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CHAPTER 4: ENVIRONMENTAL IMPACT ANALYSIS

Introduction

This Chapter analyzes the environmental impacts from the actions proposed in the alternatives presented in Chapter 2 of this document. This Chapter is organized in the same way as Chapter 2 with a separate section addressing the impacts relating to each of the two separate, but related, sets of alternatives for
1) Refuge Management and 2) Refuge Boundary Expansion. The terms impacts, consequences, and affecting/effects all mean the same thing in the context of this chapter. An action affects the physical environment if it changes the physical environment; and, effects on the human environment from changes in the physical environment are addressed as the socio-economic effects.

The National Environmental Policy Act (NEPA) requires that all of the significant environmental effects must be addressed within an Environmental Impact Statement (EIS). This includes the beneficial as well as the negative effects and the direct as well as the indirect effects. A direct effect is caused by the agency action and occurs at the same time and place. An indirect effect is also caused by the agency action but occurs later in time or is further removed in distance than a direct effect; however, the indirect effect must be reasonably foreseeable to be included in the EIS. The cumulative effects must also be considered in an EIS. A cumulative effect results from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions regardless whether undertaken by Federal agency, non-Federal agency of private individuals. This Chapter provides a reasonably thorough discussion of the significant aspects of the probable environmental consequences of the proposed actions.

This Chapter has three (3) parts:

1. **Part A - Impact Analysis for the Five Refuge Management Alternatives**
2. **Part B - Impact Analysis for the Four Refuge Boundary Expansion Alternatives**
3. **Part C - Combined and Cumulative Impacts Analysis**

Part A consists of the discussion of the probable environmental consequences associated with the five Refuge Management Alternatives proposed in Chapter 2, including the “No Action Alternative” of continuing current management activities. Part B consists of the discussion of the probable environmental consequences associated with the four Refuge Boundary Expansion Alternatives proposed in Chapter 2, including the “No Action Alternative” of not expanding any of the refuge boundaries. Part C consists of a discussion of the probable environmental consequences associated with combining the two Preferred Alternatives, one from each of the two separate but related sets of alternatives. Part C also includes a discussion of the cumulative impacts associated with the two combined Preferred Alternatives.

PART A: IMPACT ANALYSIS FOR THE FIVE REFUGE MANAGEMENT ALTERNATIVES

Summary of Refuge Management Alternatives

The five Refuge Management Alternatives (A - E) are listed below with a short summary for each.

Refuge Management Alternative A: ***(NEPA No Action Alternative)*** *Continuation of Current Management*

Under this Alternative, current management programs on the Refuge Complex would continue unchanged. Management of wetland habitats including coastal marsh and prairie wetlands to benefit waterfowl, shorebirds, wading birds, and other wetland-dependent migratory birds would continue at current levels and intensities using prescribed burning, grazing, water level and salinity management, rice farming, moist soil management, and mowing and haying . Restoration and protection of native habitats including wetlands, prairie and woodlands would proceed at current annual acreage rates and using existing techniques. The Refuge Complex would continue to provide opportunities for all six of the Refuge System's priority wildlife-dependent recreational uses, including hunting, fishing, wildlife observation and photography, and environmental education and interpretation through the use of existing programs and facilities.

Refuge Management Alternative B: Emphasis on Intensifying Management of Wetland Habitats for Waterfowl, Shorebirds, Wading Birds, and Other Wetland-Dependent Migratory Birds

Under this Alternative, the Refuge Complex would focus its management efforts on active management of wetland and upland habitats to benefit waterfowl, shorebirds, wading birds, and other wetland-dependent migratory and resident birds. In marsh habitats, grazing intensity, annual prescribed burn acreage and the frequency of burning would be increased to substantially increase the amount of marsh habitat in early successional plant communities. Two new marsh semi-impoundments totaling 7,500 acres would be constructed and water management capabilities enhanced in existing impoundments through installation of new control structures and levees. The cooperative rice farming program, moist soil management, and haying and mowing programs on Anahuac NWR would be expanded to enhance shallow fresh water wetland habitats and adjacent upland prairies for resident Mottled Ducks, and for wintering and migrating waterfowl shorebirds and wading birds. The Refuge Complex would also continue to provide and promote opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses, with an emphasis on providing more public hunting opportunities.

Refuge Management Alternative C: Emphasis on Native Habitat Restoration and Addressing Major Threats to the Ecosystem

Under this Alternative, the Refuge Complex would focus its management efforts on restoring wetlands, native prairie and woodlots, and on reversing trends of loss and degradation of these native habitats by increasing efforts to address coastal erosion, saltwater intrusion, and loss of freshwater and sediment inflows. Restoration of native prairie and prairie wetlands would occur on all suitable upland sites. A portion of the historic fresh and intermediate component of the Refuge Complex's coastal marshes would be restored and ongoing interior marsh loss addressed by working with agencies and other stakeholders on major hydrologic restoration projects that restore freshwater inflows and further restrict saltwater intrusion across watersheds, and through refuge-specific projects. Efforts to address coastal wetland loss resulting from shoreline erosion along the Gulf, Galveston Bay and the GIWW would be intensified by increasing coordination among agencies and other stakeholders to develop and implement major projects aimed at stabilizing shorelines, and by implementing smaller scale projects on the Refuge Complex. The Refuge Complex would continue to provide the current level of opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses.

Refuge Management Alternative D: ***(Preferred Alternative)*** *Emphasis on an Integrated Management Approach Combining: 1) Expanded Habitat Management and Restoration Programs, 2) New Research and Wildlife Population Monitoring, and 3) Increased Efforts to Address Major Threats to the Ecosystem*

Under this Alternative, the Refuge Complex would continue and expand current habitat management and native habitat restoration programs, with increased monitoring and research to assess management actions and facilitate an adaptive management approach. Wetland habitat management activities for waterfowl, shorebirds and other wetland-dependent migratory birds including prescribed burning, controlled grazing, management of marsh semi-impoundments, and moist soil management would be refined and expanded through development of new infrastructure. Concurrently, additional restoration of native habitats including wetlands, prairie and woodlots would be undertaken to benefit a variety of native fauna, with a focus on priority species identified as in need of conservation actions through national and international conservation initiatives.

Additional shoreline protection and hydrologic restoration projects would be implemented on the Refuge Complex and coordination with other agencies would be expanded to address shoreline erosion and interior marsh loss on a landscape scale. Implementation of major projects that protect, restore and enhance coastal marshes by restoring freshwater inflows, providing sediments through the beneficial use of dredge materials, restricting saltwater intrusion, and protecting shorelines would be the goal of this interagency coordination and cooperation. Through new partnerships with universities and other agencies, additional research and monitoring would be conducted to assess the impacts of relative sea level rise and to gather baseline data on fish and wildlife populations and habitat use with an emphasis on documenting the status of several sensitive or declining species. The Refuge Complex would also continue to provide and promote opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses: hunting, fishing, wildlife observation and photography, and environmental education and interpretation. The Refuge Complex would seek to improve the quality of visitor services and of the visitor experience.

Refuge Management Alternative E: Emphasis on a Passive Management Approach

Under this Alternative, the Refuge Complex would change its management focus from active habitat management and restoration to a more passive management approach, in which plant communities and wildlife populations are influenced primarily by natural events such as lightning-caused fires, herbivory by native wildlife, and tidal or stream flooding. Active habitat management and restoration activities including prescribed burning, controlled cattle grazing, rice farming and moist soil management would be discontinued. Management of water levels and salinities through active manipulation of water control structures would be discontinued. Efforts to address threats to ecosystem health would focus on monitoring rather than active restoration or protection. The Refuge Complex would continue to provide opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses: hunting, fishing, wildlife observation and photography, and environmental education and interpretation, but administrative oversight and management would occur at reduced levels.

USFWS Habitat Management and Restoration

The primary focus of USFWS land management activities on the Refuge Complex is to fulfill the purpose for which the Refuge Complex was established, i.e., for the conservation and management of migratory birds and their habitats. A complete description of USFWS management activities and programs on the Refuge Complex is found in Chapter 3, Affected Environment.

The major habitat management and restoration activities implemented on the Refuge Complex by the USFWS can be grouped into three major categories:

- Wetland Specific Management and Restoration
    - Water level and salinity management in coastal marshes

    - Wetland restoration
    - Moist soil management
    - Cropland management – cooperative rice farming program

- Upland Specific Management and Restoration

    - Native prairie restoration
    - Woodlot restoration and protection

- General Habitat Management and Restoration Activities

    - Fire Management – Wildland Fire Suppression and Prescribed Burning
    - Controlled Livestock Grazing
    - Invasive Species Management
    - Shoreline Protection and Restoration
    - Mowing and Haying

The management of fish, wildlife and plant populations on the Refuge Complex involves an active Biological Program with ongoing field surveys, monitoring and research studies. Management of American alligator populations on the Refuge Complex includes a commercial harvest program on the McFaddin and Anahuac NWRs.

Implementation of a management action under the Refuge Complex' habitat or biological programs is intended to have a beneficial effect on a specific resource, or resolve an existing or potential environmental or natural resource problem. Therefore, management actions are intended and generally cause positive environmental impacts. However, not all results of management actions are positive, or entirely eliminate or resolve the targeted environmental problems and concerns. In addition, with most management activities on the Refuge Complex, actions that directly affect one resource have links to other resource areas (e.g., hydrology, vegetation and habitats, and fish and wildlife).

In addition to habitat and fish and wildlife management activities, the Refuge Complex administers all six of the National Wildlife Refuge System's priority public uses: hunting, fishing, wildlife observation and photography, and environmental interpretation and education. Recreational uses of the Gulf of Mexico beaches on and adjacent to the McFaddin NWR also occur. Public recreational and educational programs on the Refuge Complex provide societal benefits and promote an increased awareness of and support for conservation of natural resources among the general public, but these uses also have direct impacts to fish and wildlife and habitats and other resources. The Refuge Complex law enforcement program is a critical aspect of management to ensure public safety and protection of natural resources.

The USFWS acquired lands for establishment of all four refuges in the Refuge Complex subject to reserved and outstanding mineral interests. The mineral estates underlying the refuges are privately owned, and the USFWS must allow reasonable use of the surface of the refuges for exploration and development of underlying oil and gas reserves. Management of existing and new oil and gas exploration and development activities is important for protecting habitats and fish and wildlife resources on the Refuge Complex. New activities are managed through the issuance of Special Use Permits, which contain stipulations aimed at protecting these resources.

The USFWS also works with private landowners, primarily to facilitate implementation of wetland habitat restoration and enhancement projects. Refuge staff provides technical assistance to private landowners, and works with landowners and the USFWS Division of Ecological Services to develop projects under the USFWS Partners for Fish and Wildlife Program. Community outreach efforts also include establishment of partnerships with conservation organizations, local governments, and industry to further natural resource conservation in the region. Two non-profit groups, the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, actively support a variety of refuge management programs and activities. Volunteers contribute approximately 10,000 hours annually on the Refuge Complex.

Impacts to Cultural Resources

The impacts to cultural resources on the Refuge Complex from the actions proposed in the Refuge Management alternatives are discussed in a separate section at the end of Part A of this Chapter. The impacts for all of the alternatives are grouped together in one discussion because the impacts are very similar and not substantial.

I. IMPACT ANALYSIS FOR REFUGE MANAGEMENT ALTERNATIVE A (NEPA NO ACTION) – CONTINUATION OF CURRENT MANAGEMENT

Overview

Under this Alternative, current management programs on the Refuge Complex would continue unchanged. Management of wetland habitats including coastal marsh and freshwater prairie wetlands to benefit waterfowl, shorebirds, wading birds, and other wetland-dependent migratory birds would continue at current levels and intensities using prescribed burning, controlled grazing, water level and salinity management, rice farming, and moist soil management. Restoration and protection of native habitats including wetlands, prairie and woodlands would proceed at current annual acreage rates and using existing techniques. The Refuge Complex would continue to provide opportunities for all six of the Refuge System's priority wildlife-dependent recreational uses, including hunting, fishing, wildlife observation and photography, and environmental education and interpretation through the use of existing programs and facilities.

A. Natural Resources Section

1. Impacts to Air Quality

The USFWS fire management program on the Refuge Complex includes both the suppression of unplanned wildland fires and prescribed burning. Under Refuge Management Alternative A, suppression of wildland fires would continue as described in the Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Under Refuge Management Alternative A, the USFWS would also continue its current prescribed burning program on the Refuge Complex with generally the same frequency and magnitude. Most burning would be conducted in emergent marsh habitats (during fall and early winter) on the Refuge Complex, with some burning in upland grassland habitats during spring, and with an overall annual burning objective of 12,000 - 15,000 acres. Prescribed burning is defined by Texas's Outdoor Burning Rule as "the controlled application of fire to naturally occurring vegetative fuels under specified environmental conditions and confined to a predetermined area, following appropriate planning and precautionary measures (Therriault 2001)."

The USFWS fire management program has the greatest potential of all refuge management activities to impact the region's air quality. Smoke from unplanned wildland fires and from planned prescribed burning can be transported by prevailing winds and affect air quality and transportation safety over a large area which includes the cities of Houston, Beaumont and Port Arthur and numerous smaller local communities. Smoke is made up primarily of carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons and other organics, nitrogen oxides, and trace minerals. The composition of smoke varies with fuel type. In general, particulate matter is the major pollutant of concern from wildland fire and prescribed fire smoke. Particulate matter is a general term for a mixture of solid particles and liquid droplets found in the air. Particulate matter from smoke tends to be very small (less than one micron in diameter) and, as a result, is more of a health concern than the coarser particles that typically make up road dust. Because of their size range, particulates scatter light effectively and therefore, reduce visibility easily.

The human health effects from smoke run from irritation of the eyes and respiratory tract to more serious disorders including asthma, bronchitis, reduced lung function, and premature death. Particulate matter is the main source of health effects, but carbon dioxide and toxic air pollutants from wildfires can also cause health concerns (Therriault 2001).

The atmospheric conditions that affect the movement and dispersal of smoke include the following: wind direction, wind speed, mixing height (the elevation in the atmosphere that the smoke mixes and disperses), transport wind speed and direction (the direction and speed of upper level winds responsible for moving the smoke from the immediate area), and Category day/dispersion (a combination of mixing height and transport wind speed to give an over all indicator of smoke dispersion potential). The Category Day 1, 2, 3, 4 or 5 equates to poor, fair, good, very good and excellent smoke dispersal (USFWS 2003).

The USFWS uses prescribed burning on the Refuge Complex to reduce accumulations of hazardous vegetative fuels and to maintain and improve habitat for wintering and migrating waterfowl and other migratory birds. Although prescribed burning under Refuge Management Alternative A would continue to be beneficial to the Refuge Complex's habitats and wildlife (as discussed under *Section II.A.4 Vegetation and Habitats* and *Section 4.A.5 Wildlife below*), prescribed burning has the potential to negatively impact local air quality through the production of smoke. Because prescribed burning is conducted on the Refuge Complex under strict prescriptions which include implementing smoke management measures, impacts to local and regional air quality from the USFWS fire management program are minimal. Prescription parameters which must be met prior to ignition and for the predicted duration of a prescribed burn specifically aimed at preventing smoke impacts include surface and transport wind direction and speed, mixing height, ambient air temperature and humidity, and fuel moisture. Both current and predicted climatic conditions are considered when deciding whether to proceed with a burn, and are regularly monitored for the duration of the burn as a further safeguard. Reducing smoke impacts to surrounding communities is also an important consideration in planning and implementing suppression actions on all wildland fires occurring on the Refuge Complex.

Prescribed burning on the Refuge Complex also reduces the potential for smoke impacts to air quality from unplanned wildland fires by effectively managing vegetative fuels. Most lightning-ignited wildland fires on the Refuge Complex occur during the months of June through October, when prevailing winds typically include a southerly component which transports smoke towards communities and other smoke-sensitive areas. Wildland fires are less likely to start in areas with reduced fuel loads because of prescribed burning, and fires that do start burn with less intensity, produce less smoke, and are easier to suppress than in unburned areas with excessive accumulations of hazardous fuels.

2. Impacts to Geology and Soils

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

Under Refuge Management Alternative A, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss. Under this Alternative, management and restoration activities would continue with generally the same frequency and magnitude, but could expand as additional partnerships are developed and cooperative projects implemented.

On McFaddin and Texas Point NWRs, these partnerships have focused on augmenting coarse sediment supply along the Gulf shoreline. In 2001, 1,700 linear feet of dunes were restored on the eastern portion of McFaddin NWR, adjacent to Sea Rim State Park. On Texas Point NWR, dredge material from the Sabine-Neches Ship Channel was beneficially used to augment sediment supply and restore marsh along the Gulf shoreline. Structural erosion abatement projects have also been implemented. Over 1.5 miles of rock breakwaters have been constructed along the GIWW on McFaddin NWR in recent years. These breakwaters have trapped up to 18 inches of sediment and created conditions that allowed for the natural creation of new marsh. Smooth cordgrass plantings along over three miles of the GIWW in the past seven years has established vegetated shorelines that trap sediments, build elevation and new wetlands,

and temporarily slow erosion. Shoreline restoration **and** stabilization efforts on Anahuac NWR have been ongoing for the last 25 years. Several shoreline stabilization studies were conducted on the Anahuac NWR to develop shoreline protection techniques, which involved locating the most suitable native plant species capable of stabilizing the shoreline (Webb 1974, Webb and Dodd 1976). Stabilization of the eroding shoreline on Anahuac NWR has involved the placement of barriers of shell and stone on the eroding shoreline, restoring vegetation along Galveston Bay, and the construction of offshore breakwaters and sprigging smooth cordgrass transplants between the shoreline and the breakwaters.

The historic barrier beach/dune system has been almost entirely lost on both the Texas Point and McFaddin NWRs. Shoreline erosion and retreat along the Gulf on these refuges is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. Morton *et al*. (2004) found beach erosion between Sabine Pass and High Island to be among the highest in Texas. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and significant portions of the McFaddin NWR shoreline is eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of habitat, loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of plant productivity may decrease the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water (DeLaune *et al*. 1983, Nyman *et al*. 1993). (On McFaddin NWR, coastal erosion and damage from storm tidal surges have destroyed a portion of Texas State Highway 87, a coastal highway that has been closed since 1989.)

Shoreline erosion and retreat is resulting in loss of coastal habitats throughout the Refuge Complex. The shore of East Galveston Bay on the Anahuac NWR is eroding at 1.2 meters annually (Carrol 1974). Paine and Morton (1986) determined the East Bay shoreline of Anahuac NWR consistently eroded at a rate of 3 feet/year between 1850 and 1982. The erosion threatens approximately 6,000 acres of inland brackish and intermediate marshes with saltwater intrusion. Erosion along the some sections of the GIWW is occurring at rates between 5 to 10 feet annually. This is resulting in current or pending loss of intermediate and brackish marsh habitats on Anahuac and McFaddin NWRs, further threatening these habitats with saltwater intrusion.

Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of channels have led to erosional loss of organic marsh soils and conversion of vegetated marshes to open water. Conversion of vegetated marshes to open water has also occurred throughout the region in areas where rapid land subsidence has resulted in submergence of wetlands. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). In some areas, rapid land subsidence caused by underground fluid withdrawals has been correlated with submergence of wetlands and conversion of vegetated marshes to open water (White and Tremblay 1995). Conversion of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et a*l. 1993). It is likely that conversion of vegetated marshes to open water has been greatest in areas subject to both saltwater intrusion and rapid subsidence.

Dune restoration and the use of dredged material on McFaddin and Texas Point NWRs are contributing to increasing coarse sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994). Restoring the Gulf barrier beach/dune system to historic elevations is also protecting inland marshes, and plant productivity therein, by reducing saltwater intrusion. Offshore rock breakwaters and shoreline armoring on the Refuge Complex also reduce the erosion of shoreline. Restoring emergent marsh by planting smooth cordgrass along shorelines reduces land loss and increase sedimentation and vertical accretion within vegetation stands.

In addition to ongoing impacts, relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov). Recent scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

The relatively small scale of ongoing shoreline restoration projects under Refuge Management Alternative A is not likely to be sufficient to counter the effects of relative sea level rise and altered hydrological regimes on coastal land loss, and accelerated rates of shoreline retreat and land loss will likely continue under this Alternative. For example, restoration of the historic barrier beach and dunes on McFaddin NWR would require a large-scale project affecting an additional 16 miles of Gulf shoreline. Under this Alternative, increased saltwater intrusion from more frequent tidal flooding from the Gulf into inland marshes on McFaddin and Texas Point NWRs will continue to negatively impact soil formation and vertical accretion by causing direct mortality of some plant species and an overall reduction in above and below-ground plant productivity.

Other USFWS management activities under Refuge Management Alternative A would also impact soils and soil formation. Structural marsh management techniques, such as weirs and impoundments, may affect marsh vertical accretion (Nyman *et al*. 1993). (Water management in coastal marshes on the Refuge Complex is fully detailed below in *Section 4.a. Impacts to Vegetation and Habitats from Habitat Management* ***and*** *Restoration Activities*). In a survey in Louisiana regarding the effects of weir management on marsh loss, Nyman *et al*. (1993) concluded that weirs did not affect marsh loss or accretion, but that weirs may have different effects under different hydrological conditions, and that the effects of herbivore activity (muskrats) were important. Bryant and Chabreck (1998) found three structurally managed marshes in the Chenier Plain of Louisiana had significantly lower accretion than adjacent unmanaged marshes, while the fourth managed marsh had higher accretion than the adjacent unmanaged marsh. The managed marsh with higher accretion rates remained permanently flooded, while the three managed marshes with lower accretion underwent frequent drainage. It was hypothesized that structurally managed marshes are hydrologically isolated from tidal sediment subsidies and that frequent forced drying oxidized organic material in the soil. Gabrey and Afton (2001) found that belowground biomass was higher in unimpounded than impounded marshes. Perez and Cahoon (2005) did not find any difference in marsh accretion between structurally managed marshes on McFaddin NWR and adjacent unmanaged marsh.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Marsh accretion in the Chenier Plain region's fresher marshes is very dependent on the accumulation of organic matter, as opposed to mineral sediment deposition which is very important in the deltaic marshes of southeastern Louisiana. USFWS water management activities in fresh to brackish coastal marshes on the Refuge Complex typically reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying. In meeting these objectives, these management activities should also benefit soil formation and vertical accretion in marshes by increasing plant productivity and preventing oxidation of marsh soils.

Flood waters from hurricanes and winter storms have been found to be sources of mineral sediment deposition for coastal marshes (Rejmanek *et al*. 1988, Reed 1989 and Nyman *et al*. 1995). A potential problem with structural marsh management is that high levees prevent sediment-laden flood waters from entering impounded marshes (Bryant and Chabreck 1998). Chabreck (1994) recommended using low levees in structural marsh management to provide access for storm driven sediment. The low levees that enclose most of the structurally managed marshes on the Refuge Complex do not prevent inundation during hurricanes or tropical storms. In many cases, salt prairie ridges form part of the high ground enclosing the structurally managed unit. These ridges are relatively low and tropical disturbances regularly overtop them, flooding interior marshes. These flood events typically result in blackwater conditions and reduced habitat quality and plant vigor, but may provide sediment subsidies for the marsh. Accretion monitoring plots not subjected to structural marsh management on McFaddin NWR detected no sediment deposition following the passage of Hurricane Rita in September of 2005 (USGS unpublished data), indicating that the relationship between storm-driven flood water and sediment deposition is not yet well understood and likely varies between storms and locations. While structurally managed marshes impede sediment-laden flood waters to some degree (Bryant and Chabreck 1998), excessive flooding and saltwater intrusion stresses plant communities (DeLaune *et al*. 1994) and can impede vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003).

Vegetation management activities such as prescribed burning can also affect soils and vertical accretion in marshes. Insufficient data exists to fully evaluate the effects of fire on marsh accretion. Evidence exists suggesting root mass is a significant contributor to vertical accretion via peat formation (DeLaune *et al*. 1983, Nyman *et al*. 1993). In a study on the McFaddin NWR, both root volume and sediment elevation recovered faster in a burned area relative to an unburned area after salt water flooding (M. Ford and D. Cahoon, unpubl. data). Gabrey and Afton (2001) found that unburned and cover-burned Chenier plain marshes showed no differences in belowground biomass. Fire has been shown to increase primary productivity in some Gulf coast marshes (Hackney and Cruz 1981, Gabrey and Afton 2001). While these studies examined the effects of cover burns (burns conducted when sufficient water is present in the marsh to restrict biomass consumption to aerial plant material), root and peat burns can have a profound impact on marsh accretion. Root fires consume the litter layer and shallow root systems, while peat fires burn deeper into the soil consuming available organic matter (Lynch 1941). In most situations, root and peat fires are avoided by carefully monitoring water levels and soil moisture. Nyman and Chabreck (1995) concluded that fire should be used with caution until its effects on marsh accretion is better understood.

3. Impacts to Hydrology and Water Quality

a. Hydrology

The Chenier Plain region's coastal marshes were historically influenced by high annual precipitation and substantial freshwater riverine inflows, creating a continuum of coastal estuarine marsh types associated with a natural salinity gradient, from fresh to saline. Fresh and intermediate marshes formed a substantial component of this continuum. The natural hydrologic regimes of the coastal marshes in the region, and on the Refuge Complex, have been greatly modified by the construction of major navigation channels including the GIWW and the Houston and Sabine-Neches Ship Channels, dams and reservoirs upstream of estuaries, numerous smaller canals and ditches, roads, levees and impoundments, and by the deepening and channeling of most natural waterways and other inland drainage improvements. The hydrological consequences of these activities include saltwater intrusion, reduced or restricted freshwater and nutrient/sediment inflows, and altered hydroperiods (wetting and drying cycles). Hydrological changes in turn have impacted natural biological diversity and in some cases contributed to a net loss of estuarine wetlands (Moulton *et al*. 1997).

Under Refuge Management Alternative A, the USFWS would continue wetland management and restoration activities aimed at minimizing or mitigating impacts of altered hydrological regimes on plant, fish and wildlife resources. These include structural marsh management, marsh restoration using dredge material, moist soil management, cooperative rice farming, and shoreline protection and restoration.

Water management activities in marsh habitats on the Refuge Complex include water level and salinity management and establishment of freshwater inflows. An extensive management infrastructure comprised of water control structures, levees, and water delivery systems (including pumps, ditches and canals) is used to manage and manipulate water and soil salinities and water levels within structurally-managed marsh units on the Refuge Complex. Similar water management infrastructure is used to intensively manage moist soil units and rice fields. Recovery of tail waters from moist soil and rice farming activities also contribute freshwater inflows to marshes on the Anahuac NWR. Shoreline restoration and protection activities under this Alternative include maintenance of existing projects and coordination with partners towards implementing additional small scale projects along the Gulf, GIWW and Galveston Bay shorelines. Under this Alternative, the USFWS would continue to coordinate with the U.S. Army Corps of Engineers and other agencies to evaluate opportunities to beneficially use dredge material to restore marshes which have converted to open water. The USFWS would also continue to coordinate with State and Federal agencies on a large-scale hydrological restoration project for marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass.

Conversion of vegetated marshes to open water has occurred throughout the Chenier Plain region in areas where increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels has caused erosional loss of organic marsh soils.

As discussed in *Section I.A.2* above, salt water intrusion and soil waterlogging has been associated with peat collapse and subsequent conversion of coastal marsh to open water (DeLaune *et a*l. 1994). Naidoo *et a*l. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Work conducted by Nyman *et al.* (1995b) indicate that marshhay cordgrass has higher root production at lower salinity levels. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993). Excessive flooding, salt water intrusion, and sulfide stress can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Loss of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et a*l. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et a*l. 2001). It is likely that conversion of vegetated marshes to open water has been greatest in areas subject to both saltwater intrusion and rapid subsidence.

Relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al.* 1993).

The wetland management and restoration activities implemented by the USFWS under Refuge Management Alternative A would continue to help maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes. In turn, these habitats would continue to support a natural diversity of native plant, fish and animal communities. Restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater inflows and managing water levels to mimic historic hydroperiods (wetting and

drying cycles) in coastal marshes on the Refuge Complex also will help to prevent the conversion of vegetated marsh to open water, promote plant productivity and contribute to marsh surface elevation gain (accretion).

