue to provide opportunities for public use, and current refuge regulations would remain in effect (see chapters 2 and 3).

The refuge provides economic benefits mainly through spending in the local area by refuge visitors and staff and the sales taxes derived from local spending. It also provides benefits from public use, as in the increasingly important ecotourism industry.

Adverse Impacts

Adverse impacts under this alternative are the same as those discussed under section 4.14.1, *Impacts on Socioeconomic Environment That Would Not Vary by Alternative*.

4.14.3 Impacts on Socioeconomic Environment under Alternative B (FWS-Preferred Alternative)

Benefits
Under alternative B, the refuge would moderately expand public uses and strive to maintain a better balance among the wildlife-dependent public uses on the refuge. Wildlife observation and photography would be enhanced by creating new trails, providing additional parking opportunities, expanding the Wildlife Tour Route, and constructing observation towers. We would expand Visitor Center operational hours to seven days per week year round and increase the number of environmental education and interpretation programs on and off the refuge. This would help improve the quality of and access to environmental education in the region, and ultimately foster environmental stewardship and support for conservation in their own lives.

Adverse Impacts
Adverse impacts under this alternative are the same as those discussed under section 4.14.1, *Impacts on Socioeconomic Environment That Would Not Vary by Alternative*.

4.14.4 Impacts on Socioeconomic Environment under Alternative C

Benefits
Benefits under alternative C are similar to those discussed in section 4.14.3, *Impacts on Socioeconomic Environment under Alternative B,* except environmental education and interpretation programs would be further emphasized and expanded. The expansion of these public uses could bring new and increased numbers of visitors to the refuge which may also lead to increases in visitor spending in the surrounding areas.

Adverse Impacts
Adverse impacts under this alternative are the same as those discussed under section 4.14.1, *Impacts on Socioeconomic Environment That Would Not Vary by Alternative*.

4.14.5 Impacts on Socioeconomic Environment under Alternative D

Benefits
As discussed in section 4.12.5 above, public use and access would be maximized to the greatest extent practical, while minimizing impacts to wildlife. Fishing opportunities, which are not authorized under any other alternative, would be provided in select areas of the refuge. We would maximize public outreach, enhance and develop new environmental interpretation and education programs, aggressively expand partnerships, and increase staff presence at programs and events. Similar to alternative B, we would expand Visitor Center operational hours to 7 days per week year round and increase the number of environmental education and interpretation programs on and off the refuge. By doing so, we would provide more opportunities to reach visitors, and ultimately foster environmental stewardship and support for conservation in their own lives.

We anticipate that the expansion of public uses would bring new and increased numbers of visitors to the refuge, which may also lead to increases in visitor spending in the surrounding areas.

Adverse Impacts
Adverse impacts under this alternative are the same as those discussed under section 4.14.1, *Impacts on Socioeconomic Environment That Would Not Vary by Alternative*.

4.15 Cumulative Impacts

According to the Council on Environmental Quality (CEQ) regulations on implementing NEPA (40 CFR 1508.7), a cumulative impact is the 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.

This cumulative impacts assessment includes the actions of other agencies or organizations, if they are interrelated and influence the same environment. Thus, this analysis considers the interaction of activities at the refuge with other actions occurring over a larger spatial and temporal frame of reference.

4.15.1 Cumulative Impacts on the Physical and Natural Environment

The area surrounding the refuge is highly developed and influenced by suburban and urban development. The actions in the area of the refuge that we considered for the cumulative impacts assessment include further residential development in the surrounding area, potential deer control at Morristown Historical Park, and existing commercial development in the area, including major corporation headquarters in the vicinity of the refuge. Based on the environmental analysis that is presented in this document, the actions of the refuge when added to other actions in the surrounding area will provide an overall minor, long-term benefit to the environment. Overall, the refuge has removed over 10 buildings and restored the footprint of the buildings and associated lawns to natural habitat conditions, which provides an overall benefit. In addition, vehicle use associated with habitat management activities and visitors is a very small percentage of the number of vehicles that use local roads and the interstate highway in the area. This use will not add cumulative adverse impacts to air quality in a noticeable way. Increased residential development within the watershed will likely lead to additional pesticide and herbicide use and greater levels of impervious surface. The refuge will continue to act as a water quality buffer and help to mitigate the adverse effects associate with this development. This residential development will also fragment forested areas surrounding the refuge. The larger acres of intact habitat and native vegetation will provide a consistent area of habitat available for local plant and animal species populations.