The relatively small-scale hydrologic and shoreline restoration projects to be maintained and implemented in the future on the Refuge Complex under Refuge Management Alternative A are not likely to be sufficient to counter the effects of relative sea level rise and altered hydrological regimes on coastal land loss. If this is the case, current rates of shoreline retreat and conversion of vegetated marshes to open water will likely continue, and may accelerate. For example, restoration of the historic barrier beach and dunes on McFaddin NWR would require a large-scale project affecting an additional 16 miles of Gulf shoreline. Under this Alternative, increased saltwater intrusion from more frequent tidal flooding from the Gulf into inland marshes on McFaddin and Texas Point NWRs will continue to negatively impact soil formation and vertical accretion by causing direct mortality of some plant species and an overall reduction in above and below-ground plant productivity. Under this scenario, these marshes will become increasingly susceptible to submergence and conversion to open water.

b. Water Quality

Potential sources of contaminants affecting water quality include accidental releases from oil and gas exploration and production activities on and adjacent to the Refuge Complex, including spills and leaks from wells, production facilities, and pipelines. In addition, a high volume of petrochemicals is transported through the Refuge Complex on a daily basis via the GIWW. Municipal development and agricultural practices may also impact water quality in the Refuge Complex. Non-point pollution sources, such as storm drain run-off from local cities and towns, are a major source of pollution that enters the Galveston Bay estuarine ecosystem (Galveston Bay Estuary Program 1995). Point source pollution from upstream facilities such as landfills is also of concern. Rice cultivation contributes important freshwater inflows to the Galveston Bay and Sabine Lake estuarine ecosystems, but agricultural practices as a whole may also contribute excess nutrients and toxins to surface waters within these coastal watersheds. Herbicide application is used on rice, soybeans, sorghum, and hay throughout the region. Concentrations of herbicides are greatest during May, June and July, with the lowest concentrations occurring in the fall and winter. Nitrates from nutrient loading are common in agricultural areas where fertilizer application enters into streams, creeks, and bayous during storm events.

Under Refuge Management Alternative A, the USFWS would continue to periodically monitor water quality on the Refuge Complex through its Environmental Contaminants program, and continue to work with local, state and federal agencies to address water quality issues. Oil and gas exploration and production activities would continue to be managed, including enforcing conditions of Special Use Permits aimed at preventing pollution from accidental releases. The USFWS would continue to coordinate with State and Federal spill response agencies to maintain preparedness and to effectively respond to accidental spills affecting water quality (and fish, wildlife and habitats) on the Refuge Complex. Overall, these activities would reduce the impacts of point and non-point source pollution sources and accidental spills to water quality and fish, wildlife and plant resources.

4. Impacts to Vegetation and Habitats

USFWS management activities affecting vegetation and habitats on the Refuge Complex under Refuge Management Alternative A include habitat management and restoration activities in wetland and upland habitats. These include structural water management in coastal marshes, marsh restoration, rice farming, moist soil management, native prairie restoration, and coastal woodlot restoration and protection. Habitat management and restoration activities with impacts to vegetation in both wetland and upland habitats include prescribed burning, controlled grazing, invasive plant and animal control, shoreline restoration and protection and mowing **and** haying.

Public uses on the Refuge Complex, including hunting, fishing, wildlife observation and photography, and environmental education and interpretation, have direct and indirect impacts on vegetation and habitats.

Systematic monitoring of vegetation and habitats under the Refuge Complex Biological Program allows ongoing assessment of management activities.

Management of oil and gas activities on the Refuge Complex through issuance of Special Use Permits is aimed at minimizing and mitigating for the impacts of these activities on habitats and fish and wildlife resources.

a. Impacts to Vegetation and Habitats from Habitat Management and Restoration Activities

(1). Wetland Specific Management and Restoration

As discussed under *Sections I.A.2*. and *I.A.2*., wetlands management and restoration activities on the Refuge Complex impact geology, soils and hydrologic regimes. Such activities also strongly influence the vegetative communities found in Refuge Complex coastal marshes and prairie wetland habitats.

(a). Water Management in Coastal Marshes

Coastal marshes provide important food resources and cover to a diversity of wetland-dependent resident and migratory fish and wildlife species. These marshes also provide buffering of tidal storm surge, reduce flooding, and filter excessive nutrients and other contaminants. Threats to the Chenier Plain region's coastal marshes include altered hydrology resulting in increased saltwater intrusion and loss of freshwater and sediment inflows, rising sea levels and land subsidence, and waterborne and airborne contaminants (discussed in *Sections I.A.2*. and *I.A.3*. above). These processes are resulting in coastal land loss as shorelines are eroded and recede and as inland vegetated wetlands convert to open water, which in turn is decreasing habitat quantity and quality for native fish and wildlife.

Under Refuge Management Alternative A, structural water management to control salinities and water levels within marsh habitats on the Refuge Complex would continue. The following water management activities in marsh habitats would continue Complex-wide:

- Approximately 12,000 acres of marsh habitats on the Anahuac NWR would continue to be managed via large water control structures on Oyster Bayou, Onion Bayou, East Bay Bayou, Jackson Ditch, and Oil Field Ditch and their associated levees and canal/ditch systems. Such water management infrastructure includes more than 100 small water control structures, and numerous smaller levee and canal/ditch systems. There are also four marsh impoundments on Anahuac NWR. These leveed units are generally managed as deeper permanent freshwater habitats, although periodic drawdowns and mechanical manipulations of soil surfaces are needed to manage vegetation and maintain a desired mosaic of open water and emergent marsh habitats. These include the 250-acre Shoveler Pond on the northwest portion of the refuge, and Rail Reservoir (150 acres) and the two East Unit reservoirs (98 and 162 acres) located on the west side of the East Unit. The East Unit reservoir extends onto private land so its management must be coordinated with that landowner.

- Approximately 18,000 acres of the McFaddin NWR's structurally managed marshes would continue to be managed via large water control structures on Willow Slough, Wild Cow Bayou, 5-Mile Cut and the GIWW, and their associated levees and canal/ditch systems.

- Water management on Texas Point NWR would continue to be conducted in a passive manner. The refuge is drained from west to east through several branches of Texas Bayou and interconnected tidal cuts and streams. Three rock weirs, located in constructed ditches, were installed in 2001 and 2002 to protect and restore emergent marshes in the eastern portion of the refuge. These structures are reducing saltwater intrusion and dampening tidal energies, which were causing emergent marsh loss (conversion to open water), while allowing ingress and egress of marine organisms. A north south levee, historically built as an access road to an oil and gas well, traverses the central portion of the refuge and is maintained with culverted water crossings.

Managed marsh units within the Refuge Complex are under varying degrees of structural control, and may best be described as marsh semi-impoundments. A few units are entirely or almost entirely behind man-made levees and water control structures, and are intensively managed through manipulation of the water control structures and water delivery systems including ditches and canals. Most are managed less intensively, relying to some degree on natural topography and drainage to control hydrologic regimes.

Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976). Merino *et al*. (2005) found that managed areas, particularly those without complete levees, had more submerged aquatic vegetation than unmanaged areas. Marsh restoration using semi-impoundments in Louisiana reversed the deleterious effects of excessive tidal exchange caused by channelization (Hess *et al.* 1989). This restoration project caused both emergent and submergent vegetation to flourish. Monitoring efforts on and around McFaddin NWR indicated that diversity indices for both emergent and submergent plants were higher within structurally managed marshes compared to adjacent unmanaged marshes (USFWS 2006). This was largely due to the presence of plants with lower salinity tolerances, indicating that this marsh management program is at least partially meeting objectives. Chabreck (1994) stresses that careful planning and implementation is required in order for structural marsh management to reverse the negative effects of hydrological alterations and maintain critical wetland functions.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al.* 1983, Nyman *et al.* 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exacerbate flooding, further reducing plant vigor.

Structural marsh management on the Refuge Complex helps to maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes and the native plant, fish and animal communities that depend on these habitats. USFWS water management activities in fresh to brackish coastal marshes on the Refuge Complex reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying, therefore benefiting soil formation and vertical accretion by increasing plant productivity and preventing oxidation of marsh soils. Ultimately, restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater and sediment inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) in coastal marshes on the Refuge Complex may help to prevent the conversion of vegetated marsh to open water.

The above notwithstanding, periodic climatic events such as flooding during periods of high rainfall or due to tidal storm surge and prolonged drought influence and sometimes are the dominant factors controlling hydrologic regimes and the response of vegetative communities in the Refuge Complex' coastal marshes.

(b). Marsh Restoration

Under the Refuge Management Alternative A, the level and scope of wetlands restoration activities, as well as their benefits to the Refuge Complex, would generally continue. For example, in the year 2000, approximately 50 acres of emergent marsh were restored and created on and adjacent to Texas Point NWR through a U.S. Army Corps of Engineers, Galveston District project implemented under Section 206 of the Water Resources Development Act. This COE Continuing Authorities Program is entitled Ecosystem Restoration through the beneficial use of dredged material. This project was conducted in partnership with the Texas General Land Office, which provided non-Federal matching funding through the Texas Coastal Erosion and Response Act program. Approximately 850,000 cubic yards of dredged material from the Sabine-Neches Ship Channel were used to increase elevation in a subsided marsh which had been converted to open water allowing reestablishment of emergent vegetation, and restored additional emergent marsh which had eroded into the Gulf.

Under Refuge Management Alternative A, the following marsh restoration efforts would continue.

- Additional strategies and projects to restore and enhance wetlands through the beneficial use of dredged materials would be developed through coordination with the U.S. Army Corps of Engineers, Texas General Land Office, Texas Parks and Wildlife Department, Texas Department of Transportation and others.

- Coordination would continue with the Texas Parks and Wildlife Department and other agencies on a proposed hydrological restoration project at the Keith Lake Fish Pass, aimed at curtailing emergent marsh loss on J.D. Murphree WMA, Sea Rim State Park, and private lands in the eastern portion of the Salt Bayou watershed in Jefferson County.

Marsh restoration efforts under Refuge Management Alternative A would increase the amount of vegetated emergent marsh in areas which have converted to open water, providing more productive habitat for native fish and wildlife. This practice also increases net sediment supply to marshes which provides nutrients and increases plant productivity (Chabreck 1976, 1994).

(c). Moist Soil Management

Freshwater prairie wetlands on the Gulf Coast have been reduced mainly through development and agriculture (Moulton *et al*. 1997). Like coastal marshes, shallow freshwater prairie wetlands provide important food resources and cover to a diversity of wetland-dependent resident and migratory birds and wildlife.

Under Refuge Management Alternative A, 500 acres of moist soil units would continue to be managed annually on Anahuac NWR to provide and enhance shallow freshwater wetland habitat for migratory birds and other wetland-dependent wildlife. Water management (drawdowns and flooding) in moist soil units is accomplished with water control structures, levees, and water delivery systems including pumps and canal systems. Conventional farm machinery with discs and roller choppers are used to manipulate soils and vegetation.

The purposes of moist-soil management are to increase wetland productivity and waterfowl use on migrating and wintering grounds (Fredrickson and Taylor 1982). Moist soil management is the process of exposing soils by lowering water levels or mechanically manipulating vegetation or soils to create a seedbed for native wetland plants to germinate, grow and reproduce. Flooding provides foraging habitat and cover for diverse communities of migrating and wintering waterfowl and other waterbirds (Fredrickson and Taylor 1982). The seeds, tubers, rhizomes and vegetative portions of moist soil plants provide important foods for waterfowl and other migratory birds.

Moist soil management contributes to increasing and maintaining the biological diversity of an area. Moist-soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). Over 80 percent more species have been found to occur in moist-soil impoundments than in adjacent row crops and include invertebrates, herpetofauna (amphibians and reptiles), prairie and marsh passerines (small- to medium-sized perching birds), shorebirds, wading birds, waterfowl, gallinaceous birds (e.g., pheasants, wild turkeys), raptors, and mammals (Fredrickson and Taylor 1982).

Water management and mechanical soil manipulations in moist soil units on the Refuge Complex are timed to promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia. Approximately 150 acres of the Anahuac's NWR's moist soil units are flooded throughout the summer to provide brood rearing habitat for Mottled Ducks and whistling ducks. The management regime favors the establishment of perennial wetland plants, including several species of floating and submerged aquatic plants, including arrow head, white water lily, and lotus.

(d). Cooperative Rice Farming Program

Under the Refuge Management Alternative A, the USFWS would continue to implement a cooperative rice farming program to provide shallow freshwater wetland habitat, primarily for wintering and migrating migratory birds. Anahuac NWR is the only refuge on the Refuge Complex with a cooperative farming program. Farming on the Refuge is accomplished through cooperative agreements with local farmers.

The USFWS has agreements with three local farmers who farm rice on approximately 500 to 700 acres annually on a three-year rotation, leaving approximately 1,000 to 1,200 acres of the Refuge farm as "maintenance" acreage. The farmers are required to disc, spray, or mow noxious weeds on all maintenance acres each year according the USDA farm program. Cooperators are allowed to take the first rice crop and are required to maintain levees and flood fields after harvest. Generally rice is harvested in September or October. Several farmers have produced organically grown rice on the Refuge during the past ten years. Today almost 80% of the rice produced on the refuge is organically grown. Organically produced rice reduces the overall input of herbicides on the Refuge.

Rice production has declined during the last decade in counties surrounding the Refuge Complex, reducing this type of agricultural wetland habitat for waterfowl, shorebirds and other wetland-dependent species. Other changes in rice cultivation practices may also have deleterious effects on waterbird populations. Abandoned rice fields and pasturelands are susceptible to invasion by Chinese tallow, Eastern baccharis, common rush, and deep-rooted sedge, all of which decrease habitat quality and will require extensive restoration efforts.

Continuation of the cooperative rice farming program on Anahuac NWR under Refuge Management Alternative A would provide shallow freshwater wetland habitat and serve several management outcomes for migratory bird management on the Refuge Complex: creating forage for migrating and wintering waterfowl, habitat for migrating shorebirds, and fresh water habitat for breeding and brood rearing Mottled Ducks and fulvous and black-bellied whistling ducks. Flooding after harvest makes existing waste grain available to waterfowl and often produces a second crop of rice, which is also left for wildlife. Fall and winter flooding allows migratory waterfowl to exploit waste rice and other weeds found in the fields. During migration and wintering periods, waterfowl and waterbirds extensively use post-harvest rice fields that were cultivated and at least partially flooded (Czech and Parsons 2002). Managed rice fields on the Refuge Complex provide wintering and migrational habitat for Blue-winged Teal, Northern Pintail, Green-winged Teal and Snow geese, several shorebirds species including Long-billed Dowitchers and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted sandpipers, and for several wading bird species. Mottled Ducks also heavily use habitats adjacent to rice fields for nesting (Stutzenbaker 1988). Rice farming also helps to offset waterfowl consumption of crops on adjacent privately-owned croplands.

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Over 9 million acres of native tallgrass prairie once occurred along the western Gulf Coast in Texas and Louisiana (Smeins *et al*. 1991). Based on remnant stands of native grasslands, prairies on the upper Texas coast were characterized by little bluestem, brownseed paspalum, and Indiangrass or eastern gammagrass and switchgrass associations, depending on hydrology (Diamond and Smeins 1984). It is now estimated that 99.8% and 99.6% of little bluestem and eastern gamma grass/switchgrass prairies, respectively, have been lost in Texas (McFarland 1995). The little bluestem/brownseed paspalum community has been identified as a threatened natural community and the eastern gammagrass-switchgrass community has been identified as an endangered natural community by the Texas Organization for Endangered Species (Diamond *et al*. 1992). Both communities are assigned a Global conservation status rank of "Critically Imperiled" (G1) by The Nature Conservancy (2002).

Approximately 4,420 acres of upland non-saline grasslands (not including acres cultivated through the cooperative farming program) occur on the Anahuac NWR. Of this total, approximately 2,914 acres are

permanently fallowed former agricultural fields which have naturally revegetated over time and currently contain native and non-native grasses, forbs and woody vegetation. Sites within these habitats have been enhanced by transplanting, sprigging and seeding of native grasses and forbs. On the East Unit, approximately 441 acres of permanently fallowed cropland has been restored to native prairie through an intensive restoration process. This involves control of exotic and native woody vegetation, restoring natural contours and hydrology by removing rice field levees and ditches, working the soil and planting with native prairie plant seed mixtures. The highest quality native prairie on Anahuac NWR occurs in relatively small, fragmented areas which were never cultivated or were cultivated for a relatively short time. These "remnant" prairie areas total approximately 1,065 acres.

Approximately 1,152 acres of non-saline prairie grasslands occur on McFaddin NWR, almost all of which are found on the North Unit. A total of 172 acres of non-saline prairie grasslands occur on the northern portion of Texas Point NWR. These grasslands have not been cultivated, but have been reduced in quality by a variety of factors including invasion by exotic Chinese tallow and McCartney rose.

Under Refuge Management Alternative A, the following prairie habitat restoration and management activities would continue to be used in an integrated approach on non-saline grassland habitats on the Refuge Complex: 1) restore an additional 245 acres of permanently fallowed cropland on Anahuac NWR to native prairie; 2) increase native plant diversity in grassland habitats by seeding and sprigging native grasses and forbs; 3) conduct a rotational prescribed burning and controlled livestock grazing on upland grassland habitats; 4) utilize an integrated pest management program, consisting of herbicide application, mechanical removal, burning and controlled livestock grazing to manage invasive plant species such as Chinese tallow and deep-rooted sedge which are negatively impacting upland habitats; and 5) mow or hay approximately 100 acres annually on Anahuac NWR to control weed and woody species infestations and increase diversity and productivity of native prairie grasses and forbs.

Together, the native prairie management and restoration activities undertaken under Refuge Management Alternative A would continue to protect and enhance the 5,744 acres of non-saline grassland habitats (fallowed croplands, prairie remnants, and previously restored sites) on the Refuge Complex. Under this Alternative, 245 acres of former cropland would be restored to native prairie on Anahuac NWR, and other existing grassland habitats would be enhanced by seeding and sprigging of native plants. Impacts of burning, grazing, invasive species management and mowing and haying to vegetation and habitats are discussed below. Overall, prairie restoration and management activities on the Refuge Complex would increase the abundance of native prairie grasses and forbs, helping to restore and maintain natural biological diversity. Management and restoration of native prairie habitat on the Refuge Complex would help conserve an increasingly rare component of the western Gulf Coast ecosystem by restoring and maintaining native prairie plant associations including little bluestem/brownseed paspalum and eastern gamma grass/switchgrass prairie plant communities.

Seed viability in prairie plants is believed to be reduced in highly fragmented prairie landscapes due to loss of genetic variability as remnant stands become smaller and more isolated. Conservation of existing coastal prairie remnants in the project area is critical because they represent reservoirs of genetic material, and are extremely valuable sources of viable local seed and plant materials. Prairie plants on the upper Texas Coast evolved under relatively unique climatic conditions of high annual rainfall and hydric soils, and future restoration of native prairie in the region depends on the protection of existing viable local seed and plant material sources. Native prairie conservation efforts on the Refuge Complex under Refuge Management Alternative A would help maintain a small but potentially important source of native prairie seed.

(b). Woodlot Restoration and Protection

Although comprising less than 1 percent (approximately 127 acres) of the Refuge Complex acreage, woodlots help support a diverse avian community, which includes several sensitive songbird species. Six of the seven avian species listed as Rare and Declining within the coastal prairies region in Texas are present in the Refuge Complex's coastal woodlots. Migratory birds also depend on coastal woodlots for

cover and food. At least 63 species of migratory birds regularly use the wooded habitats of the Chenier Plain region prior to or immediately after crossing the Gulf of Mexico (Barrow *et al*. 2000). Trans-gulf or circum-gulf migratory songbirds use Texas Coastal woodlots as stopover habitat (Mueller 1981), which is critical at a time when the birds are depleted of water and energy reserves (Leberg *et al*. 1996).

Under the Refuge Management Alternative A, the following USFWS management actions would continue to have beneficial impacts on the existing 127 acres of coastal woodlots: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts.

The primary threat to coastal woodlots is encroachment by the Chinese tallow tree, which provides poor habitat for migratory songbirds. Although the Chinese tallow trees attract birds as frequently as other trees, they provide poorer forage because of sparse insect populations. Specifically, they harbor fewer insects and spiders, especially Lepidopteron larvae. A study examining arthropod communities found lower total diversity in Chinese tallow compared to native ecosystems (Hartley *et al*. 2004). Chinese tallow woodlots may thus be an "ecological trap" that provide cover but little food for migrants when they are energy-depleted after migration (Barrow and Renne 2001). In addition, activities by feral hogs can also damage understory vegetation and soils, as a result of their rooting habits, and may also cause a shift in plant succession. Such activities can also create disturbed areas that enable easier establishment of some exotic species. Feral hogs may also directly compete with several species of native wildlife for certain foods.

Overall, USFWS management activities under Refuge Management Alternative A would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging.

(3). General Habitat Management Activities

The USFWS uses fire management, controlled livestock grazing and invasive species management and mowing and haying to enhance habitats for migratory birds and other native fish and wildlife species. The integrated combination of burning, grazing and water management on the Refuge Complex maintains a diverse mosaic of wetland vegetative communities, both in plant species composition and structural attributes. Shoreline restoration and protection activities are being implemented on the Refuge Complex to counter ongoing coastal land loss caused by relative sea level rise, altered hydrological regimes and loss of coarse sediment supply. These management and restoration activities are used to conserve, enhance and restore both wetland and upland habitats on the Refuge Complex.

(a). Fire Management - Prescribed Burning and Wildland Fire Suppression

Natural fire and herbivory by native species likely occur less frequently or at reduced levels than historically in the Chenier Plain region, primarily due to human influences on this coastal ecosystem. This has reduced diversity and productivity of native wetland and upland habitats. For example, in brackish and intermediate marsh habitats, reduced disturbance generally allows marshhay cordgrass, considered a climax plant community, to become the dominant emergent plant. Dense, homogeneous stands of marshhay cordgrass are less biologically diverse and productive than marsh habitats in which burning and herbivory create a mosaic of plant communities with greater plant species composition and greater structural diversity (attributes such as stem densities, height, and erect vs. decumbent growth habits). In upland coastal prairie habitats, encroachment by native and exotic woody species, such as Eastern baccharis and Chinese tallow, occurs in areas where fire is excluded, also resulting in loss of native habitat diversity and productivity.

Under Refuge Management Alternative A, the current fire management program would continue to be implemented on the Refuge Complex. Suppression of unplanned wildland fires and prescribed burning would continue as under current conditions. Approximately 12,000 to 15,000 acres per year would be

burned under prescription. Areas would be burned on a three-year rotation; however, the actual condition of vegetation and fuel loading would dictate the need for a burn (USFWS 2001). The majority of the prescribed burning would be conducted from October through January in marsh habitats. Prescribed burning of upland grassland units would occur primarily in late winter and early spring (USFWS 2001). Prescribed burning during these periods avoids nesting seasons for migratory birds, alligators, and other wildlife.

In wetland habitats on the Refuge Complex, prescribed burning is implemented in combination with controlled livestock grazing and water level and salinity management with a primary goal of providing a diversity of high-quality wintering habitats for waterfowl, shorebirds and other marsh and waterbirds. In upland habitats, burning and grazing are used to control encroachment by woody species and to enhance germination and growth of native prairie grasses and forbs, benefiting many grassland avian species. USFWS fire management practices in non-saline coastal prairies on the Refuge Complex reflect the idea that burning prior to green-up of the warm season grasses promotes these species. This is the most common type of prescribed burn currently conducted on remnant native prairies and restored coastal prairie sites on the Refuge Complex. Burning is conducted on upland non-saline grasslands when target warm-season grass species have less than 10cm of green foliage, prior to the grasses' growth points becoming elevated. This strategy of prescribed burning is considered a restoration phase in the management of non-saline uplands on the Refuge Complex.

Fire has long had a role in the ecology of the Texas Chenier Plain marshes. Pre-European settlement, fire frequency for these marshes is estimated to be 1-3 years (Frost 1995). Lightning caused wildfires were common in coastal marshes (Hoffpauer 1968, Frost 1995). Additionally, Native Americans used fire to facilitate hunting and travel (O'Neil 1949, Givens 1962). In the past, fires in the Gulf coast prairies and marshes probably varied greatly in spatial extent. Natural firebreaks existed in many forms. Bayous, tidal creeks, fault lines, animal trails, and areas previously disturbed by fire or animal herbivory all may limit the spread of wildfires. Weather, fuel conditions, and water levels influence the effectiveness of the natural firebreaks and ultimately the size of the fire. Anecdotal data suggest that prior to the settlement and the major changes in hydrological regimes which followed, much of the vegetation that dominated these fresher marshes (i.e. Sawgrass (*Cladium mariscus* subsp. *jamaicence*), maidencain (*Panicum hemitomon*), giant cutgrass (*Zizaniopsis miliacea*), and bullwhip (*Schoenoplectus californicus*)) was less pyrogenic than common vegetation found today, such as marshhay cordgrass. This may have reduced the frequency and size of historical fires in the region's marshes compared to current vegetative conditions. Conversely, natural fire starts in the region have undoubtedly been significantly reduced because of the landscape-level conversion of upland prairie habitats to agricultural uses. Navigation canals, ditches, levees and roads constructed throughout upland and wetland habitats effectively serve as firebreaks and have greatly affected fire spread and the ultimate size of present-day natural fires.

Generally, three types of fires in coastal marshes are recognized: cover, root, and peat burns (Lynch 1941). Soil moisture and organic content, as well as surface water at the time of the fire, determine the type of burn that occurs. Water levels and soil conditions must be considered carefully to meet management objectives of prescribed burns (Bacchus 1995, Hungerford *et a*l. 1995). The USFWS carefully considers these parameters in implementing its fire management program on the Refuge Complex.

The most common and widely used fire in coastal marshes is the cover burn (Hoffpauer 1968). This type of fire, taking place when water levels are at or near the marsh surface, removes the aerial portions of the vegetation. Recommended water levels for a cover burn range from marsh surface to five inches (Lynch 1941, O'Neil 1949, Hoffpauer 1968). Cover burns temporarily remove dense emergent vegetation and attract wildlife and cattle to the new growth (Lynch 1941, Hoffpauer 1968). Cover burns would be thought of as a surface fire by most fire researchers.

Marshes recover quickly after winter cover burns. Soil moisture or surface water protects the subterranean plant parts from damage. Gabrey and Afton (2001) found in the Chenier Plain of Louisiana, that the total above ground biomass was reduced for two years while dead above ground biomass was reduced for three years post fire compared to unburned control plots. In addition, they found that plant

species composition in burned plots was the same as unburned plots, with a slight increase in richness during the first growing season post-fire.

Root burns occur in marshes under dryer conditions. The roots of plants may move into the litter layer in marshes that have not burned in several years (Lynch 1941). If the litter layer is dry enough to support combustion, a root burn may occur. Root fires burn away the litter layer and destroy shallow root systems. This type of burn can create significant changes in the plant community. Climax species such as maidencane and marshhay cordgrass are often set back, allowing subclimax species to increase. Because the fire is in the litter layer and soil is not consumed, this type of burn would also be classified as a surface fire by most fire researchers, though the results of the fire would be very different.

The last type of marsh fire is the peat burn. This takes place under the driest soil conditions. In a peat burn, the fire removes the organic subsurface fuels and in some instances will burn down to the underlying clay pan. This type of fire typically removes existing vegetation and creates open water conditions that may last for decades (Lay and O'Neil 1942, O'Neil 1949, Hoffpauer 1968). Peat burns can create quality waterfowl habitat by burning holes into the marsh that later become open water (Lynch 1941, Uhler 1944, Baldassare and Bolen 1994). Despite this, peat burns are not a management goal in most instances. The prolonged smoldering involved in peat burns would likely cause smoke management problems in surrounding communities. With the alarming loss of coastal wetlands to sea-level rise and subsidence, these types of burns cannot be justified in most situations (Nyman and Chabreck 1995). The general fire management community would classify peat burns as a ground fire.

Once a burn has been completed, many factors can affect post-fire conditions. If excessive rainfall causes water to cover the vegetation stubble for prolonged periods of time, the vegetation can die off (Hoffpauer 1968). Soils are particularly susceptible to erosion until the vegetation recovers. Excessive high tides, particularly storm driven tides, can push salt water over the burn area and cause plant mortality. For this reason many managers delay prescribed fire until the end of the hurricane season and until the fall equinox tide has passed (USFWS 2001).

Under Refuge Management Alternative A, the impacts of prescribed burning in wetland habitats (in combination with controlled grazing and water level and salinity management) would include:
1) increasing plant species diversity, 2) maintaining and enhancing desirable emergent marsh plant communities such as Olney bulrush and leafy three-square bulrush, 3) creating openings in otherwise dense stands of emergent marsh vegetation, and 4) helping to control exotic and/or invasive plants. Prescribed burning (integrated with control livestock grazing and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato.

Burning makes vegetation more desirable to herbivores and will increase grazing pressure. Post-fire herbivory, whether by geese or cattle, prolongs early successional marshes and creates habitat for other wildlife. Post-fire herbivory will slow the recovery of climax vegetation and prolong early seral stages and open marsh conditions favorable to waterfowl (USFWS 1994). Livestock turn the soil through hoof action and further set back succession (Chabreck 1968, Stutzenbaker and Weller 1989).

Interstitial vegetation, often seed producing annuals such as sprangletops (*Leptochloa* spp.) and millets (*Echinochloa* spp.), increases after a fire, particularly when followed by grazing and suitable hydrology. Burning opens up dense vegetation and allows waterfowl access to seeds and other plant parts (Lynch 1941). Fire can remove plant cover and create open water conditions conducive to Mottled Duck brood-rearing habitat (Stutzenbaker 1988). Generally speaking, burning creates open marsh conditions and sets back succession if timed properly, particularly when followed by herbivory. Burning is an effective tool to manipulate vegetation composition and create a habitat mosaic (Fredrickson and Laubhan 1996).

The impacts of prescribed burning in upland grassland habitats would include: 1) maintaining and enhancing native prairie plant communities, including several native grasses and forbs, by enhancing conditions which encourage reproduction and growth of these species; and 2) helping to control exotic and/or invasive plants, most notably Chinese tallow and Eastern baccharis, which often outcompete and replace native grasses in areas where fire has been excluded or its frequency decreased.

One of the primary objectives of burning non-saline upland grasslands on the Refuge Complex is the control of Chinese tallow. Tallow is generally non-flammable and in heavily infested situations suppresses herbaceous plants and fine fuel loading, limiting the potential for fire (Grace *et a*l. 2001). Thus, the invasion of Chinese tallow converts a fire-adapted grassland site to a non-flammable, near monotypic woodland. Work has been conducted on Brazoria NWR in the Texas Mid-Coast region on the relationship between fire and Chinese tallow. Preliminary results indicate that while total control was not realized with one treatment, some mortality was achieved (Grace 1998). Further, sites with fuel characteristics more typical of coastal prairies (high fuel loading, species composition, and continuity of fuels) achieved better control of Chinese tallow using fire than did abandoned agricultural fields.

In summary, the current USFWS fire management program on the Refuge Complex is conducted to achieve the following benefits (USFWS 2001). These beneficial impacts would continue under Refuge Management Alternative A.

- Hazardous fuels are reduced within immediate proximity to USFWS and private facilities and structures (to protect life and property). Prescribed burning lessens the potential of uncontrollable wildfires by reducing the accumulation of rank vegetation and litter.

- Habitat for waterfowl and other migratory birds is restored, maintained, or improved by maintaining early successional plant communities in marsh habitats, by increasing production and nutritional quality of these foods, and enhancing the availability of these foods by creating openings in otherwise dense stands of vegetation. For example, prescribed burning encourages tuber producing plants such as Olney and leafy bulrush preferred by waterfowl. Snow geese heavily use recent marsh burns because they can readily access roots, tubers, and young green shoots of these plant species. Both geese and ducks use burned areas as roosts or loafing areas.

- Encroachment of undesirable woody shrubs, including Chinese tallow, bigleaf sumpweed, and Eastern baccharis, is suppressed. Without fire disturbance, both marsh and prairie habitats on the Refuge Complex are subject to invasion by such woody shrubs, which in turn reduces habitat quality for many grassland-dependent avian species and other wildlife. Management of exotic and invasive species such as Chinese tallow, deep-rooted sedge and Eastern baccharis using an integrated pest management approach enhances germination, growth and reproduction of native prairie grasses and forbs. The mechanical removal of undesirable woody and weed plant species reduces competition with native plant species, and enhances germination, growth and reproduction of native prairie grasses and forbs.

While fire, whether planned or unplanned, can have positive ecological effects, detrimental impacts to vegetation and habitats ranging from an undesirable change in plant species composition to actual conversion of emergent marshes to open water can also occur. For example, fire under excessively dry conditions can result in plant mortality and/or consume organic matter and decrease marsh soil elevation, either of which could result in permanent conversion to open water. Excessively hot fires may result in root burns, which can cause mortality of desirable marsh plant species. Fire increases the soil erosion potential until regrowth occurs. Recently burned areas are especially susceptible to erosion during storm surges from tropical storms and hurricanes. Hot fires occurring without adequate soil moisture can also cause a temporary reduction in microflora and microfauna in wetland soils. Burning cannot restore lost marsh or counter the effects of excessive flooding or salinity (Chabreck 1994). Burning is not as beneficial in more saline marshes, because the resulting subclimax plant community is not as diverse (Spicer *et al*. 1986).

Proper timing of prescribed burns under appropriate environmental and climatic conditions is essential to minimize potential negative impacts to habitats. Implementation of the USFWS fire management program on the Refuge Complex (both wildland fire suppression and prescribed burning) considers factors including soil and vegetative fuel moisture, seasonality and timing, ignition patterns, habitat type and previous burn history to ensure maintenance of diverse and productive wetland and upland habitats.

(b). Controlled Livestock Grazing

Controlled grazing is used (integrated with fire management and water management) to maintain and increase diversity (plant species composition and structural attributes) and productivity in wetland and upland habitats on the Refuge Complex.

Under Refuge Management Alternative A, grazing intensity, duration, location, and timing of use would continue unchanged, as would overall impacts to vegetation and habitats on approximately 41,000 acres on the Refuge Complex. Grazing strategies currently include variations in stocking rates, timing (cool vs. warm season) and, duration. Stocking rates and rotations are determined annually according to management objectives for the various grazing units and the quantity and condition of forage in those units, and are often influenced by the availability of freshwater. Anahuac NWR implements cool season and summer cattle grazing on various marsh and upland units. Permittees graze only during the cool season, generally from November 1 through May 1 on the McFaddin and Texas Point NWRs.

Controlled grazing can be an effective and inexpensive tool in wetland and grassland management providing habitat components that benefit waterfowl and other wildlife species. The relationship of cattle grazing to wildlife varies considerably, depending on stocking rate, seasonality, plant community, and wildlife concerned (Chabreck 1968). Research indicates that dual use of grasslands by wildlife and livestock is often compatible when livestock grazing is carefully managed and wildlife needs are considered (Holechek *et al* 1982).

Studies conducted on Sabine National Wildlife Refuge in Cameron Parish, Louisiana (Valentine 1961) determined that increased grazing can change tall climax marshhay cordgrass stands to a more diverse community such as seashore paspalum, Setaria, and longtom (*Paspalum lividum*), that are more beneficial to certain types of wildlife. Depending on site conditions (elevation, soil, and hydrology) annual grasses and forbs (including millets, fall Panicum (*Panicum dichotomiflorum*), sprangletop, and Setaria) can be produced through proper grazing.

Pate (2001) found that grazed marshes remained in a sub-climax state, while habitat within grazing exclosures reverted to marshhay cordgrass. At the onset of the study Spartina spp. made up 20% of the plant community, while seashore paspalum comprised 80%. By the end of the study, communities within grazing exclosures changed to 65% Spartina spp. and 25% seashore paspalum. In contrast, the grazed area maintained high cover of seashore paspalum throughout the study. Shallowly-flooded seashore paspalum provides habitat for many species of waterfowl, wading birds and shorebirds, while marshhay cordgrass largely precludes use by these species.

Grazing (integrated with fire and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Moderate grazing following burns in marshes also results in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al*. 1979). Grazing also helps provide optimal physical structure of vegetation for waterfowl utilization in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining plant communities such as seashore paspalum which grow low to the ground. When shallowly flooded, stands of low-growing seashore paspalum and seashore saltgrass interspersed with ponds provide ideal habitat conditions for many waterfowl, shorebird and wading bird species. These

conditions also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Specifically, the beneficial effects of grazing in wetland habitats include:

- Reduces rank vegetation which enables migratory birds to access roots and tubers of mature plants and shoots of new plants.
- Reduces competing growth of marshhay cordgrass and other dominant climax plant communities, allowing for the growth of subdominant plant species, many of which are preferred foods of ducks and geese.
- Creates open water which provide loafing spots for birds and allow them to access aquatic invertebrates.
- Compliments marsh burning by prolonging the time that browse is available for goose use.
- Improves plant vigor, increases plant productivity, speeds nutrient recycling, and prevents excessive build-up of residual plant material.
- Reduces the amount of hazardous fuel loading, reducing the amount and intensity of wildfires.
- Breaks up capped soils through hoof action, which assists in seedling establishment.
- Maintains regrowth of vegetation in recently burned areas in more palatable stages for wintering waterfowl.
- Provides a reliable disturbance tool that is not as dependent on favorable weather and fuel conditions as prescribed fire.

Carefully managed grazing in coastal prairie habitats increases plant vigor of native prairie grasses and increases overall plant species composition and structural diversity.

Potential detrimental affects of grazing result primarily from overgrazing and include excessive trampling of vegetation, compaction of soils reducing percolation rates, and increased soil erosion. The deposition of excess nutrients in the form of feces in areas where livestock concentrate (USFWS 1994) may negatively impact surface water quality. Fecal coliform from geese and livestock are the main pollutants contaminating the shellfish waters of East Galveston Bay (Galveston Bay Estuary Program 1995). Warm-season grazing of wetland areas can reduce seed production of annual grasses (Chabreck 1968). Overgrazing in prairie habitats, usually caused by prolonged grazing intensity, can reduce native prairie plant diversity. While prairie ecosystems are adapted to short duration high intensity grazing patterns, extended duration grazing can reduce native grasses and some native forbs, particularly those that are more palatable and are preferentially selected by livestock. Soil disturbance by excessive hoof action can provide conditions favorable for establishment of exotic and invasive plant species such as Chinese tallow, and cattle can spread seed of undesirable plant species by physically carrying them or ingesting them.

Under Refuge Management Alternative A, the USFWS would continue to monitor grazing programs and adjust grazing strategies so as to minimize detrimental impacts.

(c). Invasive Species Management

Under Refuge Management Alternative A, the level and scope of invasive species management activities, as well as their impacts to native vegetation and habitats on the Refuge Complex, would generally continue as described below. The USFWS would continue to control exotic and invasive plant species to

conserve biological diversity of the Refuge Complex and to maintain habitat quality for migratory birds and other native wildlife. An Integrated Pest Management (IPM) program is currently used to control the following exotic and invasive plant species (USFWS 1996):

- Chinese tallow, Eastern baccharis, willow, and deep-rooted sedge in freshwater marshes, prairies, woodlots and on levees and roadsides.
- Water hyacinth, alligatorweed, Salvinia, common reed and cattail in waterways and managed wetland units.
- Red rice, coffeebean, barnyard grass, and other grasses in rice.
- Broadleaf weeds and King Ranch bluestem in remnant and restored prairies.

The IPM program for invasive plant management on the Refuge Complex includes using herbicide application, mechanical control, prescribed burning, controlled grazing and water level and salinity management, usually in some combination of strategies. Combinations of treatments often are most successful and provide more long lasting results. In general, mowing and burning are used on upland grassland habitats to control invasive plant species. Burning and controlled grazing are the primary tools used in marsh habitats. Discing or roller chopping are used in rice fields and moist soil units to manage invasive species. Spot treatments with herbicides are typically used in wetland and upland habitats when target stands are small enough to treat by hand. Aerial herbicide application has been required to initiate control on large mature stands of Chinese tallow. The long-range goal of the USFWS IPM program on the Refuge Complex is to reduce the dependence on and use of chemical herbicides to control and manage invasive plant species.

In wetland habitats, these activities include and result in removal of undesirable invasive plant species including cattail, common reed, and California bulrush that form dense, homogeneous stands which result in loss of open water as ponds close. Control of exotic floating aquatic plants such as water hyacinth, alligatorweed and Salivinia also restores open water habitats, and promotes the growth of native floating and submerged aquatic plant species important to native fish and wildlife.

The control of Chinese tallow and deeprooted sedge in prairie and woodlots results in increased diversity of native plants. In woodlots, reduction of Chinese tallow and increasing native tree and shrub abundance is likely to increase abundance of forage insects for migrating birds (especially Lepidopteran larvae) (Barrow and Renne 2001). Control of feral hogs would decrease damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging, and reduce the creation of disturbed areas that enable establishment of Chinese tallow and other undesirable plants.

Under Refuge Management Alternative A, the USFWS would also continue to control exotic animal species on the Refuge Complex to conserve native biological diversity and to maintain habitat quality for migratory birds and other native wildlife. Feral pigs are the primary species currently impacting habitats on the Refuge Complex. Rooting and wallowing by feral pigs cause significant habitat and infrastructure damage. These soil disturbances in marsh and upland sites allow invasive plants to establish and reduce the value of the habitats to wildlife. Feral pigs are particularly damaging to water management infrastructure. They wallow and root extensively on levees and within rice fields and moist soil units effecting the management of thousands of acres of habitat. Feral hogs are prolific and are able to exploit wetland and upland habitats. Under Alternative A, the USFWS would continue to control feral hog activities on the Refuge Complex by using State animal damage control agency personnel to capture and remove hogs or kill them on-site. In addition, Refuge Complex law enforcement personnel would continue to conduct periodic lethal control activities. Although nutria have not reached population levels capable of damaging habitats in recent years on the Refuge Complex, this exotic animal has been highly destructive in coastal wetlands in neighboring Louisiana and other coastal states. Control activities for nutria which could be implemented under Refuge Management Alternative A include trapping and removal by State animal damage control agents, Refuge staff or qualified individuals under Special Use Permit for nuisance animal control.

(d). Shoreline Protection and Restoration

Under Refuge Management Alternative A, the following USFWS management actions would continue to have beneficial impacts on beach/dune and other shoreline habitats, and to inland wetland habitats which they protect:

- McFaddin and Texas Point NWRs: (1) maintain existing dune restoration project and explore opportunities for additional dune restoration along the Gulf of Mexico on McFaddin NWR; (2) maintain existing shoreline protection and seek opportunities for additional protection along the GIWW shoreline; and (3) implement additional projects to beneficially use dredged materials from the Sabine-Neches Ship Channel to reduce land loss by restoring sediment supply to the Gulf shoreline on and adjacent to Texas Point NWR.

- Anahuac NWR: Maintain existing offshore rock breakwaters and continue efforts to construct additional breakwaters and restore emergent marsh by planting smooth cordgrass along the East Galveston Bay shoreline.

- Complex-wide: (1) coordinate with the U.S. Army Corps of Engineers on their ongoing Section 227 National Shoreline Erosion Demonstration Project in Jefferson County and their Shoreline Erosion Feasibility Study for Galveston and Jefferson counties; and (2) coordinate with the U.S. Army Corps of Engineers, Texas General Land Office, Texas Parks and Wildlife Department, Texas Department of Transportation and others to develop strategies to restore and enhance wetlands through the beneficial use of dredged materials.

Altered hydrological regimes and relative sea level rise resulting in erosion and land loss along the Gulf and Bay shorelines are major threats to wetland and upland habitats on the Refuge Complex. Barrier beaches and dunes along the Gulf of Mexico provide habitat for a variety of plant and animal species, protect and stabilize the coastline and help protect landward wetland habitats. Shoreline erosion threatens Gulf of Mexico beach and dune habitats throughout the Chenier Plain region. Although shoreline erosion during storms is a natural process, a severe sediment deficit in the Gulf's littoral system resulting from construction of navigation channels, jetties and upstream dams on rivers has greatly accelerated rates of shoreline retreat. Rising sea levels and land subsidence are also causative factors in the accelerated loss of coastal habitats.

Virtually all of the historical low barrier beach/dune system on the McFaddin and Texas Point NWRs has been lost as the Gulf shoreline has eroded and retreated. In addition to direct loss of habitat, loss of elevation along the Gulf shoreline has increased saltwater intrusion from tidal flooding from the Gulf into inland marshes. Tidal overwash of the low remaining beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity in Refuge marshes. On Anahuac NWR, shoreline erosion along Galveston Bay is resulting in loss of salty prairie habitat and threatens interior marshes with saltwater intrusion. Erosion of the GIWW banks on both refuges poses a significant threat of saltwater intrusion. Breaching of the channel's banks would directly connect interior marshes with the GIWW.

Under Refuge Management Alternative A, shoreline protection and restoration activities would continue to positively impact vegetation resources and habitats by restoring upland and protecting existing wetland habitats. Restoration of barrier beaches and dunes along the Gulf of Mexico protects interior intermediate marshes and their plant communities from excessive inundation with saltwater during high tidal events, as well as restoring an upland native habitat type which has been almost completely lost. Use of dredged material along existing shorelines protects existing marshes by reducing shoreline retreat and direct loss of these habitats, and provides a substrate for reestablishment of marsh vegetation. Breakwaters enhance marine habitat by functioning as an artificial reef, providing opportunities for oyster spat, barnacles, algae, baitfish, and predator fish utilization. Restoring emergent marsh by planting smooth cordgrass between the breakwaters and existing shorelines restores vegetated wetlands that have

converted to open water. The stands of smooth cordgrass also provides habitat for snails, shrimp, crabs, insects, and numerous benthic organisms.

The relatively small scale of ongoing shoreline restoration projects under Refuge Management Alternative A on the Refuge Complex is not likely to effectively counter the future effects of relative sea level rise and altered hydrological regimes, and accelerated rates of shoreline retreat and land loss will likely continue to occur. For example, total restoration of the barrier beach/dunes on McFaddin NWR would require work along an additional 16 miles of Gulf shoreline. Increased saltwater intrusion from more frequent tidal flooding from the Gulf into inland marshes will continue to negatively impact vegetation and habitats on McFaddin and Texas Point NWRs by causing direct mortality of some plant species and an overall reduction in plant productivity.

(e). Mowing and Haying

Mowing and haying consists of the mechanical removal of vegetation in situations where grazing, burning, or herbicide applications are impractical, undesirable, or ineffective methods of vegetation management. Under Refuge Management Alternative A, approximately 100 acres per year of upland grassland habitats would continue to be mowed or hayed on the Refuge Complex.

Mowing and haying stimulates growth of many native grasses, while reducing vigor of undesirable herbaceous weeds and woody plants. Reduction of this herbaceous cover often results in the “release” of native prairie plants. Mowing and haying is often used where the vegetation to be controlled is undesirable to livestock, or where the terrain or soil conditions are difficult to graze without excessive environmental damage. Mowing and haying facilitates more control over the amount and locations of vegetation management, however, costs per acre are much higher than for controlled grazing or prescribed burning.

b. Impacts from Public Use Programs

The greatest potential for impacts to vegetation resources and habitats associated with public use on the Refuge Complex likely comes from motorized boating. Many Refuge Complex hunt areas and fishing areas are accessible only or primarily by motorized boat. Wetland vegetation, especially submerged aquatic vegetation, can be impacted by motorboat activity. For example, propeller scarring has been shown to detrimentally impact seagrass beds in the Laguna Madre in South Texas (Pulich *et al*.1997, Dunton *et al*. 1998) and in Florida (Madley *et al*. 2004). Propeller scarring leaving permanent channels in shallow pond and waterway bottoms on the Refuge Complex has also raised concerns about the potential for increased saltwater intrusion, with concurrent negative impacts on emergent and submergent aquatic vegetation.

Foot traffic in areas open to hunting, fishing, wildlife observation and photography, and environmental education and interpretation can lead to vegetation trampling, and in heavy use areas, cause plant mortality. On the Refuge Complex, the more extreme impacts occur in areas heavily used for shoreline fishing. Some vegetation trampling and trailing from hunter foot traffic occurs in marsh habitats in Refuge Complex hunt areas, although these impacts tend to be short-term.

Under current levels of use and current USFWS administration and management of these uses on the Refuge Complex, impacts to vegetation are generally localized and not substantial. This would continue under Refuge Management Alternative A. Regulations, including horsepower restrictions and area closures to motorized boating are used to protect wetland habitats and public safety. Permanent sanctuary areas are maintained throughout the Refuge Complex, which do not permit access by the public. Access for other recreational and educational uses is restricted to established trails, boardwalks, and observation platforms. Fishing piers have been constructed in many heavily used shoreline fishing areas, reducing trailing impacts.

Recreational beach uses and associated vehicular traffic on beaches within the McFaddin NWR has led to habitat damage inland of beaches. Motorized vehicles sometimes illegally travel in vegetated habitats

(dunes and/or the overwash terrace) inland of the beach, particularly when high water conditions limit or preclude travel on the beach itself. Under Refuge Management Alternative A, the USFWS would continue routine patrols of the Gulf beaches within McFaddin NWR to protect public safety and natural resources.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

No direct impacts to vegetation and habitats would occur as a result of continued implementation of the Refuge Complex biological program under Refuge Management Alternative A. Continued habitat and vegetation monitoring activities and research studies on the Refuge Complex support an adaptive management approach, by providing information which helps refine and improve exiting management practices.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative A, the USFWS would continue to manage oil and gas exploration and development activities on the Refuge Complex through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to vegetation and habitats, including required use of specialized equipment, location and size of facilities, and required pollution controls. As per federal regulations (50 CFR 29.21), the USFWS would ensure that impacted sites are restored as closely as possible to pre-project conditions upon cessation of activities. Conditions of the Special Use Permit also require mitigation for all impacted habitats. Required mitigation activities include restoration and/or enhancement of habitats on the Refuge Complex which are similar to those impacted by oil and gas activities.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex is a reduction of impacts to vegetation and habitats from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative A, the USFWS would continue to develop partnerships with private land owners to restore and enhance wetland and upland habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands.

The USFWS would also continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, Texas General Land Office and Galveston Bay Estuary Program, conservation organizations such as the Galveston Bay Foundation and local Audubon Society chapters, community organizations and Refuge volunteers. These partnerships currently support and greatly enhance a variety of refuge management programs.

It is anticipated that continuation of outreach and partnership efforts under Refuge Management Alternative A would result in additional habitat restoration and enhancement on the Refuge Complex and throughout the project area.

5. Impacts to Fish and Wildlife Resources

Under Refuge Management Alternative A, habitat management and restoration and biological program activities on the Refuge Complex are focused on conservation of the following important fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians
- Invertebrates

The USFWS also administers the six priority recreational uses of the National Wildlife Refuge System on the Refuge Complex: hunting, fishing, wildlife observation and photography, and environmental education and interpretation. These uses impact fish and wildlife resources both directly and indirectly.

The USFWS manages of oil and gas exploration and development activities on the Refuge Complex so as to ensure maximum protection of habitats and fish and wildlife resources.

USFWS community outreach and partnership programs support natural resource conservation initiatives on the Refuge Complex and throughout the project area, and contribute greatly to achieving fish and wildlife conservation objectives.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Coastal habitats in Texas are part of the southern terminus in the U.S. for most of the ducks and geese in the Central Flyway. The 2004 mid-winter waterfowl survey indicated that 7,901,489 waterfowl used the Central Flyway. Of those birds, 5,110,022 waterfowl (65%) wintered in Texas. Available wintering waterfowl habitat in Texas is shrinking due to changes in agricultural uses, industrial and urban development, increased pollutants (Cain 1988), land subsidence, rising sea levels, and man-made hydrological changes such as canals resulting in saltwater intrusion (Michot 1996). Loss or degradation of habitat on a landscape scale has increased the importance of public and private lands managed specifically for supporting wintering and migrating waterfowl.

Since the mid-1950s to the early 1990s, approximately 211,000 acres of wetlands were lost on the Texas Gulf coast, to both natural and man-made causes (Moulton *et al.* 1997), with most of the palustrine wetland lost to agriculture (in recent years agricultural lands have decreased by urban development). Palustrine emergent marshes showed the largest decline, primarily by conversion to upland agriculture and other uses; and most estuarine wetlands loss was due to land subsidence. Tacha *et al*. (1992) concluded that between 1976 and 1991 the total ducks in the Chenier Plain of Texas declined by 89%, and these decreases were highly correlated with losses and degradation of wetland habitat.[9] Many wintering and migrating waterfowl along the Texas Coast tend to prefer freshwater coastal marshes and freshwater prairie wetlands. Rice agriculture provided an especially valuable habitat for wintering waterfowl.

Declines in habitat quality caused by regular tidal overwash are adversely affecting migratory waterfowl use, especially on McFaddin and Texas Point NWRs. As beach ridges and the banks of the GIWW erode they are less effective barriers to tidal inundation and salt water intrusion during storm and other high tidal events. Overwash events create sudden and drastic spikes in salinities, often killing submerged aquatic vegetation and seed producing annual plants. Inundation of the marshes with sea water provides the sulphates which are reduced to hydrogen sulfide under conditions of high water temperatures. Hydrogen

9 During the 1969 through 1994 period, the Louisiana coastline experienced major wetland losses, similar to the Texas coast. However, there appears to have been no declines in duck populations of coastal Louisiana marshes between 1969 and 1994 (Michot, 1996).

sulfide toxicity and low dissolved oxygen cause large scale die-offs of plants and animals, including many invertebrates which provide an important food source for waterfowl and other migratory birds. Survey data indicate that waterfowl numbers have dropped to below five birds per thousand acres in affected areas following overwash events, and below one bird per thousand acres after severe events (USFWS unpublished data). Areas impacted by overwash events now encompass nearly 15,000 acres on McFaddin NWR and 1,500 acres on Texas Point NWR.

Under the Refuge Management Alternative A, the following USFWS management activities would have the greatest impacts on wintering and migrating waterfowl populations on the Refuge Complex:.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative A, approximately 30,000 acres of marsh habitats would be structurally managed on the Refuge Complex to enhance habitat for wintering waterfowl, utilizing water control structures, levees, and water delivery systems. Marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl. For example, structural management of brackish and intermediate marshes may directly increase the abundance of preferred plant species, such as Olney bulrush and widgeongrass, which provide food resources for wintering and migrating waterfowl (Chabreck 1976, Broome *et al.* 1995). Management of water levels would also provide optimal conditions for foraging and resting waterfowl.

On Anahuac NWR, 500 acres of moist soil units would continue to be managed to provide habitat for wintering and migrating waterfowl. Moist soil management provides optimal conditions for germination and growth of preferred waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia.

On Anahuac NWR, the cooperative rice farming program would continue to provide food resources for wintering and migrating waterfowl on 500-700 acres annually. Management of fallow rice fields would also provide weeds and seed that are heavily utilized by waterfowl.

Marsh and wetland restoration activities would create additional emergent marsh and open water habitats and provide additional habitat for wintering and migrating waterfowl.

(b). General Habitat Management and Restoration Activities

The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex promotes optimum habitat conditions for wintering waterfowl and many additional migratory bird species. Prescribed burning and grazing promote the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Burning and moderate grazing also results in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Burning and grazing also help provide optimal physical structure of vegetation for waterfowl utilization of emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Waterfowl habitat on the Refuge Complex is also enhanced through the control of undesirable invasive vegetation such as common reed, cattail, and California bulrush which have formed dense homogeneous stands and resulted in loss open water habitats. Infestations of exotic invasive floating plants such as water hyacinth, alligatorweed and Salvinia must also be controlled to restore and maintain open water

habitats. Maintaining an interspersion of open water and vegetated emergent wetlands provides the habitat diversity needed to support wintering waterfowl and other migratory birds. Restoring open water habitats increases the production of submerged and floating aquatic plants, an important food source. Control of Chinese tallow and deep-rooted sedge in and adjacent to freshwater marshes, moist soil units and rice fields also enhances waterfowl habitat.

Overall, continuing current wetland management and restoration on the Refuge Complex under Refuge Management Alternative A can be expected to maintain wintering and migrating waterfowl populations at levels similar to those documented over the past 20 years. On a year to year basis, overall habitat quality for waterfowl on the Refuge Complex will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers on the Refuge Complex can also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure.

Continuation of shoreline protection and restoration activities under Refuge Management Alternative A would enhance waterfowl habitat on the Refuge Complex by decreasing saltwater intrusion into inland marshes and addressing threats of additional saltwater intrusion. However, the scope and extent of these activities under Refuge Management Alternative A will likely not counteract the ongoing and future impacts of relative sea level rise, loss of coarse sediment supply, and altered hydrological regimes, especially on McFaddin and Texas Point NWRs. Declines in habitat quality caused by regular tidal overwash are adversely affecting migratory waterfowl use on these refuges. As beach ridges and the banks of the GIWW erode they are less effective barriers to tidal inundation and salt water intrusion during storm and other high tidal events. Overwash events create sudden and drastic spikes in salinities, often killing submerged aquatic vegetation and seed producing annual plants. Inundation of the marshes with sea water provides the sulphates which are reduced to hydrogen sulfide under conditions of high water temperatures. Hydrogen sulfide toxicity and low dissolved oxygen cause large scale die-offs of plants and animals, including many invertebrates which provide an important food source for waterfowl and other migratory birds. Survey data indicate that waterfowl numbers have dropped to below five birds per thousand acres in affected areas following overwash events, and below one bird per thousand acres after severe events (USFWS, unpublished data). Areas that can be heavily impacted by overwash events now encompass nearly 15,000 acres on McFaddin NWR and near 1,500 acres on Texas Point NWR.