Controlling exotic and invasive plants may involve the use of chemical herbicides. The selective use of herbicides will be based upon an IPM strategy that incorporates pest ecology, the size and distribution of the population, site-specific conditions, known efficacy under similar site conditions. Best management practices will reduce potential effects to non-target species, sensitive habitats, and quality of surface and groundwater. Herbicide applications will be targeted to control discreet pest populations in localized areas. Combinations of two or more herbicides at labeled rates would not likely result in additive or synergistic adverse effects to non-target fish, wildlife, plants, or their habitats. The Forest Service (2005) found that mixtures of herbicides commonly used in land (forest) management likely would not cause either additive or synergistic effects to non-target species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR 2004). Moreover, combined herbicides with different modes of action may be used more effectively, likely requiring less retreatment over the long term.

Herbicides applied on the refuge would be short-lived, resulting from environmental and microbial breakdown to less or non-hazardous degradation products.

All of the proposed alternatives would maintain or improve biological resources on FWS-owned lands. The long-term land protection and management activities proposed under all alternatives would complement other neighboring conservation efforts by other county, state, and federal organizations. Cumulatively, these large areas of protected lands provide many acres of protected lands for a variety of species.

Cumulative impacts from research activities are not expected, but could occur if multiple research projects were occurring on the same resources at the same time or if the duration of the research was excessive.

We do not anticipate any significant cumulative effects on biological resources by other wildlife-dependent recreational activities. Impacts caused by these activities can be found earlier in this chapter.

4.15.2 Cumulative Impacts Related to Climate Change

Climate Change Impacts on Vegetation

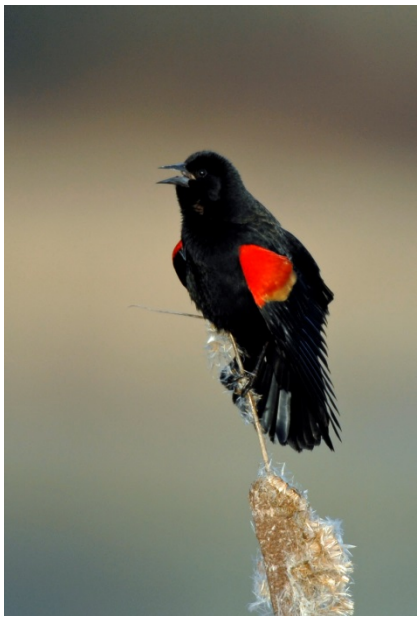
Climate is a major factor on the range, growth rate, and reproduction of trees. As with all types of flora and fauna, certain tree species are more likely to adapt to climate shifts while other species will not be as successful. Plant communities and species adapted to warmer subtropical latitudes are expected to expand and establish beyond their northern boundaries. Cool climate coniferous forests of the Northeast are considered particularly vulnerable. Other deciduous hardwood species, such as sugar maple, American beech, birches, quaking aspen, white ash, and black cherry, may be lost in portions of their range (Stout et al., 2008; Frumhoff et al., 2007). Oak-hickory and oak-pine forests may expand northward in the United States (NABCI 2010). Certain species, such as white oak, black oak, and black gum, may expand their range northward under various warming scenarios within the Northeast (Stout et al. 2008).

Impacts to red maple (*Acer rubrum*), one of the most dominant forest tree species of Great Swamp NWR, may vary greatly under different warming scenarios. Although this species is projected to be impacted under certain high emissions conditions, red maple is highly adaptable and has expanded its range in the past 100 years (Frumhoff et al 2007; Fei and Steiner 2007). Studies have shown significant growth increases (130 percent) among juvenile red maples corresponding with increases in soil temperature of up to 9ºF (Frumhoff et al., 2007). Due to the significant proportions of red maple-dominant communities at Great Swamp NWR, these varying scenarios could have significant implications for the refuge with regard to rates of succession and management responses.

Some positive effects on forests may include increased forest productivity due to longer growing seasons, increased precipitation, and increased carbon dioxide fertilization, which will increase primary production and yield greater biomass and soil inputs. Mature trees in particular are expected to fare better because of developed root systems and higher carbon reserves (Swanston et al. 2011).

Some negative effects include extreme weather events that can cause flooding, erosion, and wind damage; altered timing of aquifer recharge leading to potential declines in summer seasonal streamflow; species range shift, which would result in a decline of some species; and increased susceptibility to disturbance, disease, and pests. We anticipate expanded pest and disease ranges due to decreased probability of lower lethal temperatures, migrations to the north, and accelerated life cycles. An increase in frequency or intensity of fire may also occur where there is less summer moisture (Swanston et al. 2011).

Climate Change Impacts on Biological Resources



USFWS/George Gentry

Climate change will have a range of effects on vegetation and ecological systems. It is expected that species ranges will shift northward or toward higher elevations as temperatures rise, but responses will likely be highly variable and either species or family-specific. Under these rapidly changing conditions, migration, not evolution, will determine which species are able to survive. Species that cannot migrate will suffer the most. For example, plants, mussels, and amphibians are more vulnerable to temperature shifts that may affect their ability to survive, grow, and reproduce (USFWS 2010a). Severe weather events of greater intensity may increase flooding occurrence, which will affect various wildlife species. For example, increased flooding will threaten amphibians by enabling access of predatory fish into vernal breeding pools and by spreading pollutants.

Four types of responses by animal and plant species are possible:

1. The density of species may change locally and their ranges may shift in response to the need to find areas within their range of tolerance.
2. There will likely be changes in phenology, or the timing of such important life history events as flowering, egg-laying, and migration.
3. Changes in body sizes and behaviors may occur.
4. Genetic frequencies may shift.

Species with short generation times, such as insects and annual plants, might be helped in adapting to change because of their more rapid evolution. In addition, since insects are poikilothermic (cold-blooded) animals and sensitive to temperature fluctuation, climate change may also result in redistributions of pest insects and subsequent forest impacts (Logan et al. 2003). As growing and reproductive seasons are prolonged, some insects, including pest insects, will likely produce more generations per season (Ibanez et al. 2011). Insects that may benefit from warming scenarios may include the wooly adelgid, emerald ash borer, and gypsy moth. Certain parasitic fungi and other diseases, including Dutch elm disease, white pine blister rust and beech bark disease, are also expected to benefit from climate change (Frumhoff et al. 2007).

Evolution may be slower in long-lived species, such as trees; therefore, these species may be less adaptable (Rogers and McCarty 2000). Since so many animal species time important events in their life cycles, particularly reproduction, so that young are produced when food sources are available, changes in other phenological events, such as flowering and insect hatching, could be disastrous for species that fail to quickly adapt to decoupled synchronies. We cannot, at this time, predict how this will affect the refuge, but we can apply generally accepted conservation biology strategies to provide biologically diverse habitats and connected corridors to increase ecological flexibility and maximize ecosystem resilience.

Climate Change Impacts on Birds

According to a recent analysis of Christmas Bird Count data over the past 40 years, a significant northward shift of the winter center of abundance is occurring among at least 305 bird species in North America (Niven et al. 2009). Of these, 208 species shifted north with 123 species shifting more than 50 miles. Landbirds as a group shifted more than waterfowl or coastal species. Seventy-five percent of land birds shifted north an average of 48 miles. Landbirds were further analyzed according to four habitat guilds: woodland, grassland, shrub, and generalist. Woodland birds shifted the most, followed by shrub species, while grassland birds and generalist shifted the least. This study confirmed a northward shift of species already suspected, such as red-bellied woodpecker (*Melanerpes carolinus*), tufted titmouse (*Baeolophus bicolor*), Carolina wren (*Thryothorus ludovicianus*), and northern cardinal (*Cardinalis cardinalis*), and which are all common species at the refuge throughout the year (Niven et al. 2009).