Increased saltwater intrusion from frequent tidal overwash from the Gulf into inland marshes on these refuges will continue to negatively impact habitat quality for waterfowl, other migratory birds, and other native fish and wildlife species. Declining habitat conditions due to increased saltwater inundation could result in further significant declines in wintering waterfowl use on McFaddin and Texas Point NWRs.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Mottled ducks are year-round residents of the Chenier Plain region. This species prefers fresh to slightly brackish marshes (Gosselink *et al.* 1979), although a variety of marsh habitats, prairie, and agricultural wetlands (rice fields) are also utilized. Mottled Ducks on the Refuge Complex are part of the western Gulf Coast (WGC) population of Mottled Ducks. Banding studies have indicated that WGC Mottled Ducks do move between Mexico, Texas, Louisiana and Mississippi and Alabama, but no interchange occurs between this population and the Florida population of Mottled Ducks.

Mottled Duck numbers on the Refuge Complex (and other national wildlife refuges on the Texas Coast) have declined precipitously during the last 20 years, as indexed by annual breeding pair surveys and monthly aerial counts conducted September through March (USFWS, Division of Migratory Birds, unpublished reports). Stutzenbaker (1988) reported that the most serious threat facing Mottled Ducks is degradation and loss of habitat. In Texas, factors contributing to loss of habitat include conversion of native habitats for agricultural and urbanization, drainage, marsh subsidence, saltwater intrusion, spread of introduced species (Stutzenbaker 1988, Morton and Paine 1990), as well as increased pollutants (Cain

1988). Saltwater intrusion into wetlands that range from fresh to moderately brackish probably affects growth and survival of ducklings (Moorman *et al.* 1991). Encroachment of Chinese tallow into nesting habitat probably leads to abandonment of nesting areas (Stutzenbaker 1988). Other potential factors influencing Mottled Duck populations include declines in rice agriculture, extended periods of drought, mortality from predation due to increasing populations of alligators and possible increases in mammalian predators, a continued high incidence of lead pellet ingestion, and harvest (USFWS Division of Migratory Birds, unpublished reports).

Under Refuge Management Alternative A, the following habitat management and restoration activities would continue to be the primary management activities impacting Mottled Ducks on the Refuge Complex. All would be expected to have positive impacts on this species, although the landscape level issues described above are likely to control population dynamics of the Western Gulf Coast Mottled Duck population.

(a). Wetlands Management and Restoration

Wetland management and restoration activities on the Refuge Complex under Refuge Management Alternative A would provide and enhance habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Managing water levels and salinities in managed coastal marsh units would maintain fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. Marsh management also would enhance diversity and productivity of submerged aquatic vegetation which provides important year-round food sources for Mottled Ducks. Moist soil management and the cooperative rice farming program on Anahuac NWR would continue to provide critical shallow freshwater habitat and nutritious food resources for use by Mottled Ducks year-round. Approximately 100-150 acres of moist soil units would continue to be managed each year specifically to provide brood-rearing habitat for Mottled Ducks during summer.

(b). Uplands Management and Restoration

Native prairie restoration and management activities under Refuge Management Alternative A would benefit Mottled Ducks primarily by restoring and enhancing nesting habitat. The integrated application of prescribed burning, controlled livestock grazing, herbicide application and mowing/haying to maintain and enhance grassland habitats and reduce brush encroachment (exotic and native plants) in salty and non-saline prairies (and on levees and along fence lines) would be expected to improve nesting success of Mottled Ducks and other ground-nesting avian species.

The historical prairie-wetland continuum of the upper Texas coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and mima mounds that are characteristic of coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as “sennabean ponds,” as valuable brood rearing habitat. Protecting extant coastal prairie and restoring adjacent prairie and wetland habitats under Refuge Management Alternative A on the Refuge Complex will increase quality of habitats important to Mottled Duck recruitment and overall reproductive success.

(c). General Habitat Management Activities

Current levels of prescribed burning, grazing, and invasive species management, and shoreline protection and restoration activities would continue on the Refuge Complex under Refuge Management Alternative A. The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex which promotes optimum habitat conditions for wintering and migrating waterfowl also enhances wetland and upland habitats used by Mottled Ducks during all life history phases: pair formation, breeding, nesting, brood-rearing, molting and

wintering. Invasive plant and animal control activities would also enhance wetland and upland habitats for Mottled Ducks, as would shoreline protection and restoration activities.

Salt prairies occur as a broad zone between coastal prairies and marshes, or more commonly on the Refuge Complex, as a ridge between marshes and bays or the Gulf of Mexico. Higher, well drained, salt prairie ridges juxtaposed with lower wetland areas have been identified as important Mottled Duck nesting areas in the Chenier Plain region of Louisiana (Baker 1983) and Texas (Stutzenbaker 1988). Because of the near total loss of coastal prairie, salt prairie is now the most important Mottled Duck nesting habitat on the Refuge Complex. These cordgrass ridges are dominated by gulf cordgrass with marshhay cordgrass, knotroot bristlegrass (*Setaria parviflora*) and some brush species typically subdominant. Baker (1983) found that salt prairie invaded with Sesbania (*Sesbania* spp.) and Baccharis (*Baccharis halimifolia*) were avoided by nesting Mottled Ducks. Burned areas appeared to be undesirable for nesting to three years post-fire. Vegetation heights were comparable to unburned areas by the second year post-fire, but residual senesced vegetation remained low. Fire is necessary in the management of Mottled Duck nesting habitat. Fire must be frequent enough to keep brush at low densities, but infrequent enough to maximize years with dense nesting cover for Mottled Ducks.

Improper application of these habitat management practices has the potential to negatively impact Mottled Ducks. For example, prescribed burning may result in the excessive removal of vegetation reducing suitability as Mottled Duck nesting habitat, and burning at the wrong time of year could destroy nests (Baker 1983). Overgrazing by cattle may reduce desirable nesting habitat for Mottled Duck in marshes and salty prairies, especially after spring burns (Baker 1983, Stutzenbaker 1988).

Marsh habitats being impacted by tidal overwash of the beach ridges on McFaddin and Texas Point NWRs provide important Mottled Duck production and brood rearing habitat. Based on field observations and capture rates during banding efforts, saltwater inundation has reduced Mottled Duck use of affected areas by as much as 50 to 65% over the last 10 years. If erosion problems persist and result in increased frequency of events and water volumes entering marshes, Mottled Duck production can be expected to further decrease on the Refuge Complex.

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because the category of shorebirds, wading birds, and other marsh and waterbirds consists of a wide variety of species, individual species use microhabitats (e.g., vegetative cover and water depth) differently than other species in the same category (Gosselink *et al*. 1979, Skagen *et al*. 1999). For example, bare to sparse vegetative cover for foraging is preferred by species such as Piping Plover (Federally-listed Threatened) and the Least Tern (State-listed Endangered). Denser vegetation is preferred by other species, for example Little Blue Heron, Black-crowned Night Heron, Yellow-crowned Night Heron, Least Bittern, American Bittern, King Rail, and Clapper Rail. Other species have broad vegetation density requirements, and can utilize areas ranging from relatively bare of vegetation to dense vegetation, for example Reddish Egret (State-listed Threatened) and Wood Stork (State-listed Threatened).

This category of avian species also varies greatly in the amount of soil moisture and water depths they prefer, usually for feeding activities. These requirements range from relatively dry or shallow water (a few centimeters deep), such as the Piping Plover, to slightly deeper (but still relatively shallow) water, such as the Western Sandpiper and Least Sandpiper, to waters about 8-12 cm deep, such as the Black-bellied Plover and Willet. Other species prefer deeper waters, often within wading depth for long legged birds, such as the White-faced Ibis (State-listed Threatened) and the Least Tern. Some species can utilize deep waters as well as shallower waters (Wilson's Phalarope, Red-necked Phalarope, Olivaceous Cormorant, Double-breasted Cormorant, Laughing Gull, and Forster's Tern). Some species are year-round residents, such as Brown Pelican (Federally-listed Endangered), Double-breasted Cormorant, Great Blue Heron, Little Blue heron, Great Egret, and Black Skimmer. Other species are mostly migratory, including Wood Stork, White Ibis, and Forster's Tern.

Because of the wide diversity of habitat requirements by this category of birds, USFWS habitat management and restoration activities on the Refuge Complex which result in a mosaic of diverse habitat

types (plant species composition, structural characteristics, water levels and salinities) is desirable. As such, most of the wetland and upland habitat management and restoration activities to be continued under Refuge Management Alternative A would continue to positively impact the shorebird, wading bird and marsh bird species currently found on the Refuge Complex.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative A, actively managing water levels and salinities (e.g., by utilizing water control structures, levees, water delivery systems) would allow for continued protection of managed marsh units, which includes a wide variety of vegetation and habitat types used by many avian species in this group. In general, shorebirds and wading birds would continue to benefit from moist soil management and rice farming activities that result in increased abundance of invertebrates and plants that are a preferred food source (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002). The timing and depth of flooding on managed agricultural fields would influence the type of and intensity of use by such birds (Huner *et al*. 2002).

Under Refuge Management Alternative A, the cooperative rice farming program on Anahuac NWR would continue to provide from 500-700 acres of shallow freshwater wetland habitat, benefiting many avian species in this group. In addition, approximately 100-150 acres of the Anahuac NWR's moist soil units would continue to be managed specifically to provide wetland and mudflat habitat for shorebirds during spring and fall migrations. Targeted shorebird species include Long-billed Dowitcher, Semi-palmated Plover, Black-bellied Plover, Black-necked Stilt, Whimbrel, American Avocet, Long-billed Curlew, Hudsonian and Marbled Godwits, and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted Sandpipers. An additional 250-300 acres of moist soil units would provide wetland habitat for shorebirds, wading birds, and other marsh and waterbirds over the winter months. Wading and marsh bird species using moist soil habitats on the Refuge Complex include American Bittern, Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, Tri-colored Heron, Black-crowned and Yellow-crowned Night Herons, White Ibis, White-faced Ibis, and Roseate Spoonbill.

(b). Uplands Management and Restoration

Under Refuge Management Alternative A, restoration and enhancement of native prairie habitats on the Refuge Complex would benefit some avian species in this category primarily by providing improved habitat for migrating and wintering birds. Three Avian Species of Conservation Concern (USFWS 2002) would benefit from these activities: Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

Current prescribed burning, grazing, and invasive species management, and shoreline protection and restoration activities would continue on the Refuge Complex under Refuge Management Alternative A. The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex which promotes optimum habitat conditions for wintering and migrating waterfowl also enhances wetland and upland habitats used by many shorebird, wading bird and marsh bird species. Water management activities in coastal marshes which maximize the annual production of desirable submerged aquatic plant species provide improved habitat for invertebrates and small vertebrates, which are the primary prey items for many shorebird, wading bird and marsh bird species. Prescribed burning and controlled livestock grazing help create optimal physical structure of vegetation for shorebirds and wading birds in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for shorebirds. Invasive plant and animal control activities would also enhance wetland and upland habitats for these species. The removal of invasive vegetation that forms dense, homogeneous stands resulting in pond closure (such as common reed, cattail, and California bulrush), would improve habitat conditions for wading bird and marsh and waterbird species

that utilize open water habitats. Shoreline restoration activities including dune restoration and creation of emergent marsh and mudflats in intertidal zones behind breakwaters would benefit many shorebird and wading bird species.

Under Refuge Management Alternative A, the USFWS would also maintain a 1-acre nesting site for Least Terns and Black Skimmers on McFaddin NWR. This site is intensively managed to promote increased nesting success for these species, including providing ideal nesting substrate, excluding mammalian predators, and minimizing disturbance.

Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (*Coturnicops noveboracensis*, Mizell 1998), sparrows (Emberizidae) and wrens (Troglodytidae) (Gabrey *et al*. 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et al*. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al*. 2000). Not surprisingly, these secretive marshland bird species decline in the first year post fire. Other bird species such as Icterids (Gabrey *et al*. 2001) and Wilson's Snipe (*Gallinago delicate*), (USFWS unpublished data) increase immediately post-burn.

The susceptibility of wildlife to mortality during fire events seems to be dependent on weather, fuel characteristics (moisture, loading and continuity), fire characteristics (as influenced by ignition strategies), and the capability and behavior of the species in question. Black rail mortality has been observed where large areas are burned with little unburned escape cover available, while mortality was not observed in a burn containing a mosaic of unburned escape cover (Legare *et al*. 1998). No fire induced mortality was observed for three species of rail during fire operations on the Texas mid-coast, though data were insufficient to draw strong conclusions (Grace *et al*. 2005). Burns conducted under fuel and weather conditions that allow for patches of unburned habitat within the unit may minimize wildlife mortality. Burns ignited in a way that maximizes escape options, primarily through the use of backing and widely spaced strip flanking fires, probably minimizes wildlife mortality while maintaining fire-dependent habitat. The USFWS uses these techniques in prescribed burning operations on the Refuge Complex.

Some management activities under Refuge Management Alternative A could negatively impact some species of shorebirds, wading birds, and marsh and waterbirds. For example, some species in this group have a relatively narrow range of optimal water depth for feeding and other activities, ranging from almost dry sediment to relatively deeper water (Skagen *et al*. 1999). Management activities that increase water depth may negatively impact those species that prefer shallow or no water, and those that prefer deeper water are negatively impacted when management activities lower water levels. Similar impacts could occur with management of vegetative cover, as some species prefer areas devoid of vegetation, while others prefer heavy vegetative cover. Other habitat management activities could negatively impact some species of shorebirds, wading birds, marsh and waterbirds, especially if improperly implemented or timed. Grazing could negatively impact some ground-nesting species such as Black-necked Stilts by trampling nests and grazing on emergent pond vegetation used by those birds, and may also disturb nesting pairs (Whyte and Cain 1979).

Most avian species in this group (especially migrants) have evolved with unpredictable available resources, and are able to find suitable microhabitats in an adequately diversified landscape that contains a mosaic of microhabitats, both spatially and temporally. Under Refuge Management Alternative A, the USFWS strategy of management to maintain a mosaic of available habitats on the Refuge Complex should provide an adequate range of habitats for this group of avian species.

(4). Impacts to Landbirds

Landbird species found on the Refuge Complex require a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf coast (Mueller 1981, Barrow *et al*. 2000). Some raptor species prefer intermingled field and forested areas (e.g., red-tailed hawks and owls). Other landbird species prefer grassland habitats including marshes and prairies (Peterson *et al*.

1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

All habitat management and restoration activities conducted on the Refuge Complex under Refuge Management Alternative A would benefit avian species in this group. Although comprising a relatively small portion of the overall habitats on the Refuge Complex, restoration, management and protection of native prairies and coastal woodlots are of particular significance because of the importance of these habitats to many passerine species, including many neotropical migratory songbirds.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative A, the following wetland management and restoration activities would continue to have positive impacts on several landbird species including managing water levels and salinities in coastal marshes, marsh restoration, moist soil management, and cooperative rice farming program. Several land bird species listed as Avian Species of Conservation Concern (USFWS 2005), including the Seaside Sparrow, Nelson's Sharptailed Sparrow and Sprague's Pipit, would benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Together, the native prairie management and restoration activities undertaken under Refuge Management Alternative A would continue to protect and enhance the 5,744 acres of non-saline grassland habitats (fallowed croplands, prairie remnants, and previously restored sites) on the Refuge Complex. Under this Alternative, 245 acres of former cropland would be restored to native prairie on Anahuac NWR, and other existing grassland habitats would be enhanced by seeding and sprigging of native plants.

Many animal species typical of northern prairies, such as Henslow's Sparrows, Smooth Green Snakes, and Prairie Voles, were all found year-round in the Gulf coastal prairies. Dickcissels still nest in these coastal grasslands, and many other avian species utilize Gulf coastal prairies as wintering and/or migratory habitat. Many of the landbirds that would benefit from protection and management of native coastal prairie habitats under Refuge Management Alternative A are species that are declining in the Coastal Prairies Region of Texas (Shackelford and Lockwood 2000), and/or are among several species recently listed by the USFWS as "Avian Species of Conservation Concern" in the Gulf Prairies Bird Conservation Region (USFWS 2005). For example, White-tailed Hawk, Northern Bobwhite, Yellow and Black Rail, Buff-breasted Sandpiper, Short-eared Owl, Sedge Wren, and LeConte's Sparrow are all Avian Species of Conservation Concern that would benefit from conservation of prairie habitats on the Refuge Complex.

Native prairie remnants and other upland grassland habitats on the Refuge Complex provide wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow , and nesting habitat for species including Dicksissel and Eastern Meadowlark. These are also important nesting habitats for Mottled Ducks. Several species of raptors commonly observed on the Refuge Complex include Red-tailed Hawk, Red-shouldered Hawk, Turkey Vulture, American Kestrel, White-tailed Kite, Northern Harrier, and Short-eared Owl (USFWS 1997a). Many other raptor species are observed during spring and fall migrations. Landbirds listed as Avian Species of Conservation Concern utilizing prairie grassland habitats and which would benefit from native prairie restoration and management activities on the Refuge Complex under Refuge Management Alternative A include LeConte's Sparrow, Henslow's Sparrow, Sedge Wren, Loggerhead Shrike, and White-tailed Hawk.

Woodlot Restoration and Management

Under Refuge Management Alternative A, the following USFWS management actions would continue to have beneficial impacts on coastal woodlots: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts.

Although comprising less than 1 percent (approximately 127 acres) of the Refuge Complex acreage, woodlots help support a diverse avian community, which includes several sensitive songbird species. Six of the seven avian species listed as Rare and Declining within the coastal prairies region in Texas are present in the Refuge Complex' coastal woodlots. Migratory birds also depend on coastal woodlots for cover and food. At least 63 species of migratory birds regularly use the wooded habitats of the Chenier Plains prior to or immediately after crossing the Gulf of Mexico (Barrow *et al.* 2000). Trans-gulf or circum-gulf migratory songbirds use Texas Coastal woodlots as stopover habitat (Mueller 1981), which is critical at a time when the birds are depleted of water and energy reserves (Leberg *et al.* 1996).

A primary threat to coastal woodlots is encroachment by the Chinese tallow tree, which provides poor habitat for migratory songbirds. Although the Chinese tallow trees attract birds as frequently as other trees, they provide poorer forage because of sparse insect populations. Specifically, they harbor fewer insects and spiders, especially *Lepidopteron* larvae. Chinese tallow woodlots may thus be an "ecological trap" that provide cover but little food for migrants when they are energy-depleted after migration (Barrow and Renne 2001). In addition, activities by feral hogs can also damage understory vegetation and soils, as a result of their rooting habits, and may also cause a shift in plant succession. Such activities can also create disturbed areas that enable easier establishment of some invasive species. Feral hogs may also directly compete with several species of native wildlife for certain foods.

Overall, implementation of the USFWS management actions under Refuge Management Alternative A would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging. Species to benefit would include three neotropical migratory birds considered Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler. Since woodlot acreage is small relative to its importance to migrating neotropical migratory birds and other bird species that require trees and/or understory for cover, such positive impacts for each acre protected are proportionately significant.

(c). General Habitat Management Activities

Current prescribed burning, grazing, and invasive species management, and shoreline protection and restoration activities would continue on the Refuge Complex under Refuge Management Alternative A. The integrated combination of water level and salinity management, fire management and controlled livestock grazing on the Refuge Complex which promotes optimum habitat conditions for wetland-dependent migratory birds also enhances wetland and upland habitats used by many land bird species. Exotic and invasive plant and animal control activities would also enhance wetland and upland habitats for these species, especially in grassland and coastal woodlot habitats. For example, control of Chinese tallow would lead to increased diversity of native woody plants in the coastal woodlots, as well as increased forage insects (especially Lepidopteran larvae) for migrating passerines and other birds. Chinese tallow stands have an ecological trap effect for migrant songbirds that are drawn to the cover of the woodlots, but then find insufficient food resources to replenish depleted energy reserves (Barrow and Renne 2001).

Seaside sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al*. (2001) reported that breeding seaside sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is

possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested.

Gabrey *et al*. (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (1995) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post-fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife.

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Under Refuge Management Alternative A, the USFWS would continue to structurally manage marshes, restore coastal wetlands, and conduct vegetative management activities including prescribed burning, controlled livestock grazing, exotic plant and animal control, and shoreline restoration and protection. These management activities would protect, restore and enhance estuarine wetlands and help maintain wetland habitat diversity and productivity important to a variety of fish and shellfish species.

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al*. 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al*. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al*. 1990, Kneib 1991, Rozas 1995).

Structural marsh management is employed on portions of the Refuge Complex to enhance wetland habitats for migratory birds, to reduce impacts of saltwater intrusion and subsequent marsh loss and to maintain the historic salinity gradient that characterized coastal marshes of the Chenier Plain. Managing water levels and salinities using water control structures and levees in managed marsh units can restrict access to managed areas for some aquatic organisms, such as fish and crustaceans (Rogers *et al*. 1992, Kuhn *et al*. 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a natural stable or deteriorating deltaic marsh (Peterson *et al*.1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown.

Target salinity ranges typical of structurally managed marshes on the Refuge Complex range from fresh to the low end of brackish, being primarily intermediate (0.5-5.0ppt). While these salinity ranges are used by estuarine species, a study of fisheries use along a salinity gradient in Galveston Bay (Zimmerman *et al*. 1990) found estuarine fisheries were not greatly attracted to intermediate (oligohaline) marshes of the Trinity River delta. This study concluded that the oligohaline environment was not favorable for development of preferred foods, primarily epiphytic algae and peracarid crustaceans. Further, while transient species such as juvenile shrimp, crabs, and fishes had ready access to oligohaline marshes in this area, they did not use them extensively. These data indicate that while water control structures may limit ingress/egress of estuarine organisms, the habitat within may not be optimum for these organisms compared to brackish and saline marshes available on the Refuge Complex.

Impacts of structural marsh management to fisheries resources have been reduced on the Refuge Complex by incorporating design features into existing water control structures such as vertical slots which allow passage of estuarine organisms, managing structures to facilitate ingress and egress by opening gates during key movement periods, and utilizing rock weirs to counter erosion and enlargement of tidal waterways (as opposed to traditional fixed crest weirs). Ingress/egress slots allow more marine organism passage than fixed crest weirs, with larger openings allowing greater fisheries access (Herke *et al.* 1992). These slots provide a means of allowing movement of estuarine organisms in and out of structurally managed marshes, but assist in maintaining the fresher end of the coastal marsh continuum that so many of the Refuge Complex's priority species depend on.

Periods of peak ingress and egress movements are associated with water level fluctuations and tidal cycles. Highest peak fisheries resource movements are often related to periods of combined lunar cycles and major tidal movements. Manipulating water control structures during the full moon and new moon of the lunar cycle allows opportunity for the maximum ingress potential of fisheries resources. Holding slight levels of excess water for several days prior to these cycles and releasing during peak ingress periods greatly increases access to the unit from fisheries species dependent on coastal estuaries. Many species will move towards fresher water during incoming tides (Guillory 1996). The USFWS uses these techniques on the Refuge Complex to enhance fisheries utilization of managed marsh units. In addition, the continuum of fresh to saline aquatic environments on the Refuge Complex supports highly diverse aquatic vertebrate and invertebrate communities. Disruption of salinity gradients would likely cause adverse impacts on blue crabs (Guillory 1996). Many of the refuge marshes would exceed these thresholds without some type of hydrologic management.

Much of the work on fisheries use of flooded marshes has focused on saline marshes with a high component of *Spartina alternaflora* (Zimmerman *et al.* 1990, Baltz *et al.* 1993, Peterson and Turner 1994, Knieb and Wagner 1994, Minello *et al*. 1994, Rozas *et al*. 1998, Zimmerman *et al.* 2000). Brown shrimp, white shrimp, and blue crabs are associated with salt marsh dominated estuaries (Weinstein 1979, Wenner and Beatty 1993). Many of the salt marshes of the western Gulf coast are experiencing rapid subsidence, saltwater intrusion and conversion to open water. Research has suggested that marsh conversion to open water will reach a point beyond which fisheries will decline due to a reduction of total marsh edge (Browder *et a*l. 1989). Further, fisheries habitat gained due to marsh breakup is not sustainable in the long term (Browder *et al.* 1989, Condrey and Fuller 1992). Under this Alternative, activities which maintain and restore productive wetland habitats and help reduce rates of marsh loss would also benefit fisheries resources in the long-term.

(6). Impacts to Threatened and Endangered Species

Three avian species occurring on the Refuge Complex are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican. Under Refuge Management Alternative A, protection, restoration and management of coastal wetland habitats on the Refuge Complex would continue to benefit the three avian T&E species. Bald eagles observed on the Refuge Complex are usually associated with large concentrations of wintering waterfowl. Brown pelicans utilize shorelines tidal saline ponds for resting and foraging. Shoreline restoration and protection activities would provide improved habitat for Piping Plover and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon, Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Conservation and management of both wetland and upland habitats aimed at ensuring biological integrity and biological diversity under Refuge Management Alternative A would benefit Threatened and Endangered species and many other sensitive or declining native fish and wildlife species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found on the Refuge Complex include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species on the Refuge Complex. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic animals.

In general, habitat management and restoration activities under Refuge Management Alternative A which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of wildlife species.

USFWS management activities under Refuge Management Alternative A which maintain and restore freshwater wetland habitats (structural management of marshes, moist soil management, rice farming) are particularly beneficial to amphibians and reptiles. Reliable freshwater habitat is critical for most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators. Habitat conditions which increase the abundance of insects, crustaceans, and other small prey benefit most species of amphibians and reptiles during at least a portion of their lifecycle. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas.

Under Refuge Management Alternative A, some management activities would continue to have negative impacts on some wildlife species. Control of invasive woody species in wetland and upland habitats may decrease habitat quality for certain mammals such as raccoon and striped skunk. Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, and some reptiles, and invertebrates.

Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et al*. 1989) summarizes by saying “Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil litter stabilize.” Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data). It appears that fire management practices that favor desired vegetation conditions seem to be compatible with maximizing arthropod diversity as long as a mosaic of burned an unburned habitats is maintained.

b. Impacts from Public Use Programs

The following analysis of impacts of public use programs on fish and wildlife resources focuses on the six wildlife-dependent uses which are the priority public uses of the National Wildlife Refuge System: hunting, fishing, wildlife observation and photography, and environmental education and interpretation. Impacts of beach recreational uses on McFaddin NWR are discussed under the specific wildlife species or groups of species affected by this use.

(1). Impacts to Waterfowl

(a). Waterfowl Hunting

The most direct effect of hunting on the Refuge Complex is the mortality of harvested waterfowl species resulting from the hunting activities. However, because regulations governing harvest in the Central and Mississippi Flyways are developed annually under the USFWS national migratory bird hunting regulation frameworks, and are designed to ensure that viable waterfowl populations are sustained over the long-term, continuation of the waterfowl hunting program on the Refuge Complex under Alternative A will not have any measurable effect on overall populations and the long-term viability of these populations.

Many studies have documented the effects of hunting intensity on the number of birds utilizing an area (Reichholf, 1976, Madsen *et al*. 1992 as cited by Fox and Madsen 1997, Wolder 1993). These studies have shown that relatively light hunting pressure can reduce waterfowl abundance in hunted areas. Distribution and habitat use, feeding patterns, and the nutritional status of waterfowl have also been shown to be affected by hunting activities. Hunting activity can cause birds to alter habitat use, change feeding locations (Madsen 1995), feed more at night (Morton *et al.* 1989) and reduce the amount of time spent feeding (Korschgen *et al.* 1985, Madsen 1995). Collectively, these changes in behavior have the potential to adversely impact the nutritional status of waterfowl (Belanger and Bedard 1995).

Means of access to and within Refuge Complex hunt areas include motorized boating (primarily in Oyster, Onion and East Bay bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake and hunt area access ditches on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), non-motorized boating, motorized vehicles, and walking. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use, but these impacts are likely less than those caused by motorized boating.