Habitat specific and migratory species, especially northern forest birds, have been determined to be particularly vulnerable to global climate change. Changes in migratory timing, including the seasonal availability of food resources, would be a major contributing factor to these declines (NABCI 2010). Due to their ability to adapt to varying conditions, common generalist resident bird species may be less affected or increase under various emissions scenarios. Thirty-six percent of the 165 wetland breeding birds in the United States show medium or high vulnerability to climate change (NABCI 2010). Wetland birds that occur at Great Swamp NWR that are projected to decline due to climate driven drought and flood cycles include common loon (*Gavia immer*), sora (*Porzana carolina*), and American bittern (*Botaurus lentiginosus*) (Frumhoff et al. 2007). Waterfowl and wading bird habitat may be affected as climate change results in changes in rainfall and temperature. Waterfowl range contraction is anticipated as milder, warmer winters shift northward, reducing the need to migrate as far south. The Great Swamp is a low, flat floodplain in the lower, receiving end of its watershed. More frequent rain events of greater intensity will increase flooding occurrence and a greater possibility of nests being destroyed by flooding.

Northern grassland areas are expected to become drier with increased evapotranspiration caused by global climate change impacts. It is also suspected that increased atmospheric carbon dioxide may contribute to faster succession of woody species in grassland habitats (NABCI 2010). Approximately 50 percent of grassland bird species of the United States, including the State-listed bobolink (*Dolichonyx oryzivorus*), are expected to be impacted by global climate change (NABCI 2010). Christmas bird count data indicates that grassland birds were the only general group of birds unable to shift north in response to global climate change over the last 40 years. This inflexible response has been attributed to the poor quality of northern grassland habitats (NABCI 2010).

Department of the Interior Secretarial Order 3226 states that “there is a consensus in the international community that global climate change is occurring and that it should be addressed in governmental decision making. This order ensures that climate change impacts are taken into account in connection with Departmental planning and decision making.” Additionally, it calls for the incorporation of climate change considerations into long-term planning documents, such as a CCP.

The Wildlife Society published an informative technical review report in 2004 titled “Global Climate Change and Wildlife in North America” (Inkley et al. 2004). It interprets results and details from such publications as the Intergovernmental Panel on Climate Change reports (1996 to 2002) and describes the potential impacts and implications on wildlife and habitats. It mentions that projecting the impacts of climate change is hugely complex because not only is it important to predict changing precipitation and temperature patterns,

but more importantly their rate of change, as well as the exacerbated effects of other stressors on the ecosystems. Those stressors include loss of wildlife habitat to urban sprawl and other developed land uses, pollution, ozone depletion, non-native species, disease, and other factors. Projections over the next 100 years indicate major impacts such as extensive warming in most areas, changing patterns of precipitation, and significant acceleration of sea level rise. According to the Wildlife Society report, "…other likely components of on-going climate change include changes in season lengths, decreasing range of nighttime versus daytime temperatures, declining snowpack, and increasing frequency and intensity of severe weather events" (Inkley et al. 2004). The report details known and possible influences on habitat and wildlife, including: changes in primary productivity, changes in plant chemical and nutrient composition, changes in seasonality, sea level rise, snow, permafrost, sea ice decline, increased invasive species, pests and pathogens, and impacts on major vertebrate groups.

The effects of climate change on populations and range distributions of wildlife are expected to be species specific and highly variable with some effects considered negative and others considered positive. Generally, the prediction in North America is that the ranges of habitats and wildlife would generally move upwards in elevation and northward as temperature rises. Species with small or isolated populations and low genetic variability would be least likely to withstand impacts of climate change. Species with broader habitat ranges, wider niches, and greater genetic diversity should fare better or may even benefit. This would vary depending on specific local conditions, changing precipitation patterns, and the particular response of individual species to the different components of climate change (Inkley et al 2004). The report notes that developing precise predictions for local areas is not possible due to the scale and accuracy of current climate models, which is further confounded by the lack of information concerning species-level responses and to ecosystem changes, their interactions with other species, and the impacts from other stressors in the environment. In other words, only crude generalizations can be made about the implications of our refuge management on regional climate change.

Our evaluation of the proposed actions concludes that only one area of activities may contribute negligibly, but incrementally, to stressors regionally affecting climate change: our use of vehicles and equipment to administer the refuge. We discuss the direct and indirect impacts of those activities elsewhere in chapter 4. We also discuss measures to minimize the impacts of both. With regards to our equipment and facilities, we are trying to reduce our carbon footprint wherever possible by using alternative energy sources and energy saving appliances, using recycled or recyclable materials (e.g. benches and boardwalk construction), changing management plans to reduce equipment use, and other conservation measures.

In our professional judgment, most 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. We discuss our actions relative to the 18 recommendations the Wildlife Society report gives to assist land and resource managers in meeting the challenges of climate change when working to conserve wildlife resources (Inkley et al. 2004).

> *Recommendation #1: Recognize global climate change as a factor in wildlife conservation. This recommendation relates to land managers and planners becoming better informed about the consequences of climate change and the variability in the resources they work with.*

Throughout our alternatives we have highlighted the need to address climate change, specifically in regard to habitat changes. We have proposed a series of strategies involving monitoring and other potential

impacts of climate change as it relates to the long-term protection and management of habitats in light of our defined refuge purposes and proposed goals outlined in this draft CCP/EA.

The FWS is taking a major role among Federal agencies in distributing and interpreting information on climate change. There is a dedicated webpage for this issue at *http://www.fws.gov/home/climatechange/* (accessed April 2012). The FWS Northeast Region also co-hosted a workshop in June 2008 titled "Climate Change in the Northeast: Preparing for the Future." A similar workshop for all Federal, state, and nongovernmental organization land managers and conservationists of the Mid-Atlantic was held in March 2009. Both workshops provided valuable scientific information and resources to aid managers in land management planning in the context of climate change. All Northeast Region refuge supervisors and planners attended, as did over 20 refuge field staff.

> *Recommendation #2: Manage for diverse conditions. This recommendation relates to developing sound wildlife management strategies under current conditions, anticipating unusual and variable weather conditions, such as warming, droughts and flooding.*

Our proposed habitat management actions described in chapter 3 promote healthy, functioning bottomland, upland, riparian and floodplain forests, scrub-shrub, wetlands, open waters, and grasslands. We have identified monitoring elements, which will be fully developed in the Habitat Management and Population Management step-down plans (see section 3.1.1), to evaluate whether we are meeting our objectives and to assess changing conditions. We will implement an adaptive management approach as new information becomes available.

> *Recommendation #3: Do not rely solely on historical weather and species data for future projections without taking into account climate change. This recommendation relates to the point that historical climate, habitat and wildlife conditions are less reliable predictors as climate changes. For example, there may be a need to adjust breeding bird survey dates if migratory birds are returning earlier to breed than occurred historically.*

We are aware of these implications and plan to build these considerations into our Population Management Plan so that we can make adjustments accordingly. The FWS is working to establish long-term monitoring protocols and sites to document future trends in the Northeast.

> *Recommendation #4: Expect surprises, including extreme events. This recommendation relates to remaining flexible in management capability and administrative processes to deal with ecological "surprises" such as floods or pest outbreaks.*

Refuge managers have flexibility within their operations funds to deal with emergencies. The refuge has experienced "extreme" weather events with greater frequency in recent years, including flooding. For example, record flooding occurred after Tropical Storm Irene (August 2011) and an unexpected Nor'easter snowstorm (October 2011) caused massive tree damage and widespread power outages. Due to the frequency experienced, we may begin considering these types of events a "new normal" when planning annual needs. Other regional operations funds would also be redirected as needed to deal with emergencies.

> *Recommendation #5: Reduce non-climate stressors on the ecosystem. This recommendation relates to reducing human factors that adversely affect resiliency of habitats and species.*

Similar to our response to #2 above, the objectives of our habitat management program are to protect the biological integrity, diversity and environmental health of refuge lands. Our objectives to create healthy, diverse native and resilient vegetation communities and expand "core" forest habitat through the consolidation of management units would help offset the local impacts of climate change.