Monthly aerial surveys of wintering waterfowl on the Refuge Complex have documented the disproportionate use of established sanctuary areas by waterfowl, as compared to the areas open to hunting. This further supports the above studies and indicates that hunting affects the overall distribution of wintering waterfowl on the Refuge Complex. The size, location and habitat quality of sanctuary areas on the Refuge Complex remains critically important to ensure that migrating and wintering populations of waterfowl maintain sound nutritional and physiological status.

Providing waterfowl with predictable undisturbed sanctuary areas likely increases the ability of birds to meet the obligations of their annual cycle. Waterfowl undergo considerable physiological demands during winter. Heitmeyer (1988) estimated that prebasic molt in female mallards required and additional three grams per day of protein over base metabolic rates. These demands approach the estimated five grams per day associated with reproduction. Pair formation for most North American waterfowl takes place away from the breeding grounds. Waterfowl must accumulate endogenous energy reserves to meet the demands of courtship (Afton and Sayler in Baldassarre and Bolen 1994). Baldassarre and Bolen (1994) proposed that birds that do not accumulate energy reserves may have less time and energy at their disposal to initiate courtship and/or may be unable to maintain previously established pair bonds. Clearly, birds must meet high energy demands to successfully fulfill critical wintering components of their annual cycle. Further, Heitmeyer and Fredrickson (1981) build a scenario where endogenous reserves established on wintering grounds return mallards to breeding areas in better condition to begin nesting, leading to larger clutch sized and earlier nests, which tend to be more successful. Providing sanctuary areas of adequate size, encompassing and/or adjacent to quality feeding areas, may contribute to the ability of birds to meet the physiological demands required during winter and possibly the subsequent nesting cycle.

It has been shown that sanctuary areas on the wintering grounds are effective in maintaining local waterfowl populations in a landscape subject to hunting pressure (Bellrose 1954, Madsen 1998).

Heitmeyer and Raveling (1988) found that waterfowl used sanctuaries during the day and local rice fields at night. Similarly, Fleskes *et al*. (2005) found Northern Pintail used areas closed to hunting during the day and dispersed throughout the area at night. These data indicate that while sanctuaries are effective in maintaining local waterfowl populations through the hunting season, birds must disperse at night to feed.

Overall, it is expected that the maintenance of sanctuary areas on the Refuge Complex mitigates for disturbance impacts from hunting activities. In years of poor habitat quality due to climatic extremes or tidal flooding from tropical disturbances, however, it is possible that hunting activities would result in reduced abundance of wintering waterfowl on the Refuge Complex. Maintenance of traditional sanctuary areas would continue under Refuge Management Alternative A.

Maintaining current Refuge-specific hunting regulations under Refuge Management Alternative A would also help mitigate the impacts of hunting activity-related disturbance to waterfowl. Waterfowl hunting in hunt areas is allowed three days per week (with the exception of the 1,500-acre Pace Tract on Anahuac NWR which is open for hunting seven days per week), and all hunting activity is curtailed each day at noon. The non-hunted days and afternoon and evening closures provide undisturbed periods within the hunt areas, facilitating waterfowl utilization of hunt area habitats for foraging and resting. Boat use on the Refuge Complex occurs primarily in bayous, canals and ditches, limiting disturbance impacts to these narrow corridors (exceptions are Star Lake and Clam Lake on McFaddin NWR and Pole Lake on Texas Point NWR). The majority of the hunt areas therefore are not impacted by boating activity, being accessible primarily by foot. In addition, a variety of regulations govern means of access to hunt areas, including boat motor and horsepower restrictions, prohibition of airboat and all-terrain vehicle use, and establishment of areas in which only non-motorized boat access is allowed. While these regulations are in place primarily to protect habitats and public safety, they also reduce overall disturbance impacts to waterfowl and other migratory birds.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation

Primary means of access to areas on the Refuge Complex use for fishing and wildlife observation and photography include motorized and non-motorized boating (primarily in bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), motorized vehicles on refuge roads open to the public, and walking on trails, boardwalks and observation platforms and along banks and shorelines. A very small number of visitors use bicycles on public roads and levee trails on all three refuges. An even smaller number ride horses on roads at Anahuac NWR and on the Gulf beach at McFaddin NWR. Motorized vehicles and walking are used to access areas used for environmental education and interpretation on Anahuac NWR.

Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use.

Disturbance of waterfowl by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993). In wetland habitats, disturbance from “out of vehicle” approaches can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). While some species of waterfowl appear to acclimate to vehicular traffic, and even presence of visitors on trails, boardwalks, and observation platforms, other species are less tolerant of disturbance. Overall it is likely that species composition and abundance of waterfowl is decreased in areas supporting these recreational uses.

Under Refuge Management Alternative A, most of these visitor facilities on the Refuge Complex would continue to be found on the Anahuac NWR, and the primary impacts of these activities on waterfowl would occur on this Refuge.

(2). Impacts to other Migratory Birds, Shorebirds, Wading Birds, other Marsh and Waterbirds, and Landbirds

(a). Waterfowl Hunting

Although the impacts of waterfowl hunting under Refuge Management Alternative A on other wetland-dependent migratory and resident birds which are not hunted is likely less than for waterfowl, studies have demonstrated that hunting (including accessing hunt areas) does affect abundance and distribution of these other avian species. The noise associated with shooting likely reduces habitat utilization by shorebirds, wading birds, other marsh and waterbirds, and landbirds using wetland habitats within hunt areas, at least while hunting is occurring. Motorized boating disturbs and displaces many waterbird species (Dahlgren and Korschgen 1992, Knight and Cole, 1995), as will non-motorized boats, vehicles and walking through the marsh.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

Primary means of access to areas on the Refuge Complex for fishing, wildlife observation and photography include motorized and non-motorized boating (primarily in bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), motorized vehicles on refuge roads open to the public, and walking on trails, boardwalks and observation platforms and along banks and shorelines. A very small number of visitors use bicycles on public roads and levee trails on all three refuges. An even smaller number ride horses on roads at Anahuac and McFaddin NWRs. Motorized vehicles and walking are used to access areas used for environmental education and interpretation on Anahuac NWR.

Disturbance of migratory birds by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993) and shoreline areas regularly used for fishing. Along roads through wetland habitats, disturbance from “out of vehicle” approaches for observation and photography can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). Walking on trails tends to displace birds and can cause declines in species richness and abundance (Riffell *et al*. 1996). Some generalist avian species such as house finches tend to increase near trails, while specialist species such as solitary vireo move away from trails. The zone of influence around trails appears to be approximately 75m for woodland areas adjacent to grasslands (Miller *et al*. 1998).

Disturbance impacts to birds from visitation are often magnified during the breeding season. Color of clothing worn can attract or repel different passerine species based on breeding plumages of those species (Gutzwiller and Marcum 1997). Primary song occurrence and consistency of certain passerines can be impacted by a single visitor (Gutzwiller *et al*. 1994), which could limit the number of breeding pairs and production by those species in disturbed areas (Reijnen and Foppen 1994). Predation on songbird, raptors, colonial nesting species, and waterfowl nests tends to increase near more frequently visited areas (Glinski 1976, Buckley and Buckley 1978, Boyle and Samson 1985, Miller *et al*. 1998).

On Anahuac NWR, visitors are allowed to access a 10-acre area within the Yellow Rail Prairie Management Unit to attempt to flush and view Yellow Rails. This is accomplished by walking slowly through the area, and is most successful when groups of people slowly walk parallel to each other dragging a rope in between participants. This activity occurs primarily during the months of March and April, and includes several guided “Yellow Rail Walks” led by refuge staff or trained volunteers. Disturbance of rails flushed during this activity undoubtedly occurs and likely leads to reduced utilization of this area by rails. Suitable undisturbed habitats exist adjacent to this site, and is unlikely that this disturbance results in long-term negative impacts to individual rails or rail populations.

Heaviest use and vehicular traffic of beaches on and adjacent to McFaddin NWR occurs from April through September. Numerous studies have documented impacts of beach recreation on shorebirds. Beach use affects beach-nesting birds directly and indirectly. Beach use may cause direct mortality of

birds through nest and chick destruction, displacement, or reduced reproductive success (Burger 1995). Burger (1984) found that human disturbance accounted for over half of the reproductive failures of Least Tern colonies in New Jersey. Most of this loss was due to off-road vehicles and people walking through the colonies. The presence of people on the beach decreases foraging time and increases vigilance of Piping Plovers, potentially having a negative effect on chick survival and adult maintenance (Burger 1991). Flemming *et al*. (1988) suggest that population decline of piping plovers could be caused by human disturbance altering chick behavior, thereby increasing their susceptibility to inclement weather and predators, and consequently increasing mortality. Beach-nesting birds respond to recreationalists based on species' characteristics, habituation to disturbance, exposure, seasonality, and nesting dispersion (Burger and Gochfeld as cited by Knight and Gutzwiller 1995). Beach use may also cause indirect impacts to birds by increasing predators or habitat loss (Burger 1995).

Long-term declines in the abundance of some migratory shorebird species may be associated with increased human disturbance factors on beaches (Pfister *et al.* 1992). This study found that vehicles, pedestrians, and pets displace shorebirds from traditional resting areas, thereby reducing the utility of impacted areas to migrating shorebird populations. Burger and Gochfeld (1991) found that human disturbance from beach use (walking, sunbathing, swimming, and jogging) impacted the time devoted to foraging by wintering sanderlings. An increase in the number of people on the beach was associated with sanderlings spending more time directly running or flying due to disturbance.

Recreational beach uses and associated vehicular traffic have had impacts on shorebirds and other waterbirds on Gulf of Mexico beaches on and adjacent to McFaddin NWR. Species known to nest on the beach, dunes and/or overwash terrace on the Refuge include Least Tern, Wilson's Plover, Black Skimmer, Killdeer, and Common Nighthawk. Mortality of least tern chicks, and the loss of least tern, killdeer, and common nighthawk nests and eggs has been documented on the Refuge due to illegal motorized vehicle activity on the dunes and overwash terrace inland of the beach. Illegal travel on these habitats occurs primarily when high water or erosion precludes travel on the beach. Beach walkers and unleashed pets have also caused disturbance to least tern colonies located on the overwash terrace. Under Refuge Management Alternative A, the USFWS would continue routine law enforcement patrols of the Gulf beaches within McFaddin NWR to protect public safety and natural resources.

(3). Impacts to Fisheries

(a). Fishing

The most direct effect of fishing on the Refuge Complex is the mortality of harvested freshwater and saltwater fish, blue crabs, and several fish and shellfish species caught for use as bait. Fishing and crabbing on the Refuge Complex occur under regulations promulgated by the Texas Parks and Wildlife Department. These regulations are designed to ensure that viable fish and shellfish populations are sustained over the long-term. Continuation of fishing and crabbing on the Refuge Complex under Refuge Management Alternative A should not have any measurable effect on overall populations and the long-term viability of these species' populations.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

No impacts to fisheries resources are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative A.

(4). Impacts to Threatened and Endangered Species

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

It is likely that Bald Eagles, Brown Pelicans and Piping Plovers using Refuge Complex habitats are subject to the some level of disturbance by public use activities on the Refuge Complex, but these impacts are expected to be negligible. Bald Eagles are usually associated with large concentrations of wintering waterfowl that occur in refuge sanctuary areas which are not open to the public. Piping Plovers utilize beach, shoreline and intertidal mudflat habitats primarily during fall and winter, when use of these habitats by the public is lightest. Brown Pelicans readily forage and roost adjacent to human activity and infrastructure. The three T&E avian species do not nest on the Refuge Complex, their presence is transient in nature, and they are highly mobile and able to move to undisturbed areas. Overall, no impacts to Federally-listed or State-listed Threatened and Endangered species are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative A.

(5). Impacts to other Fish and Wildlife Species – Mammals, Amphibians, Reptiles, and Invertebrates

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

It is likely that mammals and amphibians and reptiles are subject to some level of disturbance from public use activities occurring on the Refuge Complex, but these impacts are expected to be negligible. Vehicles do occasionally strike and kill mammals such as Virginia opossum, armadillo, raccoon and striped skunk, and reptiles and amphibians including alligators, snakes and frogs.

(b). Commercial Alligator Harvest

Under Refuge Management Alternative A, an adult alligator harvest program would continue to be administered as an economic use on the Refuge Complex. This program is administered under regulations promulgated by Texas Parks and Wildlife Department, and these regulations are designed to ensure that viable alligator populations are sustained over the long-term. In addition, the USFWS regulates the alligator harvest program on the Refuge Complex through issuance of a Special Use Permit which contains stipulations also designed to conserve alligator populations. For example, special regulations are in place to restrict harvest of reproductive-aged alligators and maintain a natural age structure within the Refuge Complex alligator population. Continuation of the commercial alligator harvest program under Refuge Management Alternative A should not have any measurable effect on the long-term viability of alligator populations on the Refuge Complex.

(c). Control of Muskrat Populations

Under Refuge Management Alternative A, muskrat populations would be controlled in specific locations as deemed necessary to protect wetland habitats on the Refuge Complex through issuance of Special Use Permits for trapping and removal by qualified individuals. Herbivory in areas of high density muskrat populations can cause or exacerbate conditions resulting in permanent conversion of vegetated marsh to open water. This is likely to most prevalent in areas affected by saltwater intrusion or other factors contributing to marsh loss. Trapping and removal of muskrats under this program would have negligible if any impacts on overall muskrat populations and the long-term viability of these populations.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

Surveys, monitoring and research activities for waterfowl to continue under Refuge Management Alternative A include the following: 1) monthly aerial surveys of waterfowl (September through March); 2)

annual Mottled Duck breeding pair surveys; 3) national, regional and local banding studies of waterfowl, including ongoing banding studies of Mottled Ducks and snow geese; 4) data collection from harvested waterfowl at check stations including body condition indices and lead shot ingestion rates; 5) participation in the annual Audubon Society Christmas Bird Count; and 6) coordination of research studies on Mottled Ducks and other priority waterfowl species through partnerships with the USFWS Division of Migratory Birds, universities and the U.S. Geological Survey Biological Resources Division.

Surveys, monitoring and research for shorebirds, wading birds and other marsh and waterbirds to continue under Refuge Management Alternative A include the following: 1) an annual nesting survey for colonial nesting waterbirds on Gulf shoreline of Texas Point NWR; 2) periodic spring and fall shorebird surveys in various representative wetland habitats; 3) .participation in the annual Audubon Society Christmas Bird Count; and 4) research studies on priority species through partnerships with universities and the U.S. Geological Survey Biological Resources Division.

Surveys, monitoring, and research activities for resident and migratory landbirds to continue under Refuge Management Alternative A include the following: 1) periodic surveys of selected landbirds in marsh, prairie and woodland habitats; 2) participation in the annual Audubon Society Christmas Bird Count; and 3) coordination of research studies on priority species through partnerships with universities and the U.S. Geological Survey Biological Resources Division.

Surveys and monitoring activities for fisheries resources to continue under Refuge Management Alternative A include the following: 1) coordination with the USFWS Fisheries Program for periodic fisheries monitoring in representative wetland habitats; and 2) coordination with USFWS Division of Ecological Services and other State and Federal agencies to conduct periodic monitoring and studies of contaminant impacts to fisheries.

Surveys and monitoring activities indirectly benefiting T&E species to continue under Refuge Management Alternative A include the following: 1) participation in the annual coast-wide wintering Piping Plover survey; and 2) coordination of research studies on sensitive and/or declining species through partnerships with universities and the U.S. Geological Survey Biological Resources Division.

Under Refuge Management Alternative A, annual aerial basking surveys and nighttime spotlight surveys to monitor alligator population trends would continue. Data collection from harvested alligators would continue, including data collection on previously marked and released alligators. Coordination and information sharing with the Texas Parks and Wildlife Department on alligator harvest management, population monitoring, and research would continue.

Collection of information on species composition and relative abundance of invertebrates on the Refuge Complex would continue under Refuge Management Alternative A. These data are typically collected through “BioBlitz” events and other surveys conducted in partnership with universities, the U.S. Geological Survey Biological Resources Division, and volunteer naturalists. The North American Butterfly Association’s Fourth of July Butterfly Counts would also continue on the Refuge Complex. These monitoring activities are providing baseline information, previously not available, on this important resource. Many species of invertebrates provide a critically important prey base for migratory birds and other native fish and wildlife.

Surveys and monitoring and research activities are useful for tracking and documenting the impacts of various management strategies on fish and wildlife populations, distribution, movements and habitat utilization. This information facilitates implementation of an adaptive management approach which allows continual refinement and improvement of management activities. In some cases, monitoring activities are providing baseline information, previously not available, on this important resource.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative A, the USFWS would continue to manage oil and gas exploration and development activities on the Refuge Complex through the issuance of Special Use Permits.

Stipulations in the Special Use Permit include those aimed at minimizing impacts to fish and wildlife resources, including timing of activities to avoid major periods of utilization, required use of specialized equipment, location and size of facilities, and required pollution controls.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex is a reduced impact on fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative A, the USFWS would continue to develop partnerships with private land owners to restore and enhance wetland and upland habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands.

The USFWS would also continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, Texas General Land Office and Galveston Bay Estuary Program, conservation organizations such as the Galveston Bay Foundation, Ducks Unlimited and local Audubon Society chapters, community organizations and Refuge volunteers. These partnerships support and greatly enhance a variety of refuge management programs.

It is anticipated that continuation of outreach and partnership efforts under Refuge Management Alternative A would result in benefits to fish and wildlife resources as important habitats are restored and enhanced. Projects on private lands such as those implanted to date would enhance wetland habitats for wintering waterfowl, Mottled Ducks and other wetland-dependent migratory birds, and for resident wildlife including several species of reptiles and amphibians which depend on freshwater habitat. Ongoing partnerships with the Refuge Friends groups, agencies and conservation organizations and volunteers would support a variety of habitat restoration and biological program activities on the Refuge Complex, contributing directly to conservation of fish and wildlife resources.

B. Socioeconomic Resources Section

1. Economic Impacts

Economic impacts from management activities on the Refuge Complex occur in the regional economy in two different ways.

First, there are the direct economic impacts that occur as a result of the economic stimulus of three elements:

1) Direct expenditures made by USFWS to manage operations at the Refuge Complex,
2) Value of production from agricultural programs on the Refuge Complex, and
3) Expenditures made by recreational visitors to the Refuge Complex.

Second, there are indirect and induced economic impacts which are additional economic activity that occur as a result of the re-spending of these direct economic elements. The indirect and induced economic impacts are measured as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the direct economic elements. Total economic impacts (direct, indirect and induced) of each management alternative, including the No Action Alternative, were estimated using the data and methods discussed below.

The study area for purposes of estimating economic impacts is all of Jefferson and Chambers Counties along with a small portion of Galveston County, which includes the eastern portion of the Bolivar Peninsula east of Rollover Pass.

a. Direct Economic Impacts

(1). Value of Refuge Operations (Direct Expenditures)[10]

Data on current local USFWS operational expenditures at the Refuge Complex was gathered and is summarized in Table 4-1. Expenditures that support operations from sources outside the region were not considered. This is due to the fact that these expenditures do not have a local economic impact and are thus not a focus of this analysis. The average annual expenditure estimates were based on budgets for the Refuge Complex for Fiscal Years 2001, 2002 and 2003. The largest expenditure associated with the Refuge Complex is for staff salaries, which comprises approximately 65 percent of total budgeted costs. Deferred maintenance projects are the second largest local expenditure and comprise approximately 20 percent of the annual budget. These projects cover the costs of continuing habitat management and restoration at the Refuge Complex. The third highest cost is for annual maintenance of facilities and equipment.

Table 4-1
Annual Average Operational Costs for the Refuge Complex (Direct Expenditures)

Salaries	$1,736,727
Utilities	$35,000
Supplies	$28,000
Travel	$39,123
Heavy Equip. Rental	$50,000
Equipment Replacement	$27,000
Annual Maintenance (Facilities and Equipment)	$231,000
Deferred Maintenance	$533,333
Special Programs	$15,000
Total	$2,695,184

To support these activities, the USFWS purchases a variety of inputs from the local economy. This includes such things as labor (FWS jobs or contract), materials (e.g. equipment, construction materials, office supplies, plants, rock, fuel, chemicals, etc.), and services (e.g. dirt work, water well development, repairs, etc.) It was assumed for the analysis that the costs summarized in Table 4-1 would represent spending patterns under Refuge Management Alternative A (No Action).

(2). Value of Production from Refuge Agricultural Programs

This section presents data that is used to estimate the value of agriculture production within the Refuge Complex, specifically grazing operations and rice production.

(a). Cattle Grazing

Information from the USFWS and the Texas Agricultural Statistical Service was used to value current grazing operations within the Refuge Complex. First, information concerning the historical grazing use within the Refuge Complex over the last 6 years was accumulated. The annual grazing rate is expressed in Animal Unit Months (AUMs) which is the standard industry measure for cattle grazing. Cattle grazing on the Refuge Complex for the last 6 years is summarized in Table 4-2.

Table 4-2
Annual Grazing AUMs on Refuge Complex

Year	Anahuac NWR	McFaddin NWR	Texas Point NWR
2001-2002	14,352	10,240	845
2000-2001	10,542	13,979	737
1999-2000	11,459	10,669	1,140
1998-1999	13,171	6,468	1,477
1997-1998	11,418	12,056	0*
1996-1997	12,778	9,689	1,283

*Grazing did not occur on Texas Point NWR during this year due to a late decision of a permittee not to graze.

10 The Value of USFWS Operations Table is essentially done for the Refuge Management Alternative A (No Action). Under the remaining Refuge Management Alternatives (B through E), the USFWS will change the magnitude and intensity of management activities on the Refuge Complex. These actions will show increases or decreases from the baseline direct expenditures by the USFWS in the local economy as indicated in the Value Table above.

The value of grazing AUMs for cattle was then estimated as summarized in Table 4-3. For cattle AUMS, as shown in columns 2 and 3, data were obtained from the Texas Agricultural Statistical Service and include the value of cattle sold in Texas each year between 1998 to 2002. Total cattle sales were divided by the number of cows that have calved each year, which provided a value per cow sold as summarized in column 4. The value per cow was then divided by an AUM conversion factor, which resulted in an estimated value per AUM per year. This annual value was adjusted for inflation each year as summarized in column 7. The economic analysis for this report used the 5-year average value of AUMs, or $88.02/AUM in inflation-adjusted dollars.

Table 4-3
Estimated Value of AUMs for Refuge Complex

Year	Value of Production (1,000$s)a	Cows that have Calved (1,000 Head)a	Value Per Cow	Conversion to AUMs (AUMs/cow)b	Value of Production Per AUM Nominal $	Value of Production Per AUM Real (2002$)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1998	$7,830,000	5,880	$1,332	16	$83.23	$89.97
1999	$7,050,000	5,870	$1,201	16	$75.06	$80.10
2000	$7,784,000	5,780	$1,347	16	$84.17	$88.00
2001	$8,357,000	5,810	$1,438	16	$89.90	$91.87
2002	$8,296,000	5,750	$1,443	16	$90.17	$90.17
					5-yr Average	**$88.02**

a Texas Agricultural Statistical Service, "Texas Agriculture Statistics, 2001", Austin, Texas.
b J.P. Workman, Range Economics, 1986, McMillian Publishing, Inc. New York, New York.

Using the value per AUM and the five-year average grazing use, the value of current grazing operations within the Refuge Complex were estimated as shown in Table 4-4.

Table 4-4
Estimated Production Value of Grazing Activities on Refuge Complex*

	Anahuac NWR	McFaddin NWR	Texas Point NWR
Annual Ave.	12,287	10,517	1,096
Value Per AUM	$88.02	$88.02	$88.02
Total Output	**$1,081,532**	**$925,743**	**$96,510**

*A similar process was used to estimate the value of grazing operations under the other alternatives. This effort included some development assumptions regarding the number of annual AUMs expected to occur under each alternative. For instance, grazing use is expected to increase under Alternative B and D in varying ways due to the change in management while grazing use is expected to decrease under Alternative C. The most dramatic change will occur under Alternative E where the controlled grazing program would be eliminated.

(b). Rice Production

The USFWS manages a cooperative farming program within the Refuge Complex. The program supports rice farming and occurs solely on Anahuac NWR. The refuge has 1,713 base acres registered with the USDA used currently by four permittees on a three-year rotational basis. Thus, approximately 500 to 700 acres of rice are currently produced on an annual basis and would continue under Refuge Management Alternative A. The USFWS recognizes the benefits of having rice produced on the refuge as a potential food source for migratory birds. Rice operations within the refuge must be compatible with these wildlife goals. In accordance, USFWS requires permittees to meet certain stipulations including: use of only approved herbicides, maintenance schedules, use of certified rice seed and restrictions on second growth harvests. Currently, nearly two-thirds of the total acreage within the cooperative farming program is managed as an organic rice farming operation.

Using information from the Texas Agriculture Extension Service, an estimate of average returns for rice production was prepared. A summary is provided in Table 4-5.

Table 4-5
2000 Projected Returns Per Acre for Rice Texas Gulf Coast

	Quantity (cwt)	$/cwt (2002$)	Estimated Value Per Acre
Rice 1st Crop	56.9	$7.32	$416

Source: Texas Agriculture Extension Service, Rice, First and Second Crop, Texas Gulf Coast, 2000 Projected Costs and Returns per Acre

Using the estimated value per acre from Table 4-5 and the average number of acres actually farmed each year, an estimate of the value of annual rice production occurring on the Refuge Complex was prepared and is summarized in Table 4-6.

Table 4-6
Estimated Value of Rice Production (2000)

	Average Acres	Value Per Acre	Estimated Value of Production
Rice 1st Crop	600	$416.45	$249,867

(3) Value of Refuge Recreational Programs

Economic impacts occur within the local economy as recreationalists spend money while visiting the Refuge Complex. From a regional economic standpoint, the importance of this spending is dependent on where the funds originate. If funds originate outside the region, it generates additional economic activity. If they originate from inside the region and would have occurred anyway, it does not increase economic activity though it may still be important to local businesses. This analysis focused on the number of visitors that originate from outside the study area (e.g. outside Jefferson and Chambers counties) and travel to the Refuge Complex to enjoy recreational activities.

The value of refuge current recreational programs under Refuge Management Alternative A was estimated using several steps as follows:

- Estimate visitation by activity to the refuges open for recreation (uses considered included hunting, fishing, wildlife observation)
- Determine the number of out-of-area visitors that come to the Refuge Complex
- Estimate the average expenditures per Recreational Visitor Days (RVDs) at the Refuge Complex

First, estimates were generated on the number of visits made to each refuge open to recreational use (e.g. Texas Point, McFaddin and Anahuac NWRs). These estimates are based on currently available data from the USFWS on recreational use and on a series assumptions regarding how management actions will affect recreational uses during the study period. Most of the data used to estimate refuge visitation comes from the Recreation Management Information System (RMIS), which includes data on visitation reported by Refuge Complex staff. Estimated refuge visitation is expressed in RVDs, and the annual estimates of RVDs is used to calculate the logarithmic trend for each activity. The trend is then applied over the 15-year study period to determine projected visitation.

Next, the origin of recreational visitors to the Refuge Complex was determined based on USFWS data and information. This includes visitor origin for fishing and hunting which was estimated from actual licenses or staff observations. The determination also used visitor origin estimates for wildlife observation as published by the USFWS for Laguna Atascosa National Wildlife Refuge in Texas.[11] It was determined that approximately 90% of the visitors participating in wildlife observation were not local, while only about 10% of the visitors participating in hunting or fishing were not local.

11U.S. Fish and Wildlife, " Banking on Nature: The Economic Benefits to Local Communities of National Wildlife Refuge", June 1997, p. 94.

Annual RVDs by activity for non-resident recreationalists was estimated using the above factors and the estimated annual RVDs for the Refuge Complex based on USFWS data. Annual non-resident RVDs for 2003 using this method is provided in Table 4-7. Wildlife observation attracts the greatest percentage of non-resident recreationalists accounting for over 83 percent of annual non-resident visits. Because visitors may spend less than one day at the Refuge, counting brief visits as full RVDs would overstate visitor spending that can be attributed to the Refuge Complex. However, observations by USFWS staff indicated that individuals using the Refuge Complex do spend most of the day on site while recreating. Therefore, no additional adjustments were made to the RVD estimates.

Table 4-7
Estimated Annual Non- Resident Visits to the Refuge Complex (2003)

Wildlife Observation	Waterfowl Hunting	Other Hunting	Fishing	Total Non-Resident Visitors
29,099	1,167	0	4,744	35,010

Average daily expenditures made by recreators visiting the Refuge Complex were extracted from the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Texas.[12] This survey is administered every five years to recreators throughout the country. Each respondent who indicated participation in an activity were asked about the trips made to a particular state to pursue this activity including trip expenditures. Data published for Texas regarding trip expenditures associated with wildlife observation, migratory bird hunting and fishing were used to estimate an average expenditure per day as summarized in Table 4-8. This data was used to estimate total recreational expenditures that can be attributed to recreational visitors to the Refuge Complex.