> *Recommendation #6: Maintain healthy, connected, genetically diverse populations. This recommendation relates to the fact that small isolated populations are more prone to extirpations than larger, healthy, more widespread populations. Large tracts of protected land facilitate more robust species populations and can offer better habitat quality in core areas.*

As noted in chapter 2, the refuge is in many ways a biological island surrounded by dense urbanization. Where we can restore or preserve connections, we pursue these opportunities. We would also continue to work with our many conservation partners at the State and regional level to support and complement restoration and protection efforts, expand existing conserved tracts and target others to create corridors.

> *Recommendation #7: Translocate individuals. This recommendation suggests that in some cases, it may be necessary to physically move wildlife from one area to another to maintain species viability. This recommendation also cautions that translocation is not only expensive, but also poses ecological risks to native ecosystems (e.g., introduction of disease and other unpredictable consequences). The potential for irreversible consequences should be carefully considered and translocation should be severely limited as a conservation strategy to cope with climate change.*

As described in chapter 3, we would evaluate the feasibility and ecological risk of reintroducing bog turtle hatchlings to increase population viability and genetic diversity on the refuge. This would likely only occur if the refuge's populations were determined to be in danger of collapse and the risk of introducing disease (or other environmental consequences) has been determined to be low. All reintroductions are regulated by State and federal permits.

> *Recommendation #8: Protect coastal wetlands and accommodate sea level rise. This recommendation relates to impacts of sea level rise and provides suggestions for reducing and coping with these risks, such as establishing inland buffer zones to provide an opportunity for habitats and wildlife to migrate inland.*

The refuge is not located within or near the coastal zone; therefore, this recommendation does not apply.

> *Recommendation #9: Reduce the risk of catastrophic fire. This recommendation acknowledges that fire can be a natural part of the ecosystem, but that climate change could lead to more frequent fires and/or a greater likelihood of a catastrophic fire.*

Our plans to use prescribed fire as a management tool; control invasive plants, especially dense monotypic stands; and provide for structural diversity in combination with natural conditions and man-made firebreaks (roads, utility corridors, etc.) found across the refuge would reduce the overall risk of a catastrophic fire.

> *Recommendation #10: Reduce likelihood of catastrophic events affecting populations. This recommendation states that increased intensity of severe weather can put wildlife at risk. While the severe weather cannot be controlled, it may be possible to minimize the effects by supporting multiple, widely spaced populations to offset losses.*

Our response to recommendations #2, #3, and #6 above describes the actions we are taking to minimize this risk. Unfortunately, the limited footprint of the refuge and scarcity of large tracts of nearby undeveloped lands limits opportunities for the refuge itself to support multiple, widely spaced populations. We will work with other regional conservation land managers to support this effort.

> *Recommendation #11: Prevent and control invasive species. This recommendation emphasizes the increased opportunities for invasive species to spread because of their adaptability to disturbance. Invasive species control will be essential, including extensive monitoring and control to preclude larger impacts.*

Invasive species control is currently a major initiative within the FWS and on the refuge. The Northeast Region, in particular, has taken a very active stand. In chapter 3, we provide detailed descriptions of our current and future plans on the refuge to control existing invasive plant infestations. We also describe monitoring and inventorying strategies to protect against new infestations and emerging invasive species, including EDRR.

> *Recommendation #13: Account for known climatic conditions. This recommendation states we should monitor key resources through predictable short-term periodic weather phenomenon, such as El Nino, to aid us in future management efforts.*

We plan to develop an Inventory and Monitoring Plan, which will include guidelines for inventory and monitoring, marking and banding, and disease prevention and response. This plan will help us evaluate our assumptions and success in achieving objectives, assess the health and contribution of our habitats toward our objectives, and assist us in making future management decisions. Any restoration activities or management actions would be carefully planned and their effectiveness monitored and documented so we can use this information in future management decisions.

> *Recommendation #14: Conduct medium- and long-range planning. This recommendation states that plans longer than 10 years should take into account potential climate change and variability as part of the planning process.*

This 15-year CCP addresses climate change with its emphasis on restoring and maintaining healthy, contiguous, native habitat areas; reducing human stressors on refuge lands; expanding environmental education and interpretation programs with additional focus on climate change; reducing the refuge's carbon footprint and increasing use of green technologies; and expanding partnerships. Our monitoring program and adaptive management strategies would also facilitate our ability to respond to climate change.

Recommendation #15: Select and manage conservation areas appropriately. This recommendation states that establishing refuges, parks and reserves is used as a conservation strategy to try to minimize the decline of wildlife and habitats in North America. Decisions on locating future conservation areas should take into account potential climate change and variability. For example, it is suggested that decisions on new acquisitions consider the anticipated northward migrations of many species, or the northern portion of species ranges. Managers of existing conservation lands should consider climate change in future planning.

The FWS as a whole is working with partners on making decisions on where and how to provide conservation areas in light of climate change through a science-based process known as "Strategic Habitat Conservation." Specifically, the FWS is developing Landscape Conservation Cooperatives throughout the country to provide science support for these decisions. The refuge would continue to support these nationwide initiatives, as well as more local efforts.

Recommendation #16: Ensure ecosystem processes. This recommendation suggests that managers may need to enhance or replace diminished or lost ecosystem processes, such as manually dispersing seed, reintroducing pollinators, and treating invasive plants and pests.

We have and will continue to take an aggressive approach to treating invasive plants species and pest outbreaks. If necessary, we will take actions to enhance or replace ecosystem processes, such as manually dispersing seed. None of our proposed management actions would diminish natural ecosystems processes already underway. Should our monitoring results reveal that we must take a more active role in enhancing or replacing those processes, we will reevaluate and/or refine our management objectives and strategies.

Recommendation #17: Look for new opportunities. This recommendation states that managers must be continually alert to anticipate and take advantage of new opportunities that arise. Creating wildlife conservation areas out of abandoned or unusable agricultural land, and taking advantage of industry interest in investing in carbon sequestration or restoration programs, are two examples cited.

Refuge staff has maintained many conservation partners in the area which, in turn, are networked throughout the larger region. We are aware of many opportunities for land protection or habitat restoration through this broad-based network. Our Northeast Region has field offices and a Regional Office that integrates the other FWS program areas, including those that work with private entities. We have developed outreach materials, and make ourselves available to interested organizations and groups, to provide more detailed information on the FWS and Refuge System missions, refuge goals and objectives, and partnership opportunities.

Recommendation #18: Employ monitoring and adaptive management. This recommendation states that we should monitor climate and its effects on wildlife and their habitats and use this information to adjust management techniques and strategies. Given the uncertainty with climate change and its impacts on the environment, relying on traditional methods of management may become less effective.

We agree that an effective and well-planned monitoring program, coupled with an adaptive management approach, will be essential to dealing with the future uncertainty of climate change. We have built both aspects into alternatives B, C, and D of our draft CCP/EA. We will develop detailed step-down Population and Habitat Management Plans, which will include guidelines for inventory and monitoring, to evaluate our assumptions and management effectiveness in light of on-going changes. With that information in hand, we would either adapt our management techniques, or reevaluate or refine our objectives as needed.

4.15.3 Unavoidable Adverse Effects

Unavoidable adverse effects are the effects of those actions that could cause harm to the environment and that cannot be avoided, even with mitigation measures. All of the alternatives would result in some minor, localized, unavoidable adverse effects. For example, reconfiguration and consolidation of managed habitat units would produce minor, short-term, localized, adverse effects on landbird populations and increased visitation could have minor unavoidable effects on various wildlife species. However, we do not believe that any of these effects would rise to a significant level.

Many of the habitat management and facility construction projects in the proposed alternatives have a certain level of unavoidable adverse effects, especially during the actual construction. Those effects can be mitigated to a large degree by the use of BMPs and precautions that safeguard water quality, avoid sensitive habitats, or time the actions (or include safeguards) to avoid or minimize impacts on fish and wildlife. The adverse effects generally are short-term and more than offset by the long-term gains in habitat quality and fish, wildlife, and plant productivity.