Total annual direct expenditures associated with recreation at the Refuge Complex was estimated for fiscal year 2003 by multiplying the non-resident RVDs provide in Table 4-7 by the average daily expenditures provided in Table 4-8. The summary provided in Table 4-9 shows that annual direct recreational expenditures exceeds $1 million in the secondary study area on an annual basis.

Table 4-8
Itemized Expenditures by Recreational Activity (2003$)*

Itemized Expenditures	Fishing	Migratory Bird Hunting	Wildlife Observation and Photography
Food and lodging	$10.80	$21.07	$19.77
Food	$7.83	$16.13	$11.00
Lodging	$2.97	$4.94	$8.76
Transportation	$7.27	$12.38	$8.26
Other trip costs	$9.55	$0.00	$2.84
Privilege and other fees	$2.77	$6.13	Na
Boating costs	$4.09	$1.31	Na
Bait	$1.97	$0.00	Na
Ice	$0.57	$0.00	Na
Heating and cooking fuel	$0.14	$0.00	Na
Average Daily Costs	**$47.97**	**$61.96**	**$50.63**

*Estimated with data from the U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.

12 U.S. Department of Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation.

Table 4-9
Annual Direct Expenditures Associated with Recreational Visitors at the Refuge Complex (2003)

Expenditure Type	Total Recreational Expenditures (2003$)
Food	$415,563
Lodging	$284,225
Transportation (Gas)	$313,534
Other trip costs (Misc.)	$82,552
Boating costs	$3,049
Bait	$0
Ice	$0
Sum	**$1,098,923**

b. Indirect and Induced Economic Impacts

Indirect and Induced economic impacts are described as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the following three elements: direct expenditures made by the USFWS to manage operations at the Refuge Complex, value of agricultural production on the Refuge Complex, and the direct expenditures made by recreational visitors to the Refuge Complex. These direct expenditures create additional economic activity, the indirect and induced impacts, as re-spending of the direct expenditures occur. The indirect and induced impacts are estimated by using a series of economic multipliers applied to the estimates of the direct economic impacts of USFWS activities. IMPLAN was used to apply economic multipliers to the direct economic elements valued above to arrive at an estimate of the indirect and induced impacts to employment, income and indirect business taxes in the study area that can be attributable these USFWS activities.

The indirect and induced economic impacts are measured in the four following areas:

Employment: The annual average estimated employment is measured as Full-Time Equivalents (FTEs). Full-time equivalent employees equal the number of employees on full-time schedules plus the number of employees on part time schedules converted to a full-time basis. This includes direct employment at the Refuge Complex (Approximately 30 FTEs at this time) as well as the additional employment supported in the surrounding area.

Labor Income: Labor income includes employee compensation and proprietary income. Employee compensation is the total wages and salaries of workers who are paid by employers, as well as the value of benefits such as health care, life insurance, retirement payments, and non-cash compensation. Proprietary income consists of payments received by self-employed individuals as income.

Other Property Type Income: This type of income is payments in the form of rents, royalties, dividends, and includes corporate profits.

Indirect Business Taxes: Indirect business taxes include excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses.

(1). Refuge Operations

The largest economic contribution results from the direct expenditures made by the USFWS to support operations at the Refuge Complex. These operations currently support approximately 45 FTEs per year. This includes direct employment at the Refuge Complex of approximately 30 FTEs at this time, as well as an additional 15 FTEs supported in the surrounding area. Current operations generate approximately

$1.2 million in income and nearly $450,000 in indirect business taxes to local government entities. The economic impacts of refuge operations are summarized in Table 4-10.

Table 4-10
Indirect and Induced Economic Impacts of USFWS Operations at Refuge Complex

Impacts on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)	45	45	45
Labor Income	$1,066,457	$1,066,457	$1,066,457
Other Property Type Income	$222,664	$222,664	$222,664
Indirect Business Taxes	$493,149	$493,149	$493,149

(2). Refuge Agricultural Program

Current agricultural activities on the Refuge Complex, cattle grazing and rice farming, support approximately 20 FTEs per year, about $859,000 in annual income and $87,000 in indirect business taxes. See Table 4-11.

Table 4-11
Indirect and Induced Economic Impacts of Agricultural Activities on Refuge Complex

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)	20	20	20
Labor Income	$587,382	$587,382	$587,382
Other Property Type Income	$272,759	$272,759	$272,759
Indirect Business Taxes	$87,668	$87,668	$87,668

(3). Refuge Recreational Programs

Recreational activities on the Refuge Complex also generate economic activity in the regional economy by supporting approximately 25 FTEs, and generating $883,000 in annual income and $136,000 in indirect business taxes. Under this Alternative there would be a slight increase in employment during the study period which is attributed to expected growth in demand for recreational activities under current management.

Total recreational expenditures by activity were estimated by multiplying average daily expenditures by the number of RVDs that are likely to occur annually each year at the Refuge Complex for each alternative. A series of economic multipliers, estimated with IMPLAN were then applied to the total annual expenditures to estimate the impacts to employment, income and indirect business taxes in the study area that can be attributable to recreation at the Refuge Complex. See Table 4-12.

Table 4-12
Indirect and Induced Economic Impacts of Recreational Activities at Refuge Complex

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)	25	26	26
Labor Income	$609,908	$621,374	$629,040
Other Property Type Income	$224,963	$229,144	$231,939
Indirect Business Taxes	$136,816	$139,559	$141,394

2. Population Impacts

Management actions associated with the Refuge Complex are not expected to have notable impacts on population trends within the study area. Population trends in Jefferson and Chambers counties have shown increases in recent years though these increases are likely not influenced by activities at the Refuge Complex. Any population change that could be associated with implementation of alternatives

under consideration in the EIS would likely be linked to employment changes. Although the Refuge Complex under current management is expected to continue to support approximately 90 FTEs per year, the Refuge Complex is not considered a major employer in the area and thus would not support a significant proportion of the population.

3. Fiscal Impacts on Local Governments

Refuge management has the potential to impact the fiscal conditions of local government entities. This fiscal effect could be on revenues and/or expenditures. The "Economics Impacts" section above has already evaluated impacts from the various current refuge management activities on indirect business taxes. In addition to the increased indirect business taxes, the USFWS makes substantial payments to local governmental entities under the Refuge Revenue Sharing Act.

Changes in demand for government services could vary with changes in population tied to the Refuge Complex and could cause undue strain on infrastructure (e.g. roads, utilities, schools, etc). As discussed above, since notable population changes are not expected, identifiable changes in demand for government services due to changes in population are not expected. Changes in recreation activities could also cause some impacts to local government services through changes in demand though they are not expected to be notable under current management or any of the proposed alternatives.

Management actions can also affect local government services directly. For instance, the USFWS purchases water from the Chambers-Liberty Counties Navigation District (District) to support its management activities. This provides positive impacts to this local District that has experienced a decrease in water purchases due to a decline in rice production in the area.

4. Social Impacts

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, ecosystem management actions such as those made by the USFWS within the Refuge Complex. Additionally, Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them)
- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions)
- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability)
- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others)

The interactions between USFWS activities and people are already evident in the area. Current direct and indirect interactions between the USFWS and the local and regional population base include visitation to the refuges (e.g., recreation opportunities), participation in USFWS volunteer programs, an awareness of refuge activities (but not direct participation in these activities), or simply driving by the Refuge Complex land holdings. These interactions would basically remain the same for the vast majority of the nearby population under any of the Refuge Management Alternatives being considered in this EIS, and there

would be a relatively small magnitude and frequency of "new" impacts since the USFWS has been managing lands within the Refuge Complex for many years.

Additionally, implementation of any of the Refuge Management Alternatives would not lead to substantial new population or changes in the demographic or other characteristics of the existing population. One of the most important causes of potentially significant social effects is a new population that is 1) relatively large in relation to the existing population, and/or 2) demographically or socially different than the existing population. Since there would be little change in population or demographics directly or indirectly from any of the alternatives, this cause/effect relationship is not of concern in this EIS analysis.

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Issues would arise when management activities are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships between the USFWS and Stakeholder Groups

General categories of stakeholder groups describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A summary of potential future relationships between the USFWS and stakeholder groups follows. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole.

Residents and/or Employees – those persons who live and/or work within the area would generally continue their existing relationships with the USFWS. The reactions of those persons to any changed relationship with the USFWS would be individualistic in nature, and could range from very positive to very negative feelings depending on the goals, values and beliefs of those affected.

Landowners – existing land management issues such as water management and prescribed fire activities may continue to be controversial for some landowners in the area.

Recreationalists – the land and water of the Texas Chenier Plain region have a rich heritage of public and commercial recreational activity. While recreation plays an important part in the economy of the area, outdoor recreation opportunities are also a traditional and substantial part of the social structure and lifestyles of the area. The USFWS is constantly struggling to balance recreational opportunities with its goal of protecting natural resources. Under any of the Refuge Management Alternatives being considered, this struggle would continue, and no matter which Alternative is implemented, there would continue to be major disagreement within the nearby population over the proper amount, locations, and access to recreational resources within the Refuge Complex.

Governmental or Quasi-Governmental Agencies – relationships between governmental or quasi-governmental agencies in the area would continue existing trends under any of the Refuge Management Alternatives, with coordination of these agencies with the USFWS sometimes being difficult because of conflicting goals and objectives. The perception of the USFWS being "outsiders" who have a substantial influence on local residents and governments would continue to exist, and associated issues would likely not be resolved easily.

Business-Persons and/or Business-Owners – as with current conditions, businesspersons and/or business owners would generally have economic development and growth as major future goals that could conflict with USFWS management actions under any of the Refuge Management Alternatives. Many persons supporting economic growth as a high priority may continue to be frustrated with USFWS

actions that could be perceived as limiting or preventing economic growth. There may be a smaller portion of business persons and business owners who would support USFWS activities in recognition that these activities could bring an expanded visitor base to the area, with the resulting expansion of the ecotourism industry providing economic benefits to at least some portion of local and regional business.

Conservation or Environmental Protection Advocates – those supporting conservation of natural resources and environmental protection would generally be supportive of current USFWS management actions under Refuge Management Alternative A. However, there would also continue to be instances where conservationists and environmental protection advocates may believe that the USFWS is not doing enough or taking the correct actions to adequately preserve or protect natural resources within the Refuge Complex.

Overall, USFWS management activities and objectives under all of the Refuge Management Alternatives may in some cases conflict with some of the goals, beliefs, and objectives of many of the local stakeholders. This situation will lead to the continued need for the USFWS to interact with the public (see next section) and to find a proper balance to its activities. However, socioeconomic issues would continue to exist among the various stakeholder groups with regard to their opinion of the USFWS role, responsibilities, and actions; many of these issues would remain unresolved in the future as discussed later in this section.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. Under Refuge Management Alternative A, current USFWS public outreach efforts would continue.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

The following is a summary of socioeconomic issues associated with USFWS activities at the Refuge Complex. The proposed USFWS management actions under the Refuge Management Alternatives would have no major effect on the existence or resolution of these current issues. Under any of the alternatives for potential management actions:

- There would be points that continue to be in dispute or unsettled between different parties regarding the existence and/or management of the Refuge Complex

- Different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions

- Some people would continue to think positively about the role of the USFWS in the area; others would continue to think negatively about this role; and others would continue to have no opinion or be neutral about the USFWS role and activities within the area

- As with existing conditions, issues would be unresolved, and one party could not be determined to be “right” and the other party “wrong” with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future.

Under Refuge Management Alternative A, the No Action Alternative, existing conditions and trends would generally remain the same. The management of the Refuge Complex would not change in substantive ways.

Under the other Refuge Management Alternatives (B through E), management philosophies and priorities would change from current conditions. The USFWS management of the Refuge Complex would continue to be primarily oriented to support wildlife habitat management and enhance fish and wildlife values; however, the philosophy of the primary management approach would differ for each Refuge Management Alternative. These different management approaches and philosophies have a relationship with social structures and lifestyle, but the differences among alternatives from a specific social structure/lifestyle perspective would not be substantial except on a localized or case-specific basis. Under all Refuge Management Alternatives, the USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however the "appropriateness" of any chosen alternative would depend on individual and group values, beliefs, and goals.

While the Refuge Management Alternatives support different philosophies and priorities, and the differences among alternatives may be identifiable on a localized basis, the social structure and lifestyle conditions and trends within the Refuge Complex would generally remain the same as current conditions.

d. Environmental Justice

The need to conduct an environmental justice analysis for the Texas Chenier Plain Refuge Complex EIS/CCP/LPP is based on Executive Order (EO) 12898. Several areas have been identified as having potential minority or low-income populations within the primary or secondary study areas. EO 12898 requires an assessment as to whether these populations might be disproportionately affected by the management alternatives.

Based on the results of the socioeconomic and environmental impact analysis conducted for this project, it can be concluded that those persons who reside in and around the Refuge Complex would bear both some adverse effects and some beneficial effects by the continued operation and/or expansion of the Refuge Complex. However, any identified socioeconomic or environmental impacts from continued operation of the Refuge Complex by the USFWS would not be localized nor be placed primarily on the identified minority and/or low-income population components. Overall, the identified minority and/or low-income populations would not be disproportionately affected compared to other segments of the general population in the area.

Additionally, persons of all races and income levels were invited to participate in the public participation process for the EIS, and comments or input into the process from any minority or low-income persons were considered equally with all other persons. Therefore, implementation of any of the Refuge Management Alternatives would be in compliance with EO 12898.

II. IMPACT ANALYSIS FOR REFUGE MANAGEMENT ALTERNATIVE B: EMPHASIS ON INTENSIFYING MANAGEMENT OF WETLAND HABITATS FOR WATERFOWL, SHOREBIRDS, WADING BIRDS, AND OTHER WETLAND-DEPENDENT MIGRATORY BIRDS.

Overview

Under this Alternative, the Refuge Complex would focus its management efforts on active management of wetland habitats to benefit waterfowl, shorebirds, wading birds, and other wetland-dependent migratory and resident birds. Two new marsh semi-impoundments totaling 6,500 acres would be constructed and water management capabilities enhanced in existing impoundments through installation of new water control structures and levees. The cooperative rice farming program, moist soil management, and haying and mowing programs on Anahuac NWR would be expanded to enhance shallow freshwater wetland habitats and adjacent upland prairies for resident Mottled Ducks and for wintering and migrating waterfowl, shorebirds and wading birds. In marsh habitats, grazing intensity, annual prescribed burn acreage and the frequency of burning would be increased to substantially increase the amount of marsh habitat in early successional plant communities. The Refuge Complex would also continue to provide and promote opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses, with an emphasis on providing more public hunting opportunities.

A. Natural Resources Section

1. Impacts to Air Quality

The USFWS fire management program on the Refuge Complex has the greatest potential of all refuge management actions to impact the region's air quality. Fire management activities include both the suppression of unplanned wildland fires and prescribed burning. Smoke from unplanned wildland fires and from planned prescribed burning can be transported by prevailing winds and affect air quality and transportation safety over a large area which includes the cities of Houston, Beaumont and Port Arthur and numerous smaller local communities.

Under Refuge Management Alternative B, suppression of wildland fires would continue as prescribed in the Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Reducing smoke impacts to surrounding communities is also an important consideration in planning and implementing suppression actions on all wildland fires occurring on the Refuge Complex.

Under Refuge Management Alternative B, the prescribed burning program would be expanded relative to Refuge Management Alternative A. The USFWS would continue to use prescribed burning on the Refuge Complex primarily to maintain and improve habitat for wintering and migrating waterfowl and other migratory birds and to reduce accumulations of hazardous fuels. Most burning would be conducted in emergent marsh habitats on the Refuge Complex, with an annual burning objective of 35,000 acres (compared to 12,000 – 15,000 acres under Refuge Management Alternative A).

Although prescribed burning under Refuge Management Alternative B would continue to be beneficial to the Refuge Complex's habitats and wildlife (as discussed under *Impacts to Vegetation/Habitats* and *Impacts to Fish and Wildlife Resources* below), this management action could also negatively impact local air quality, primarily through the production of smoke. Because prescribed burning is conducted on the Refuge Complex under strict prescriptions which include implementing smoke management measures, impacts to local and regional air quality from the USFWS fire management program would nonetheless remain minimal. The potential for smoke impacts to air quality due to unpredicted climatic events would

increase relative to Refuge Management Alternative A because of increased prescribed burning activities and the additional smoke produced.

Conversely, additional prescribed burning on the Refuge Complex under controlled conditions would reduce the potential for smoke impacts to air quality from unplanned wildland fires by reducing vegetative fuels. Additional prescribed burning activities on the Refuge Complex under Refuge Management Alternative B would result in larger areas with reduced vegetative fuel loads. Most lightning-caused natural fires on the Refuge Complex occur during the months of June through October, when prevailing winds typically include a southerly component which transports smoke towards communities and other smoke-sensitive areas. Wildland fires are less likely to start in areas with reduced fuel loads because of prescribed burning, and fires that do start burn with less intensity, produce less smoke, and are easier to suppress than in unburned areas with excessive accumulations of hazardous fuels.

2. Impacts to Geology and Soils

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

As under Refuge Management Alternative A, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss under Refuge Management Alternative B. On McFaddin and Texas Point NWRs, these partnerships have focused on augmenting coarse sediment supply along the Gulf shoreline. Structural erosion abatement projects involving construction of rock breakwaters and shoreline armoring with rip rap along the GIWW on McFaddin NWR have also been implemented. On Anahuac NWR, these efforts have focused on protecting the East Galveston Bay shoreline through offshore breakwater construction and restoration of salt marsh along the shoreline. Impacts of these activities on soils and geological processes would be similar to those described under Refuge Management Alternative A. As with Alternative A, it is unlikely that the limited scope of these activities under Refuge Management Alternative B would be sufficient to counteract the effects of future relative sea level rise and altered hydrological regimes. Accelerated rates of shoreline retreat and coastal land loss would likely continue.

Both structural marsh management and prescribed burning can affect soil formation and marsh vertical accretion or elevation gain (impacts are fully described under Refuge Management Alternative A). Under Refuge Management Alternative B, the USFWS would increase the acreage of coastal marsh under structural marsh management by approximately 6,500 acres and would increase prescribed burning from 12,000 to 15,000 acres annually to approximately 35,000 acres annually. USFWS water management activities in fresh to brackish coastal marshes typically reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying. In meeting these objectives, marsh management should benefit soil formation and vertical accretion by increasing plant productivity and preventing oxidation of marsh soils. Fire may have positive or negative impacts on soil formation and marsh accretion. Insufficient information currently exists to fully evaluate these effects.

3. Impacts to Hydrology and Water Quality

a. Hydrology

Under Refuge Management Alternative B, the USFWS would continue wetland management and restoration activities aimed at minimizing or mitigating impacts of altered hydrological regimes on plant, fish and wildlife resources. The USFWS would expand structural marsh management under this Alternative through construction of 2 additional marsh semi-impoundments totaling approximately 6,500 acres, enhance hydrologic management in several existing marsh units by developing new infrastructure,

and expand cooperative rice farming and moist soil management programs. The USFWS would also continue to coordinate with State and Federal agencies on a large-scale hydrological restoration project for marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass.

The wetland management and restoration activities implemented by the USFWS under Refuge Management Alternative B would help maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes. In turn, these habitats would continue to support a natural diversity of native plant, fish and animal communities. Restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) in coastal marshes on the Refuge Complex also would help to prevent the conversion of vegetated marsh to open water, promote plant productivity and contribute to marsh surface elevation gain (accretion).

As with Refuge Management Alternative A, the relatively small-scale hydrologic and shoreline restoration projects to be maintained and implemented in the future on the Refuge Complex under Refuge Management Alternative B are not likely to be sufficient to counter the effects of relative sea level rise and altered hydrological regimes on coastal land loss. Current rates of shoreline retreat and conversion of vegetated marshes to open water will likely continue, and may accelerate, under this Alternative. For example, restoration of the historic barrier beach and dunes on McFaddin NWR would require a large-scale project affecting an additional 16 miles of Gulf shoreline. Under this Alternative, increased saltwater intrusion from more frequent tidal flooding from the Gulf into inland marshes on McFaddin and Texas Point NWRs will continue to negatively impact soil formation and vertical accretion by causing plant mortality and an overall reduction in above and below-ground plant productivity. Under this scenario, these marshes will become increasingly susceptible to submergence and conversion to open water.

b. Water Quality

Under Refuge Management Alternative B, the USFWS would continue activities described under Alternative A. Overall, these activities would reduce the impacts of point and non-point source pollution sources and accidental spills to water quality, habitats and fish and wildlife resources.

4. Impacts to Vegetation and Habitats

USFWS management activities affecting vegetation and habitats on the Refuge Complex under Refuge Management Alternative B would include all of the habitat management and restoration activities in wetland and upland habitats described under Alternative A. Changes from Alternative A would include expanded structural water management in coastal marshes, expanded rice farming and moist soil management programs, and intensified use of prescribed burning and controlled grazing.

Public uses on the Refuge Complex, including hunting, fishing, wildlife observation and photography, and environmental education and interpretation would continue under Refuge Management Alternative B. Additional waterfowl hunting opportunities would be provided and some changes to administration of the hunt programs would occur. Impacts to vegetation and habitats would be similar to those described for these uses under Refuge Management Alternative A.

Current systematic monitoring of vegetation and habitats as part of the Refuge Complex biological program would continue under Refuge Management Alternative B.

Management of oil and gas activities through issuance of Special Use Permits would continue as under Refuge Management Alternative A, and would be aimed at minimizing and mitigating for the impacts of these activities on habitats and fish and wildlife resources.

The USFWS would also continue to work with private landowners to facilitate implementation of wetland habitat restoration and enhancement projects. Community outreach efforts would include ongoing partnerships with Refuge Friends groups, agencies, volunteers, conservation organizations, community

groups and industry to further natural resource conservation on the Refuge Complex and throughout the project area.

a. Impacts to Vegetation and Habitats from Habitat Management and Restoration Activities

(1). Wetland Specific Management and Restoration

Wetland management and restoration activities under Refuge Management Alternative B would influence the vegetative communities found in Refuge Complex coastal marshes and prairie wetland habitats.

(a). Water Management in Coastal Marshes

In addition to management activities described under Refuge Management Alternative A, the USFWS would expand structural marsh management through construction of 2 additional marsh semi-impoundments totaling approximately 6,500 acres on McFaddin and Anahuac NWRs, and would enhance management capabilities in several existing managed marsh units by installing new infrastructure including water control structures and levees under Refuge Management Alternative B. The USFWS would also continue to coordinate with State and Federal agencies on a large-scale hydrological restoration project for marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass.

Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976). Merino *et al*. (2005) found that managed areas, particularly those without complete levees, had more submerged aquatic vegetation than unmanaged areas. Marsh restoration using semi-impoundments in Louisiana reversed the deleterious effects of excessive tidal exchange caused by channelization, allowing both emergent and submergent vegetation to flourish (Hess *et a*l. 1989). Monitoring on and adjacent to McFaddin NWR indicated that diversity indices for both emergent and submergent plants were higher within structurally managed marshes compared to adjacent unmanaged marshes (USFWS 2006). This was largely due to the presence of plants with lower salinity tolerances, indicating that this marsh management program is at least partially meeting objectives. Chabreck (1994) stresses that careful planning and implementation is required in order for structural marsh management to reverse the negative effects of hydrological alterations and maintain critical wetland functions.

The additional structural marsh management on the Refuge Complex would maintain or restore approximately 6,500 acres of intermediate marsh in areas which have become brackish due to channelization and saltwater intrusion. Expanded and enhanced hydrologic management and reducing water turbidities through construction of marsh terraces under this Alternative would increase production and diversity of submerged aquatic vegetation open water habitats within managed marsh units. Restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) would help to prevent the conversion of vegetated marsh in these areas to open water. By promoting plant productivity, this management activity may also contribute to marsh soil formation and surface elevation gain (marsh accretion).

The above notwithstanding, periodic climatic events such as flooding during periods of high rainfall or due to tidal storm surge and prolonged drought would continue to influence and sometimes be the dominant factors controlling hydrologic regimes and the response of vegetative communities in the Refuge Complex coastal marshes.

(b). Marsh Restoration

Under the Refuge Management Alternative B, the level and scope of marsh restoration using dredge material would continue as described under Alternative A. Marsh restoration efforts under Refuge Management Alternative B would increase the amount of vegetated emergent marsh in areas which have converted to open water, providing more productive habitat for native fish and wildlife.

(c). Moist Soil Management

Freshwater prairie wetlands on the Gulf Coast have been reduced mainly through development and agriculture (Moulton *et al*. 1997). Like coastal marshes, shallow freshwater prairie wetlands provide important food resources and cover to a diversity of wetland-dependent resident and migratory birds and wildlife.

Under the Refuge Management Alternative B, moist soil management capabilities would be developed on an additional 1,100 acres on the Refuge Complex (900 acres on Anahuac NWR and 200 acres on McFaddin and Texas Point NWRs). This would create additional shallow freshwater wetland habitat for migratory birds and other wetland-dependent wildlife.

Expanded moist soil management would increase biological diversity on the Refuge Complex. Moist-soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). Water management and mechanical soil manipulations in new moist soil units would promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia. Additional moist soil units would be flooded throughout the summer to provide brood rearing habitat for Mottled Ducks and whistling ducks. This management regime would favor the establishment of perennial wetland plants, including several species of floating and submerged aquatic plants, including arrow head, white water lily, and lotus.

Expansion of the moist soil management program under this Alternative would reduce the overall area on the Refuge Complex available for native prairie restoration.

(d). Cooperative Rice Farming Program

Under Refuge Management Alternative B, the USFWS would expand its cooperative rice farming program on Anahuac NWR by farming an additional 300-500 acres annually, from existing levels of 500-700 acres. This expanded program would provide additional shallow freshwater wetland habitat for migrating and wintering waterfowl, shorebirds, wading birds and other wetland-dependent wildlife. Currently, almost 80% of the rice produced on the refuge is organically grown, and the expanded program would give preference to organic producers. Organically produced rice reduces the overall input of herbicides on the refuge.

Rice production has declined during the last decade in counties surrounding the Refuge Complex, reducing this type of agricultural wetland habitat for waterfowl, shorebirds and other wetland-dependent species. Other changes in rice cultivation practices may also have deleterious effects on waterbird populations. Abandoned rice fields and pasturelands are susceptible to invasion by Chinese tallow, eastern baccharis, common rush, and deep-rooted sedge, all of which decrease habitat quality and will require extensive restoration efforts.

Expansion of the cooperative rice farming program on Anahuac NWR under Refuge Management Alternative B would serve several outcomes for migratory bird management: creating forage for migrating and wintering waterfowl, habitat for migrating shorebirds, and fresh water habitat for breeding and brood rearing Mottled Ducks and Fulvous and Black-bellied whistling ducks. Flooding after harvest makes existing waste grain available to waterfowl and often produces a second crop of rice, which is also left for wildlife. Fall and winter flooding allows migratory waterfowl to exploit waste rice and other weeds found in the fields. During migration and wintering periods, waterfowl and waterbirds extensively use post-harvest ricefields that were cultivated and at least partially flooded (Czech and Parsons 2002).

Expansion of the cooperative rice farming program would reduce the overall area on Anahuac NWR available for native prairie restoration.

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Under Refuge Management Alternative B, upland grassland habitats would continue to be managed using the management tools described in Refuge Management Alternative A. Under this Alternative, no additional native prairie habitat would be restored. Together, the management actions undertaken under Refuge Management Alternative B would continue to protect and enhance the 5,774 acres of non-saline grasslands on the Refuge Complex. Impacts of burning, grazing, invasive species management and mowing/haying to vegetation and habitats are discussed below. Overall, prairie management activities on the Refuge Complex would increase the abundance of native prairie grasses and forbs, helping to restore and maintain natural biological diversity.

(b). Woodlot Restoration and Protection

Under Refuge Management Alternative B, the USFWS would continue management activities as described under Alternative A on the 127 acres of existing woodlots: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts.

Overall, implementation of the USFWS management actions under this Alternative would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging.

(3). General Habitat Management Activities

Under Refuge Management Alternative B, the USFWS would expand prescribed burning, controlled livestock grazing and mowing and haying to enhance wetland and upland habitats for migratory birds. The integrated combination of burning, grazing and water management on the Refuge Complex maintains a diverse mosaic of wetland vegetative communities, both in plant species composition and structural attributes. Invasive species management and shoreline restoration and protection activities would continue as described under Refuge Management Alternative A.

(a). Fire Management - Prescribed Burning and Wildland Fire Suppression

Under Refuge Management Alternative B, the fire management program would continue to involve both suppression of unplanned wildland fires and prescribed burning. Suppression activities would continue as described in the Refuge Complex Fire Management Plan (USFWS 2001). The prescribed burning program would be expanded to an annual objective of approximately 35,000 acres (primarily in marsh habitats), and increase of 20,000 acres above current levels. Although most burning would continue to be conducted on a three-year rotation, annual and bi-annual burning in selected fresh and intermediate marsh habitats would be conducted. Most prescribed burning would be conducted from October through January in marsh habitats. Prescribed burning of upland grassland units would occur primarily in late winter and early spring.

Prescribed burning (integrated with control livestock grazing and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, and seashore saltgrass. Interstitial vegetation, often seed producing annuals such as sprangletops (*Leptochloa* spp.) and millets (*Echinochloa* spp.) and forbs such as purple ammenia and Delta duck potato, increases after a fire, particularly when followed by grazing and suitable hydrology.

The impacts of prescribed burning in upland grassland habitats include: 1) maintaining and enhancing native prairie plant communities, including several native grasses and forbs, by enhancing conditions which encourage reproduction and growth of these species; and 2) helping to control invasive plants, most notably Chinese tallow and Eastern baccharis, which often outcompete and replace native grasses in areas where fire has been excluded or its frequency decreased.

In summary, beneficial impacts of an expanded (larger areas burned annually and more frequent burning) prescribed burning program under this Alternative would be similar to but more extensive than those described for burning under Refuge Management Alternative A, and include:

- Hazardous fuels would be reduced within immediate proximity to USFWS and private facilities and structures (to protect life and property). Prescribed burning over larger areas annually and more frequent burns would further lessen the potential of uncontrollable wildfires by reducing the accumulation of rank vegetation and litter.

- Habitat for waterfowl and other migratory birds would be enhanced by maintaining a larger proportion of marsh habitats on the Refuge Complex in early successional plant communities which provide important food resources, by increasing production and nutritional quality of these foods, and by enhancing the availability of these foods by creating openings in otherwise dense stands of vegetation.

- Encroachment of undesirable woody shrubs, including Chinese tallow, bigleaf sumpweed, and Eastern baccharis, would be further suppressed. Without fire disturbance, both marsh and prairie habitats on the Refuge Complex are subject to invasion by such woody shrubs, which in turn reduces habitat quality for many grassland-dependent avian species and other wildlife.

While fire, whether planned or unplanned, can have positive ecological effects, detrimental impacts to vegetation and habitats ranging from an undesirable change in plant species composition to actual conversion of emergent marshes to open water can also occur. For example, burning under excessively dry conditions could result in plant mortality and consume organic matter and decrease marsh soil elevation, which in turn could result in permanent conversion to open water. Hot fires may result in root burns, which can cause mortality of desirable marsh plant species. Fire increases the soil erosion potential until regrowth occurs. Recently burned areas are especially susceptible to erosion during storm surges from tropical storms and hurricanes. Hot fires occurring without adequate soil moisture can also cause a temporary reduction in microflora and microfauna in wetland soils. Burning cannot restore lost marsh or counter the effects of excessive flooding or salinity (Chabreck 1994). Burning is not as beneficial in more saline marshes, because the resulting subclimax plant community is not as diverse (Spicer *et al*. 1986).

Proper timing of prescribed burns under appropriate environmental and climatic conditions is essential to minimize negative impacts. Under Refuge Management Alternative B, the USFWS prescribed burning program would continue to consider factors including soil and vegetative fuel moisture, seasonality and timing, ignition patterns, habitat type and previous burn history to ensure maintenance of diverse and productive wetland and upland habitats on the Refuge Complex. Potential for some adverse affects to vegetation and habitats to occur would increase under this Alternative because of the additional acreage burned annually and the increased frequency of burning.

(b). Controlled Livestock Grazing

Controlled grazing on the Refuge Complex is used (integrated with fire management and water management) to maintain and increase diversity (plant species composition and structural attributes) and productivity in wetland and upland habitats. Under Refuge Management Alternative B, grazing intensity and duration would be increased in most fresh and intermediate marsh habitats on the Refuge Complex. Controlled grazing would still be applied on approximately 41,000 acres of the Refuge Complex, but higher stocking rates would be used and grazing periods would be extended in selected refuge units.

Controlled grazing can be an effective and inexpensive tool in wetland and grassland management providing habitat components that benefit waterfowl and other wildlife species. The relationship of cattle grazing to wildlife varies considerably, depending on stocking rate, seasonality, plant community, and wildlife concerned (Chabreck 1968). Research indicates that dual use of grasslands by wildlife and livestock is often compatible when livestock grazing is carefully managed and wildlife needs are considered (Holechek 1982).

Studies conducted on Sabine National Wildlife Refuge in Cameron Parish, Louisiana (Valentine 1961) determined that increased grazing can change tall climax marshhay cordgrass stands to a more diverse community such as seashore paspalum, Setaria, and longtom (*Paspalum lividum*), that are more beneficial to certain types of wildlife. Depending on site conditions (elevation, soil, and hydrology) annual grasses and forbs (including millets, fall Panicum (*Panicum dichotomiflorum*), sprangletop, and Setaria) can be produced through proper grazing.

Pate (2001) found that grazed marshes remained in a sub-climax state, while habitat within grazing exclosures reverted to marshhay cordgrass. At the onset of the study Spartina spp. made up 20% of the plant community, while seashore paspalum comprised 80%. By the end of the study, communities within grazing exclosures changed to 65% Spartina spp. and 25% seashore paspalum. In contrast, the grazed area maintained high cover of seashore paspalum throughout the study. Shallowly-flooded seashore paspalum provides habitat for many species of waterfowl, wading birds and shorebirds, while dense stands of marshhay cordgrass preclude use by these species.

Grazing (integrated with fire and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Increased grazing intensity and duration in marsh habitats under this Alternative would increase the abundance of target plant species and communities in intermediate and brackish marsh habitats on the Refuge Complex, including Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. The grazing regime under this Alternative would provide additional areas with optimal physical structure of vegetation for waterfowl utilization by creating openings in otherwise dense stands of vegetation and maintaining plant communities such as seashore paspalum which grow low to the ground. When shallowly flooded, stands of low-growing seashore paspalum and seashore saltgrass interspersed with ponds provide ideal habitat conditions for many waterfowl, shorebird and wading bird species. These conditions also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Specifically, the beneficial impacts of grazing in wetland habitats would be similar but more extensive than those described under Refuge Management Alternative A, and include:

- Rank vegetation would be reduced, enabling migratory birds access to roots and tubers of mature plants and shoots of new plants.

- Competing growth of marshhay cordgrass and other dominant climax plant communities would be reduced, allowing for the growth of subdominant plant species, many of which are preferred foods of ducks and geese.

- Additional open water habitat would be created, which provides loafing areas for birds and allow them to access aquatic invertebrates.

- Marsh burning would be complemented by prolonging the time that browse is available for goose use.

- Plant vigor and plant productivity would be increased, nutrient recycling enhanced, and excessive build-up of residual plant material prevented.

- Hazardous fuel loading would be reduced, reducing the amount and intensity of wildfires.

- Capped soils would be broken through hoof action, assisting in seedling establishment of many preferred food plants.

- Vegetation in recently burned areas would be maintained in more palatable stages for wintering waterfowl.

Potential detrimental affects of grazing result primarily from overgrazing and include excessive trampling of vegetation, compaction of soils reducing percolation rates, and increased soil erosion. The deposition of excess nutrients in the form of feces in areas where livestock concentrate (USFWS 1994) may negatively impact surface water quality. Fecal coliform from geese and livestock are the main pollutants contaminating the shellfish waters of East Galveston Bay (Galveston Bay Estuary Program 1995). Warm-season grazing of wetland areas can reduce seed production of annual grasses (Chabreck 1968). Overgrazing in prairie habitats, usually caused by prolonged intensive grazing, can reduce native prairie plant diversity. While prairie ecosystems are adapted to short duration high intensity grazing patterns, extended duration grazing can reduce native grasses and some native forbs, particularly those that are more palatable and are preferentially selected by livestock. Soil disturbance by excessive hoof action can provide conditions favorable for establishment of exotic and invasive plant species such as Chinese tallow, and spread seed of undesirable plant species by physically carrying them or ingesting them.

Under Refuge Management Alternative B, the USFWS would continue to monitor grazing programs and adjust grazing strategies so as to avoid detrimental impacts. The potential for some adverse impacts to vegetation and habitats to occur would increase under this Alternative. Upland areas adjacent to marshes but contiguous within an individual grazing unit would be subject to higher grazing intensities and be most susceptible to potential adverse impacts.

(c). Invasive Species Management

Under Refuge Management Alternative B, the level and scope of invasive species management activities, as well as their impacts to native vegetation and habitats on the Refuge Complex, would generally continue as described for Alternative A. The USFWS would continue to control invasive plant species to conserve native biological diversity of the Refuge Complex and to maintain habitat quality for migratory birds and other native wildlife. An Integrated Pest Management (IPM) program would be implemented to control the following exotic and invasive plant species (USFWS 1996):

- Chinese tallow, Eastern baccharis, willow, and deep-rooted sedge in freshwater marshes, prairies, woodlots and on levees and roadsides.

- Water hyacinth, alligatorweed, Salvinia, common reed and cattail in waterways and managed wetland units.

- Red rice, coffeebean, barnyard grass, and other grasses in rice.

- Broadleaf weeds and King Ranch bluestem in remnant and restored prairies.

In wetland habitats, these activities would result in removal of undesirable invasive plant species including cattail, common reed, and California bulrush that form dense, homogeneous stands which result in loss of open water as ponds close. Control of exotic floating aquatic plants such as water hyacinth, alligatorweed and Salivinia also restores open water habitats, and promotes the growth of native floating and submerged aquatic plant species important to native fish and wildlife.

Control of Chinese tallow and deep-rooted sedge in prairie and woodlots would result in increased diversity of native plants. In woodlots, reduction of Chinese tallow and increasing native tree and shrub

abundance is likely to increase abundance of forage insects for migrating birds (especially Lepidopteran larvae) (Barrow and Renne 2001).

Under Refuge Management Alternative B, the USFWS would also continue to control exotic animals on the Refuge Complex to conserve native biological diversity and to maintain habitat quality for migratory birds and other native wildlife. Feral hog control would be conducted as described under Alternative A. Control of feral hogs would decrease damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging, and reduce the creation of disturbed areas that enable establishment of Chinese tallow and other undesirable plants. Control activities for nutria under this Alternative would be the same as those under Refuge Management Alternative A, and if implemented would decrease damage to wetland habitats.

(d). Shoreline Protection and Restoration

Under Refuge Management Alternative B, shoreline protection and restoration activities would continue as described under Alternative A. These activities would positively impact vegetation resources and habitats by restoring upland and protecting existing wetland habitats. Restoration of barrier dunes and beaches along the Gulf of Mexico would protect interior intermediate marshes and their plant communities from excessive inundation with saltwater during high tidal events, as well as restoring an upland native habitat type which has been almost completely lost. Use of dredged material along existing shorelines would protect existing marshes by slowing erosion and shoreline retreat, providing a substrate for reestablishment of marsh vegetation and restoration, and increasing net sediment supply to marshes which would provide nutrients and increase plant productivity (Chabreck 1976, 1994). Breakwaters would continue to enhance marine habitat by functioning as an artificial reef, providing opportunities for oyster spat, barnacles, algae, baitfish, and predator fish utilization. Restoring emergent marsh by planting smooth cordgrass between the breakwaters and existing shorelines would restore vegetated wetlands that have converted to open water. The stands of smooth cordgrass also would provide habitat for snails, shrimp, crabs, insects, and numerous benthic organisms.

The relatively small scale of ongoing shoreline restoration projects under Refuge Management Alternative B on the Refuge Complex is not likely to effectively counter the future effects of relative sea level rise and altered hydrological regimes, however, and accelerated rates of shoreline retreat and land loss would likely continue to occur. For example, total restoration of the barrier beaches and dunes on McFaddin NWR would require work along an additional 16 miles of Gulf shoreline. Increased saltwater intrusion from more frequent tidal flooding from the Gulf into inland marshes would continue to negatively impact vegetation and habitats on McFaddin and Texas Point NWRs by causing direct mortality of some plant species and an overall reduction in plant productivity.

(e). Mowing and Haying

Under the Refuge Management Alternative B, approximately 400 acres of upland grassland habitats would be mowed or hayed annually on the Refuge Complex, an increase of approximately 300 acres from current levels. Mowing and haying would result in invigorating growth of many native grasses, while reducing vigor of undesirable herbaceous weeds and woody plants including Chinese tallow and Eastern baccharis. Reduction of this herbaceous and woody cover often results in the “release” of native prairie plants.

b. Impacts from Public Use Programs

Assuming an increase in visitation to the Refuge Complex under Refuge Management Alternative B due to improved and expanded waterfowl hunting opportunities and new hunting programs for doves and snipe, rails and gallinules and to development of new visitor facilities, impacts to vegetation and habitats described below would likely increase over current levels.

The greatest potential for impacts to vegetation resources and habitats on the Refuge Complex due to recreational uses likely comes from motorized boating activities. Many Refuge Complex hunt areas and

fishing areas are accessible only or primarily by motorized boat. Wetland vegetation, especially submerged aquatic vegetation, can be impacted by motorboat activity. For example, propeller scarring has been shown to detrimentally impact seagrass beds in the Laguna Madre in South Texas (Pulich *et al.*1997, Dunton *et al*. 1998) and in Florida (Madley *et al*. 2004). Propeller scarring leaving permanent channels in shallow pond and waterway bottoms on the Refuge Complex has also raised concerns about the potential for increased saltwater intrusion, with concurrent negative impacts on emergent and submergent aquatic vegetation.

Foot traffic in areas open to hunting, fishing, wildlife observation and photography, environmental education and interpretation can lead to vegetation trampling, and in heavy use areas, cause plant mortality. On the Refuge Complex, the more extreme impacts occur in areas heavily used for shoreline fishing. Some vegetation trampling and trailing from hunter foot traffic occurs in marsh habitats in Refuge Complex hunt areas, although these impacts tend to be short-term.

Although visitation would increase under this Alternative, administration and management of these uses would continue and impacts to vegetation and habitats would be expected to remain localized and not substantial. Regulations, including horsepower restrictions and area closures to motorized boating would remain in effect to protect wetland habitats and public safety. Permanent sanctuary areas would be maintained throughout the Refuge Complex, which do not permit access by the public. Access for other recreational and educational uses would be restricted to established trails, boardwalks, and observation platforms. Fishing piers constructed in many heavily used shoreline fishing areas would reduce trailing impacts. New facilities would be designed and located in such as manner so as to further reduce these impacts.

Recreational beach uses and associated vehicular traffic on beaches within the McFaddin NWR has led to habitat damage inland of beaches. Motorized vehicles sometimes illegally travel in vegetated habitats inland of the beach, particularly when high water conditions limit or preclude travel on the beach itself. Under Refuge Management Alternative B, the USFWS would continue routine patrols of the Gulf beaches within McFaddin NWR to protect public safety and natural resources.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

No direct impacts to vegetation and habitats would occur as a result of continued implementation of the Refuge Complex biological program under Refuge Management Alternative B. Continued habitat and vegetation monitoring activities and research studies on the Refuge Complex would support an adaptive management approach, by providing information which helps refine and improve exiting management practices.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative B, oil and gas exploration and development activities on the Refuge Complex would continue to be managed through the issuance of Special Use Permits as under Alternative A. Stipulations in the Special Use Permit include those aimed at minimizing impacts to vegetation and habitats, including required use of specialized equipment, location and size of facilities, and required pollution controls. As per federal regulations (50 CFR 29.21), the USFWS would ensure that impacted sites are restored as closely as possible to pre-project conditions upon cessation of activities. Conditions of the Special Use Permit also require mitigation for all impacted habitats. Required mitigation activities include restoration and/or enhancement of habitats on the Refuge Complex which are similar to those impacted by oil and gas activities.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex would be a reduction of impacts to vegetation and habitats from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative B, the USFWS would increase efforts to develop partnerships with private land owners to restore and enhance wetland habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project; and 3) holding workshops for landowners to demonstrate habitat enhancement methods and techniques. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands.

The USFWS would also continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, Texas General Land Office and Galveston Bay Estuary Program, conservation organizations such as the Galveston Bay Foundation, Ducks Unlimited and local Audubon Society chapters, community organizations and Refuge volunteers. These partnerships support and greatly enhance a variety of refuge management programs.

It is anticipated that continuation of outreach and partnership efforts under Refuge Management Alternative B would result in additional habitat restoration and enhancement on the Refuge Complex and throughout the project area.

5. Impacts to Fish and Wildlife Resources

Under Refuge Management Alternative B, habitat management and restoration and biological program activities on the Refuge Complex would be focused on wetlands and migratory birds, with continued consideration of the conservation of the following fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians
- Invertebrates

The USFWS would continue to administer the six priority recreational uses of the National Wildlife Refuge System on the Refuge Complex: hunting, fishing, wildlife observation and photography, environmental education and interpretation. These uses impact fish and wildlife resources both directly and indirectly.

USFWS management of oil and gas exploration and development and expanded community outreach and partnership programs would contribute to conservation of fish and wildlife resources on the Refuge Complex and throughout the project area.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Coastal habitats in Texas are part of the southern terminus in the U.S. for most of the ducks and geese in the Central Flyway. The 2004 mid-winter waterfowl survey indicated that 7,901,489 waterfowl used the Central Flyway. Of those birds, 5,110,022 waterfowl (65%) wintered in Texas. Available wintering waterfowl habitat in Texas is shrinking due to changes in agricultural uses, industrial and urban development, increased pollutants (Cain 1988), land subsidence, rising sea levels, and man-made

hydrological changes such as canals resulting in saltwater intrusion (Michot 1996). Loss or degradation of habitat on a landscape scale has increased the importance of public and private lands managed specifically for supporting wintering and migrating waterfowl.

Since the mid-1950s to the early 1990s, approximately 211,000 acres of wetlands were lost on the Texas Gulf coast, to both natural and man-made causes (Moulton *et al.*1997), with most of the palustrine wetland loss to agriculture (in recent years agricultural lands have decreased by urban development). Palustrine emergent marshes showed the largest decline, primarily by conversion to upland agriculture and other uses; and most estuarine wetlands loss was due to land subsidence. Tacha *et al*. (1992) concluded that between 1976 and 1991 the total ducks in the Chenier Plain of Texas declined by 89%, and these decreases were highly correlated with losses and degradation of wetland habitat.[13] Many wintering and migrating waterfowl along the Texas Coast tend to prefer freshwater coastal marshes and freshwater prairie wetlands. Rice agriculture provided an especially valuable habitat for wintering waterfowl.

Overall and all else being equal, expanding and enhancing wetland management and restoration under Refuge Management Alternative B can be expected to increase wintering and migrating waterfowl populations on the Refuge Complex. On a year to year basis, overall habitat quality for waterfowl on the Refuge Complex will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers on the Refuge Complex can also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure.

Under the Refuge Management Alternative B, the following USFWS management activities would have the greatest impacts on wintering and migrating waterfowl populations on the Refuge Complex.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative B, approximately 36,500 acres of marsh habitats would be structurally managed on the Refuge Complex to enhance habitat for wintering waterfowl, utilizing water control structures, levees, and water delivery systems, and management capabilities would be enhanced on several existing managed units. Marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl. Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976). Structural management of brackish and intermediate marshes may directly increase the abundance of preferred plant species, such as Olney bulrush and widgeongrass, which provide food resources for wintering and migrating waterfowl (Chabreck 1976, Broome *et al.* 1995). Management of water levels would also provide optimal conditions for foraging and resting waterfowl.

Approximately 1,100 additional acres of moist soil units would be developed on the Refuge Complex under Refuge Management Alternative B, specifically to provide additional high quality habitat for wintering and migrating waterfowl. Moist soil management would provide optimal conditions for germination and growth of preferred waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia.

On Anahuac NWR, rice production through the cooperative rice farming program would be expanded to approximately 1,000 acres annually under this Alternative to provide additional habitat for wintering and

13 During the 1969 through 1994 period, the Louisiana coastline experienced major wetland losses, similar to the Texas coast. However, there appears to have been no declines in duck populations of coastal Louisiana marshes between 1969 and 1994 (Michot, 1996).

migrating waterfowl. Management of fallow rice fields would also provide weeds and seed that are heavily utilized by waterfowl.

Marsh restoration using dredge material would create additional emergent marsh and open water habitats and provide additional habitat for wintering and migrating waterfowl.

(b). General Habitat Management and Restoration Activities

Under Refuge Management Alternative B, the USFWS would continue an integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex to promote optimal habitat conditions for wintering waterfowl and many additional migratory bird species. As compared to current conditions, enhanced water management capabilities, expanded prescribed burning and more intensive grazing under Refuge Management Alternative B would provide enhanced habitat conditions for wintering waterfowl on the Refuge Complex. Prescribed burning and grazing would promote the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Burning and moderate grazing would also result in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al.* 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex would include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Burning and grazing also would help provide optimal physical structure of vegetation for waterfowl utilization of emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions would also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Waterfowl habitat on the Refuge Complex would also be enhanced under Refuge Management Alternative B through the control of undesirable invasive vegetation such as common reed, cattail, and California bulrush which have formed dense homogeneous stands and resulted in loss open water habitats. Infestations of exotic invasive floating plants such as water hyacinth, alligatorweed and Salvinia would also be controlled to restore and maintain open water habitats. Maintaining an interspersion of open water and vegetated emergent wetlands would provide the habitat diversity needed to support wintering waterfowl and other migratory birds. Restoring open water habitats would increases the production of submerged and floating aquatic plants, an important food source for migratory birds. Control of Chinese tallow and deep-rooted sedge in and adjacent to freshwater marshes, moist soil units and rice fields would also enhance waterfowl habitat.

Continuation of shoreline protection and restoration activities under Refuge Management Alternative B would enhance waterfowl habitat on the Refuge Complex by decreasing saltwater intrusion into inland marshes and addressing threats of additional saltwater intrusion. However, the scope of these activities under Alternative B will likely not counteract the ongoing and future impacts of relative sea level rise, loss of coarse sediment supply, and altered hydrological regimes, especially on McFaddin and Texas Point NWRs. Declines in habitat quality caused by regular tidal overwash are adversely affecting migratory waterfowl use on these refuges. As beach ridges and the banks of the GIWW erode they are less effective barriers to tidal inundation and salt water intrusion during storm and other high tidal events. Overwash events create sudden and drastic spikes in salinities, often killing submerged aquatic vegetation and seed producing annual plants. Inundation of the marshes with sea water provides the sulphates which are reduced to hydrogen sulfide under conditions of high water temperatures. Hydrogen sulfide toxicity and low dissolved oxygen cause large scale die-offs of plants and animals, including many invertebrates which provide an important food source for waterfowl and other migratory birds. Survey data indicate that waterfowl numbers have dropped to below five birds per thousand acres in affected areas following overwash events, and below one bird per thousand acres after severe events (USFWS, unpublished data). Areas that can be heavily impacted by overwash events now encompass nearly 15,000 acres on McFaddin NWR and near 1,500 acres on Texas Point NWR.

Increased saltwater intrusion from frequent tidal overwash from the Gulf into inland marshes on these refuges will continue to negatively impact habitat quality for waterfowl, other migratory birds, and other native fish and wildlife species. If present erosion problems persist, total acreage of impacted marsh could increase to nearly 30,000 acres over the next 5 to 10 years. Declining habitat conditions due to increased saltwater inundation could result in further significant declines in wintering waterfowl use on McFaddin and Texas Point NWRs.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Under Refuge Management Alternative B, many habitat management and restoration activities currently conducted on the Refuge Complex would be continued, and all would be expected to have positive impacts on this species. Several habitat management and restoration activities will be expanded specifically to benefit Mottled Ducks. Management and enhancement of nesting and brood-rearing habitats would be targeted.

(a). Wetlands Management and Restoration

Wetland management and restoration activities on the Refuge Complex under Refuge Management Alternative B would provide additional enhanced habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Expanded and enhanced structural marsh management would maintain fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. It would enhance diversity and productivity of submerged aquatic vegetation in open water habitats, providing an important year-round food source for Mottled Ducks. Expanded moist soil management and cooperative rice farming programs would provide additional shallow freshwater habitat and nutritious food resources for use by Mottled Ducks year-round. Rice farming would provide an additional 300-500 acres and moist soil management an additional 1,100 acres of wetland habitat over current levels on the Refuge Complex under this Alternative. Approximately 400 acres of moist soil units would be managed each year specifically to provide brood-rearing habitat for Mottled Ducks during summer.

(b). Uplands Management and Restoration

Native prairie management activities under Refuge Management Alternative B would generally remain the same as under Alternative A, and would benefit Mottled Ducks primarily by restoring and enhancing nesting habitat. The integrated application of prescribed burning, controlled livestock grazing, herbicide application and expanded mowing and haying to maintain and enhance grassland habitats and reduce brush encroachment (exotic and native plants) in salty and non-saline prairies (and on levees and along fence lines) would be expected to improve nesting success of Mottled Ducks and other ground-nesting avian species.

The historical prairie-wetland continuum of the upper Texas coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and mima mounds that are characteristic of coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as “sennabean ponds,” as valuable brood rearing habitat. Protecting extant coastal prairie and restoring adjacent prairie and wetland habitats under Refuge Management Alternative B on the Refuge Complex would increase the quality of habitats important to Mottled Duck recruitment and overall reproductive success.

(c). General Habitat Management Activities

Annual prescribed burning would increase under Refuge Management Alternative B, to a target of 35,000 acres. Grazing intensity (higher stocking rates) and duration in fresh and intermediate marshes would be increased. The integrated combination of expanded water level and salinity management, and increased

prescribed burning and controlled livestock grazing in wetland habitats on the Refuge Complex under this Alternative would increase the acreage of optimal wetland habitat for Mottled Ducks. Invasive plant and animal control activities would also enhance wetland and upland habitats for Mottled Ducks, as would shoreline protection and restoration activities.

Salt prairies occur as a broad zone between coastal prairies and marshes, or more commonly on the Refuge Complex, as a ridge between marshes and bays or the Gulf of Mexico. Higher, well drained, salt prairie ridges juxtaposed with lower wetland areas have been identified as important Mottled Duck nesting areas in the Chenier Plain region of Louisiana (Baker 1983) and Texas (Stutzenbaker 1988). Because of the near total loss of coastal prairie, salt prairie is now the most important Mottled Duck nesting habitat on the Refuge Complex. These cordgrass ridges are dominated by Gulf cordgrass with marshhay cordgrass, knotroot bristlegrass (*Setaria parviflora*) and some brush species typically subdominant. Baker (1983) found that salt prairie invaded with Sesbania (*Sesbania* spp.) and Baccharis (*Baccharis halimifolia*) were avoided by nesting Mottled Ducks. Burned areas appeared to be undesirable for nesting to three years post-fire. Vegetation heights were comparable to unburned areas by the second year post-fire, but residual senesced vegetation remained low. Fire is necessary in the management of Mottled Duck nesting habitat. Fire must be frequent enough to keep brush at low densities, but infrequent enough to maximize years with dense nesting cover for Mottled Ducks.

Improper application of these habitat management practices has the potential to negatively impact Mottled Ducks. For example, prescribed burning may result in the excessive removal of vegetation reducing suitability as Mottled Duck nesting habitat, and burning at the wrong time of year could destroy nests (Baker 1983). Overgrazing by cattle may reduce desirable nesting habitat for Mottled Duck in marshes and salty prairies, especially after spring burns (Baker 1983, Stutzenbaker 1988). The potential for some negative impacts to Mottled Duck nesting habitat would increase under Refuge Management Alternative B. Higher cattle stocking rates and grazing durations and more frequent burning in fresh and intermediate marshes could reduce availability of suitable nesting cover in contiguous salty prairies and non-saline grassland habitats under this Alternative.

Marsh habitats being impacted by tidal overwash of the eroding beach ridges on McFaddin and Texas Point NWRs provide important Mottled Duck nesting and brood rearing habitat. Based on field observations and capture rates during banding efforts, saltwater inundation has reduced Mottled Duck use of affected areas by as much as 50% to 65% over the last 10 years. If erosion problems persist and result in increased frequency of saltwater intrusion events, Mottled Duck use and reproductive success on the Refuge Complex will likely further decline.