Forest, scrub-shrub, and grassland habitats would be reconfigured and maintained to create large (greater than 50 acres), contiguous patches to promote wildlife use, increase connectivity, decrease fragmentation, increase maintenance efficiency, and reduce maintenance costs. As a result, these vegetation communities are likely to undergo changes in species composition and structure. Reconfiguration and consolidation of habitats may cause an initial adverse effect on some plant or wildlife species; however, in the long-term, populations are expected to benefit. As previously mentioned, timing of activities would be considered to avoid potential disturbance to nesting species, as well as to minimize impacts on foraging and resting habitat during important seasonal periods, such as nesting or migration.

Some aspects of wildlife-dependent recreation, such as hunting or fishing, would result in the unavoidable adverse impacts on individual fish and wildlife as a result of providing these consumptive activities; however, we would ensure that populations are protected from adverse effects by requiring all participants follow applicable State and refuge regulations. In addition, we anticipate long-term benefits to species and habitats from connecting people with nature through these activities. Fishing, under alternative D, would be permitted in designated areas on the refuge. This activity results in the unavoidable adverse loss of individual fish; however, this activity constitutes a relatively minor impact on species populations. Similarly, the introduction of a spring wild turkey hunt under alternatives B, C, and D would result in unavoidable adverse loss of individuals; however, population data and trends will be monitored carefully to avoid adverse impacts to the overall population. The deer management hunt program, under all alternatives, would also result in the unavoidable adverse loss of individuals; however, overall health of the refuge's deer population would likely improve by maintaining or reducing (when necessary) competition for limited resources. In addition, there would be long-term benefits to refuge habitats and the other species that depend on them through reduction in browse intensity.

All of these unavoidable adverse effects on the physical and biological environment would be relatively local and more than offset by the long-term benefits to the diversity and ecological health of the broader landscape.

Some impacts on certain individuals or refuge neighbors may be unavoidable, such as a minor increase in traffic due to increases in visitation, but our responsibility is to provide equal opportunities to the American public, not a select few. We believe we have sought a fair balance in minimizing and mitigating adverse impacts while providing quality recreational opportunities to the public. All of what we propose in the arena of public use has been subject to public involvement and input during the planning process.

4.15.4 Potential Irreversible and Irretrievable Commitments of Resources

Irreversible commitments of resources are those that cannot be undone, except perhaps in the extreme long term. One example is an action that contributes to a species' extinction. Once extinct, it can never be replaced and is an irreversible loss. By comparison, irretrievable commitments of resources are those that are lost for an extended period of time, but could be undone given sufficient time and resources, although there may be a loss in productivity or use for a time. An example of an irretrievable commitment is converting what was once a mature forest and actively managing and maintaining it as early successional habitat. If, for some reason, that early successional habitat was no longer an objective, those acres could progress gradually to mature forest again over a period of 70 or more years, or we could determine it best to expedite the reversion by planting shrubs and trees and controlling invasive plants.

4.15.5 Environmental Justice

On February 11, 1994, President Clinton signed Executive Order No. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," to focus Federal attention on the environmental and human health conditions of minority and low-income populations, with the goal of achieving environmental protection for all communities. The order directs Federal agencies to develop environmental justice strategies to aid in identifying and addressing disproportionately high, adverse human health or environmental effects of their programs, policies, and activities on minority and low-income populations. The order is also intended to promote nondiscrimination in Federal programs substantially affecting human health and the environment, and to provide minority and low-income communities' access to public information and participation in matters relating to human health or the environment.

We expect none of the four proposed alternatives to have significant adverse cumulative impacts on for the towns or counties in which the refuge lies. We would expect none of the alternatives to alter the demographic or economic characteristics of the local community. The actions we propose would neither disproportionately affect any communities nor damage or undermine any businesses or community organizations. Consequently, no adverse impacts would be expected including changes in the community character or demographic composition.

Overall, we expect none of the alternatives would place disproportionately high, adverse environmental, economic, social, or health effects on minority or low-income persons. Our programs and facilities are open to all who are willing to adhere to the refuge's rules and regulations, we acquire land only from willing sellers, and we do not discriminate in our responses for technical assistance in managing private lands. In addition, proposed refuge construction projects under alternatives B, C, and D would occur within the refuge boundary and are not expected to have disproportionate adverse effects on any group or area.