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because the category of shorebirds, wading birds, and other marsh and waterbirds consists of a wide variety of species, individual species use microhabitats (e.g., vegetative cover and water depth) differently than other species in the same category (Gosselink *et al*. 1979, Skagen *et a*l. 1999). For example, bare to sparse vegetative cover for foraging is preferred by species such as Piping Plover (Federally listed Threatened) and the Least Tern (State-listed Endangered). Denser vegetation is preferred by other species, for example Little Blue Heron, Black-crowned Night Heron, Yellow-crowned Night Heron, Least Bittern, American Bittern, King Rail, and Clapper Rail. Other species have broad vegetation density requirements, and can utilize areas ranging from relatively bare of vegetation to dense vegetation, for example Reddish Egret (State-listed Threatened) and Wood Stork (State-listed Threatened).

This category of avian species also varies greatly in the amount of soil moisture and water depths they prefer, usually for feeding activities. These requirements range from relatively dry or shallow water (a few centimeters deep), such as the Piping Plover, to slightly deeper (but still relatively shallow) water, such as the Western Sandpiper and Least Sandpiper, to waters about 8-12 cm deep, such as the Black-bellied Plover and Willet. Other species prefer deeper waters, often within wading depth for long legged birds, such as the White-faced Ibis (State-listed Threatened) and the Least Tern. Some species can utilize deep waters as well as shallower waters (Wilson's Phalarope, Red-necked Phalarope, Olivaceous Cormorant, Double-breasted Cormorant, Laughing Gull, and Forster's Tern). Some species are year-

round residents, such as Brown Pelican (Federally listed Endangered), Double-breasted Cormorant, Great Blue Heron, Little Blue heron, Great Egret, and Black Skimmer. Other species are mostly migratory, including Wood Stork, White Ibis, and Forster's Tern.

Because of the wide diversity of habitat requirements by this category of birds, USFWS habitat management and restoration activities on the Refuge Complex which result in a mosaic of diverse habitat types (plant species composition, structural characteristics, water levels and salinities) is desirable. As such, most of the wetland and upland habitat management and restoration activities to be continued under Refuge Management Alternative B would continue to positively impact the shorebird, wading bird and marsh bird species currently found on the Refuge Complex.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative B, expanded and enhanced structural marsh management would improve habitat conditions in a wide variety of vegetation and habitat types used by many avian species in this group. Water management activities in coastal marshes which maximize the annual production of desirable submerged aquatic plant species provide improved habitat for invertebrates and small vertebrates, which are the primary prey items for many shorebird, wading bird and marsh bird species.

Under Refuge Management Alternative B, the cooperative rice farming and moist soil management programs would be expanded to provide additional shallow freshwater wetland habitat. In total, rice farming would provide approximately 1,000 acres on Anahuac NWR, and Complex-wide moist soil management would provide 1,600 acres under this Alternative. Approximately 300 acres of the Anahuac NWR's moist soil units would be managed specifically to provide wetland and mudflat habitat for shorebirds during spring and fall migrations. Targeted shorebird species would include Long-billed Dowitcher, Semi-palmated Plover, Black-bellied Plover, Black-necked Stilt, Whimbrel, American Avocet, Long-billed Curlew, Hudsonian and Marbled Godwits, and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted Sandpipers. Under this Alternative, 1,200 acres of moist soil units would provide wetland habitat for shorebirds, wading birds, and other marsh and waterbirds over the winter months. Wading and marsh bird species using moist soil habitats on the Refuge Complex include American Bittern, Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, Tri-colored Heron, Black-crowned and Yellow-crowned Night Herons, White Ibis, White-faced Ibis, and Roseate Spoonbill.

In general, shorebirds and wading birds would also benefit from expanded moist soil management and rice farming activities under this Alternative. Rice farming and moist soil management result in increased abundance of invertebrates and plants that are a preferred food source (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002). The timing and depth of flooding on managed agricultural fields influences the type of and intensity of use by such birds (Huner *et al*. 2002).

(b). Uplands Management and Restoration

Under Refuge Management Alternative B, restoration and enhancement of native prairie habitats would continue as described under Alternative A. Some avian species in this category would benefit, primarily from improved habitat for migrating and wintering birds. Three Avian Species of Conservation Concern (USFWS 2005) would benefit from these activities: Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

Under Refuge Management Alternative B, the USFWS would continue the integrated combination of water level and salinity management, prescribed burning and controlled livestock grazing in wetland habitats on the Refuge Complex. The USFWS would expand prescribed burning and controlled livestock grazing programs under this Alternative. These management activities promote optimum habitat

conditions for wintering and migrating waterfowl and also enhance wetland and upland habitats used by many shorebird, wading bird and marsh bird species.

These management tools would help create optimal physical structure of vegetation for many species of shorebirds and wading birds in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for shorebirds and wading birds. Conversely, expanded burning and grazing under this Alternative may reduce habitat availability for some marsh bird species which require dense, tall stands of vegetation. Higher grazing intensities would increase the potential for some negative impacts. Grazing could negatively impact some ground-nesting species such as Black-necked Stilts by trampling nests and grazing on emergent pond vegetation used by those birds, and may also disturb nesting pairs (Whyte and Cain 1979).

Some species in this group have a relatively narrow range of optimal water depth for feeding and other activities, ranging from almost dry sediment to relatively deeper water (Skagen *et al*. 1999). Management activities that increase water depth may negatively impact those species that prefer shallow or no water, and those that prefer deeper water are negatively impacted when management activities lower water levels. Similar impacts could occur with management of vegetative cover, as some species prefer areas devoid of vegetation, while others prefer heavy vegetative cover. However, most avian species in this group (especially migrants) have evolved with unpredictable available resources, and are able to find suitable microhabitats in an adequately diversified landscape that contains a mosaic of microhabitats, both spatially and temporally. As under Refuge Management Alternative A, overall management under Alternative B would be aimed at maintaining a mosaic of available habitats. This should provide an adequate range of habitats for this group of avian species.

Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (Mizell 1998), sparrows (Emberizidae) and wrens (Troglodytidae) (Gabrey *et a*l. 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et a*l. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al*. 2000). Not surprisingly, these secretive marshland bird species decline in the first year post fire. Other bird species such as Icterids (Gabrey *et al*. 2001) and Wilson's Snipe (*Gallinago* delicate*)* (USFWS unpublished data) increase immediately post-burn.

The susceptibility of wildlife to mortality during fire events seems to be dependent on weather, fuel characteristics (moisture, loading and continuity), fire characteristics (as influenced by ignition strategies), and the capability and behavior of the species in question. Black rail mortality has been observed where large areas are burned with little unburned escape cover available, while mortality was not observed in a burn containing a mosaic of unburned escape cover (Legare *et al*. 1998). No fire induced mortality was observed for three species of rail during fire operations on the Texas mid-coast, though data were insufficient to draw strong conclusions (Grace *et al*. 2005). Burns conducted under fuel and weather conditions that allow for patches of unburned habitat within the unit may minimize wildlife mortality. Burns ignited in a way that maximizes escape options, primarily through the use of backing and widely spaced strip flanking fires, probably minimizes wildlife mortality while maintaining fire-dependent habitat. The USFWS uses these techniques in prescribed burning operations on the Refuge Complex.

Exotic and invasive plant and animal control activities would continue as described under Refuge Management Alternative A, and would also enhance wetland and upland habitats for many avian species in this group. The removal of invasive vegetation that forms dense, homogeneous stands resulting in pond closure (such as common reed, cattail, and California bulrush), would improve habitat conditions for wading bird and marsh and waterbird species that utilize open water habitats. Shoreline restoration activities including dune restoration and creation of emergent marsh and mudflats in intertidal zones behind breakwaters would benefit many shorebird and wading bird species.

Under Refuge Management Alternative B, the USFWS would continue to maintain a 1-acre nesting site for Least Terns and Black Skimmers on McFaddin NWR. This site is intensively managed to promote increased nesting success for these species, including providing ideal nesting substrate, excluding mammalian predators, and minimizing disturbance.

Overall, species requiring less dense, more open marsh habitats would benefit from expanded prescribed burning and intensified controlled grazing under Refuge Management Alternative B, while the amount of habitat for species requiring dense stands of vegetation would decrease.

(4). Impacts to Landbirds

Landbird species found on the Refuge Complex require a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf coast (Mueller 1981, Barrow *et al*. 2000). Some raptor species prefer intermingled field and forested areas (e.g., red-tailed hawks and owls). Other landbird species prefer grassland habitats including marshes and prairies (Peterson *et a*l. 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

All habitat management and restoration activities conducted on the Refuge Complex under Refuge Management Alternative B would benefit avian species in this group. Although comprising a relatively small portion of the overall habitats on the Refuge Complex, restoration, management, and protection of native prairies and coastal woodlots are of particular significance because of the importance of these habitats to many passerine species, including many neotropical migratory songbirds.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative B, several wetland management and restoration activities would continue to have positive impacts on several land bird species including managing water levels and salinities in coastal marshes, marsh restoration, moist soil management, and the cooperative rice farming program. Several land bird species listed as Avian Species of Conservation Concern (USFWS 2005), including the Seaside Sparrow, Nelson's Sharptailed Sparrow and Sprague's Pipit, would benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Under Refuge Management Alternative B, approximately 5,774 acres of upland grassland habitats would be maintained and enhanced using an integrated combination of prescribed fire, controlled livestock grazing, herbicide application and expanded mowing/haying.

Native prairie remnants and other upland grassland habitats on the Refuge Complex provide wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow and Nelson's Sharptailed Sparrow, and nesting habitat for species including Dicksissel and Eastern Meadowlark. These are also important nesting habitats for Mottled Ducks. Several species of raptors commonly observed on the Refuge Complex include Red-tailed Hawk, Red-shouldered Hawk, Turkey Vulture, American Kestrel, White-tailed Kite, Northern Harrier, and Short-eared Owl (USFWS 1997a). Many other raptor species are observed during spring and fall migrations. Many of the landbirds that would benefit from protection and management of native coastal prairie habitats under Refuge Management Alternative B are species that are declining in the Coastal Prairies Region of Texas (Shackelford and Lockwood 2000), and/or are among several species recently listed by the USFWS as "Avian Species of Conservation Concern" in the Gulf Prairies Bird Conservation Region (USFWS 2005). For example, White-tailed Hawk, Loggerhead Shrike, Northern Bobwhite, Yellow and Black Rail, Buff-breasted Sandpiper, Short-eared Owl, Sedge Wren, Henslow's Sparrow, and LeConte's Sparrow are all Avian

Species of Conservation Concern that would benefit from conservation of prairie habitats on the Refuge Complex under this Alternative.

No additional restoration of native prairie would take place under Refuge Management Alternative B. Benefits to several grassland-dependent songbirds and other native wildlife from ongoing restoration of 270 additional acres of prairie under Alternative A would not be realized.

Woodlot Restoration and Management

Under Refuge Management Alternative B, the USFWS would continue current management activities to protect 127 acres of existing coastal woodlots: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts.

Overall, implementation of the USFWS management actions under this Alternative would have similar impacts to those described under Alternative A. These activities would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging. Species to benefit would include three neotropical migratory birds considered Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler.

(c). General Habitat Management Activities

Prescribed burning, controlled grazing, invasive species management, and shoreline protection and restoration activities would continue on the Refuge Complex under Refuge Management Alternative B. The integrated combination of water level and salinity management, fire management and controlled livestock grazing on the Refuge Complex which promotes optimum habitat conditions for wetland-dependent migratory birds also enhances wetland and upland habitats used by many land bird species. Invasive plant and animal control activities would also enhance wetland and upland habitats for these species, especially in grassland and coastal woodlot habitats. For example, control of Chinese tallow would lead to increased diversity of native woody plants in the coastal woodlots, as well as increased forage insects (especially Lepidopteran larvae) for migrating passerines and other birds. Chinese tallow stands have an ecological trap effect for migrant songbirds that are drawn to the cover of the woodlots, but then find insufficient food resources to replenish depleted energy reserves (Barrow and Renne 2001).

The USFWS would expand prescribed burning and controlled livestock grazing programs under Refuge Management Alternative B. Seaside Sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al*. (2001) reported that breeding Seaside Sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested.

Gabrey *et al*. (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (2005) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife. Increased burning frequency under Refuge Management Alternative B has potential to either positively or negatively impact some landbird species.

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al.* 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al*. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al*. 1990, Kneib 1991, Rozas 1995).

Under Refuge Management Alternative B, the USFWS would continue to structurally manage marshes, restore coastal wetlands, and conduct vegetative management activities including prescribed burning, controlled livestock grazing, exotic plant and animal control, and shoreline restoration and protection. These management activities would protect, restore and enhance estuarine wetlands, and ensure wetland habitat diversity and productivity important to a variety of fish and shellfish species. The continuum of fresh to saline aquatic environments on the Refuge Complex support highly diverse aquatic vertebrate and invertebrate communities. Disruption of salinity gradients would likely cause adverse impacts on blue crabs (Guillory 1996). Many of the refuge marshes would exceed these thresholds without some type of hydrologic management.

Under Refuge Management Alternative B, an additional 6,500 acres of marsh would be structurally managed. Managing water levels and salinities using water control structures and levees in managed marsh units can restrict access to managed areas for some aquatic organisms, such as fish and crustaceans (Rogers *et al*. 1992, Kuhn *et al*. 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a natural stable or deteriorating deltaic marsh (Peterson *et al* 1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown.

Impacts of structural marsh management to fisheries resources have been reduced on the Refuge Complex by incorporating design features into existing water control structures such as vertical slots which allow passage of estuarine organisms, managing structures to facilitate ingress and egress by opening gates during key movement periods, and utilizing rock weirs to counter erosion and enlargement of tidal waterways (as opposed to traditional fixed crest weirs). These design features and management regimes would be also be incorporated under Refuge Management Alternative B.

(6). Impacts to Threatened and Endangered Species

Three avian species occurring on the Refuge Complex are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon, Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Under Refuge Management Alternative B, protection, restoration and management of coastal wetland habitats on the Refuge Complex would continue as under Alternative A, and would benefit the three avian T&E species. Bald eagles observed on the Refuge Complex are usually associated with large

concentrations of wintering waterfowl. Brown Pelicans utilize shorelines tidal saline ponds for resting and foraging. Shoreline restoration and protection activities would provide improved habitat for Piping Plover and Brown Pelican. Conservation and management of both wetland and upland habitats aimed at ensuring biological integrity and biological diversity under Refuge Management Alternative B would benefit Threatened and Endangered species and many other sensitive or declining native fish and wildlife species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found on the Refuge Complex include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species on the Refuge Complex. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic animals.

In general, habitat management and restoration activities under Refuge Management Alternative B which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of wildlife species.

USFWS management activities under Refuge Management Alternative B which maintain and restore freshwater wetland habitats (structural management of marshes, moist soil management, rice farming) would be particularly beneficial to amphibians and reptiles. Expanded structural marsh management, cooperative rice farming and moist soil management programs under this Alternative would provide additional reliable freshwater habitat critical for most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas.

Under Refuge Management Alternative B, some management activities would continue to have negative impacts on some wildlife species. Control of invasive woody species in wetland and upland habitats may decrease habitat quality for certain mammals such as raccoon and striped skunk. Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, and some reptiles, and invertebrates.

Under Refuge Management Alternative B, the USFWS would prescribe burn more acres annually and initiate annual burning in some habitats. Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et a*l. 1989) summarizes by saying “Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil-litter stabilize.” Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data). It appears that fire management practices that favor desired vegetation conditions seem to be compatible with maximizing arthropod diversity as long as a mosaic of burned an unburned habitats is maintained.

b. Impacts from Public Use Programs

Assuming an increase in visitation to the Refuge Complex under Refuge Management Alternative B, impacts to fish and wildlife resources would likely increase over current levels described under Refuge Management Alternative A. This assumption is based upon the expanded waterfowl hunting opportunities and new hunting programs for doves and snipe, rails and gallinules and the new visitor facilities to support fishing, wildlife observation and photography, and environmental education and interpretation provided under this Alternative.

(1). Impacts to Waterfowl

(a). Waterfowl Hunting

Under Refuge Management Alternative B, additional waterfowl hunting opportunities would be provided by opening additional areas of the Refuge Complex for September teal hunting, providing additional hunting days (7-days per week) on a portion of McFaddin NWR, allowing guided hunting on portions of the Refuge Complex, and opening the refuges for snipe, gallinule and rail hunting. Assuming an increase in visitation fro hunting, the impacts discussed below would increase over current levels.

The most direct effect of hunting on the Refuge Complex is the mortality of harvested waterfowl species resulting from the hunting activities. However, because regulations governing harvest in the Central and Mississippi Flyways are developed annually under the USFWS migratory bird hunting regulation frameworks, and are designed to ensure that viable waterfowl populations are sustained over the long-term, continuation of the waterfowl hunting program on the Refuge Complex under Refuge Management Alternative B will not have any measurable effect on overall populations and the long-term viability of these populations.

Many studies have documented the effects of hunting -intensity on the number of birds utilizing an area (Reichholf 1973, Wolder 1993, Madsen *et al*. 1992 as cited by Fox and Madsen 1997). These studies have shown that relatively light hunting pressure can reduce waterfowl abundance in hunted areas. Distribution and habitat use, feeding patterns, and the nutritional status of waterfowl have also been shown to be affected by hunting activities. Hunting activity can cause birds to alter habitat use, change feeding locations (Madsen 1995), feed more at night (Morton *et al.* 1989) and reduce the amount of time spent feeding (Korschgen *et al.* 1985, Madsen 1995). Collectively, these changes in behavior have the potential to adversely impact the nutritional status of waterfowl (Belanger and Bedard 1995). Cumulatively, the expanded hunting programs under this Alternative would increase disturbance impacts to waterfowl. Of these activities, 7-days per week hunting and the hunting of snipe, rails and gallinules have the greatest potential to reduce waterfowl utilization within hunt areas on the Refuge Complex.

Means of access to and within Refuge Complex hunt areas would remain the same as under Refuge Management Alternative A and would include motorized boating (primarily in Oyster, Onion and East Bay bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake and hunt area access ditches on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), non-motorized boating, motorized vehicles, and walking. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use, but these impacts are likely less than those caused by motorized boating.

Monthly aerial surveys of wintering waterfowl on the Refuge Complex have documented the disproportionate use of established sanctuary areas by waterfowl, as compared to the areas open to hunting. This further supports the above studies and indicates that hunting affects the overall distribution of wintering waterfowl on the Refuge Complex. The size, location and habitat quality of sanctuary areas on the Refuge Complex remains critically important to ensure that migrating and wintering populations of waterfowl maintain sound nutritional and physiological status.

Providing waterfowl with predictable undisturbed sanctuary areas likely increases the ability of birds to meet the obligations of their annual cycle. Waterfowl undergo considerable physiological demands during winter. Heitmeyer (1988) estimated that prebasic molt in female mallards required and additional three grams per day of protein over base metabolic rates. These demands approach the estimated five grams per day associated with reproduction. Pair formation for most North American waterfowl takes place away from the breeding grounds. Waterfowl must accumulate endogenous energy reserves to meet the demands of courtship (Afton and Sayler in Baldassarre and Bolen 1994). Baldassarre and Bolen (1994) proposed that birds that do not accumulate energy reserves may have less time and energy at their disposal to initiate courtship and/or may be unable to maintain previously established pair bonds. Clearly, birds must meet high energy demands to successfully fulfill critical wintering components of their annual cycle. Further, Heitmeyer and Fredrickson (1981) build a scenario where endogenous reserves established on wintering grounds return mallards to breeding areas in better condition to begin nesting, leading to larger clutch sized and earlier nests, which tend to be more successful. Providing sanctuary areas of adequate size, encompassing and/or adjacent to quality feeding areas, may contribute to the ability of birds to meet the physiological demands required during winter and possibly the subsequent nesting cycle.

It has been shown that sanctuary areas on the wintering grounds are effective in maintaining local waterfowl populations in a landscape subject to hunting pressure (Bellrose 1954, Madsen 1998). Heitmeyer and Raveling (1988) found that waterfowl used sanctuaries during the day and local rice fields at night. Similarly, Fleskes *et al*. (2005) found Northern Pintail used areas closed to hunting during the day and dispersed throughout the area at night. These data indicate that while sanctuaries are effective in maintaining local waterfowl populations through the hunting season, birds must disperse at night to feed.

The continued maintenance of sanctuary areas on the Refuge Complex would be required to mitigate for disturbance impacts from hunting activities under Refuge Management Alternative B. Maintaining existing and developing new refuge-specific hunting regulations under this Alternative would also be necessary help mitigate the impacts of hunting activity-related disturbance to waterfowl. Monitoring would be required to assess impacts of modified/expanded hunting programs, and to make necessary future adjustments. As with the current hunting program, it is possible that hunting activities under Refuge Management Alternative B would result in reduced abundance of wintering waterfowl on the Refuge Complex in years of poor habitat quality due to climatic extremes or tidal flooding from tropical disturbances.

(b). Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

Under Refuge Management Alternative B, existing visitor facilities on the Refuge Complex would be maintained and several new facilities would be developed to support these uses on Anahuac, McFaddin and Texas Point NWRs. Means of access for these uses and the presence of visitors result in disturbance impacts to waterfowl, as described under Refuge Management Alternative A. Increased visitation and the presence of new facilities would increase these impacts and expand the areas within which impacts would occur.

Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use.

Disturbance of waterfowl by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993). In wetland habitats, disturbance from “out of vehicle” approaches can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). While some species of waterfowl appear to acclimate to vehicular traffic, and even presence of visitors on trails, boardwalks, and observation

platforms, other species are less tolerant of disturbance. Overall it is likely that species composition and abundance of waterfowl is decreased in areas supporting these recreational uses.

(2). Impacts to other Migratory Birds, Shorebirds, Wading Birds, other Marsh and Waterbirds, and Landbirds

(a). Waterfowl Hunting

Although the disturbance impacts of waterfowl hunting under Refuge Management Alternative B on other wetland-dependent migratory and resident birds which are not hunted is likely less than for waterfowl, studies have demonstrated that hunting (including accessing hunt areas) does affect abundance and distribution of these other avian species. The noise associated with shooting likely reduces habitat utilization by shorebirds, wading birds, other marsh and waterbirds, and landbirds using wetland habitats within hunt areas, at least while hunting is occurring. Motorized boating disturbs and displaces many waterbird species (Dahlgren and Korschgen 1992, Knight and Cole 1995), as will non-motorized boats, vehicles and walking through the marsh.

Under Refuge Management Alternative B, the Refuge Complex would be opened to the hunting of snipe, rails and gallinules. Harvest would result in direct mortality of individuals of these species. Because regulations governing harvest in the Central and Mississippi Flyways are developed annually and are designed to ensure that viable migratory bird populations are sustained over the long-term, harvest should not have any measurable effect on overall populations and the long-term viability of these populations. Hunting of snipe and rails on the Refuge Complex would likely be accomplished by walking and non-motorized boating, with hunters freely moving through hunt areas rather than hunting a specific location (as over a decoy spread for waterfowl). Additional movement would increase potential for disturbance to migratory birds, and increase the likelihood of conflicts with waterfowl hunters.

Under Refuge Management Alternative B, a small portion of Anahuac NWR would be open to hunting of doves. Harvest of doves would result in direct mortality, but Federal and State regulations governing harvest would ensure that dove populations are sustained over the long-term. Additional refuge-specific regulations would be in place to reduce impacts to habitat and wildlife including means of access and required use of non-toxic ammunition.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

Under Refuge Management Alternative B, existing visitor facilities on the Refuge Complex would be maintained and several new facilities would be developed to support these uses on Anahuac, McFaddin and Texas Point NWRs. As described under Refuge Management Alternative A, means of access and the presence of visitors result in disturbance impacts to migratory birds. Under Refuge Management Alternative B, increased visitation and the presence of new facilities would increase these impacts and expand the areas within which impacts would occur.

Disturbance of migratory birds by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993) and shoreline areas regularly used for fishing. Along roads through wetland habitats, disturbance from “out of vehicle” approaches for observation and photography can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). Walking on trails tends to displace birds and can cause declines in species richness and abundance (Riffell *et al*. 1996). Some generalist avian species such as house finches tend to increase near trails, while specialist species such as solitary vireo move away from trails. The zone of influence around trails appears to be approximately 75m for woodland areas adjacent to grasslands (Miller *et al.* 1998).

Disturbance impacts to birds from visitation are often magnified during the breeding season. Color of clothing worn can attract or repel different passerine species based on breeding plumages of those species (Gutzwiller and Marcum 1997). Primary song occurrence and consistency of certain passerines

can be impacted by a single visitor (Gutzwiller *et al*. 1994), which could limit the number of breeding pairs and production by those species in disturbed areas (Reijnen and Foppen 1994). Predation on songbird, raptors, colonial nesting species, and waterfowl nests tends to increase near more frequently visited areas (Glinski 1976, Buckley and Buckley 1978, Boyle and Samson 1985, Miller *et al*. 1998).

(3). Impacts to Fisheries

(a). Fishing

The most direct effect of fishing on the Refuge Complex is the mortality of harvested freshwater and saltwater fish, blue crabs, and several fish and shellfish species caught for use as bait. Fishing and crabbing on the Refuge Complex occur under regulations promulgated by the Texas Parks and Wildlife Department. These regulations are designed to ensure that viable fish and shellfish populations are sustained over the long-term.

Continuation of fishing and crabbing on the Refuge Complex under Refuge Management Alternative B, including expanding the hours that McFaddin NWR is open to the public, should not have any measurable effect on overall populations and the long-term viability of these species' populations.

b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

No impacts to fisheries resources are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative B.

(4). Impacts to Threatened and Endangered Species

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that Bald Eagles, Brown Pelicans and Piping Plovers using Refuge Complex habitats would be subject to the some level of disturbance by public use activities under Refuge Management Alternative B. These impacts are expected to be negligible. Bald Eagles are usually associated with large concentrations of wintering waterfowl that occur in refuge sanctuary areas which are not open to the public. Piping Plovers utilize beach, shoreline and intertidal mudflat habitats primarily during fall and winter, when use of these habitats by the public is lightest. Brown Pelicans readily forage and roost adjacent to human activity and infrastructure. The three T&E avian species do not nest on the Refuge Complex, their presence is transient in nature, and they are highly mobile and able to move to undisturbed areas. Overall, no impacts to Federally-listed or State-listed Threatened and Endangered species are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative B.

(5). Impacts to other Fish and Wildlife Species – Mammals, Amphibians, Reptiles, and Invertebrates

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that mammals and amphibians and reptiles would be subject to some level of disturbance from public use activities occurring on the Refuge Complex, under Refuge Management Alternative B. These impacts are expected to be negligible. Vehicles would occasionally strike and kill mammals such as Virginia opossum, armadillo, raccoon and striped skunk, and reptiles and amphibians including alligators, snakes and frogs.

(b). Commercial Alligator Harvest

Under Refuge Management Alternative B, the current adult alligator harvest program would continue to be administered as an economic use on the Refuge Complex. This program is administered under regulations promulgated by Texas Parks and Wildlife Department, and these regulations are designed to ensure that viable alligator populations are sustained over the long-term. In addition, the USFWS regulates the alligator harvest program on the Refuge Complex through issuance of a Special Use Permit which contains stipulations also designed to conserve alligator populations. For example, special regulations are in place to restrict harvest of reproductive-aged alligators and maintain a natural age structure within the Refuge Complex alligator population. Continuation of the commercial alligator harvest program under Refuge Management Alternative B should not have any measurable effect on the long-term viability of alligator populations on the Refuge Complex.

(c). Control of Muskrat Populations

Herbivory in areas of high density muskrat populations can cause or exacerbate conditions resulting in permanent conversion of vegetated marsh to open water. This is likely to most prevalent in areas affected by saltwater intrusion or other factors contributing to marsh loss. Under Refuge Management Alternative B, muskrat populations could be controlled in specific locations as deemed necessary to protect wetland habitats on the Refuge Complex through issuance of Special Use Permits for trapping and removal by qualified individuals. Trapping and removal of muskrats under this program would have negligible if any impacts on overall muskrat populations and the long-term viability of these populations.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

Under Refuge Management Alternative B, all current surveys, monitoring and research activities for migratory birds, resident wildlife, fisheries and T&E species (described under Refuge Management Alternative A) would continue. In addition, the USFWS would work with partners to expand the annual Mottled Duck breeding pair survey and to conduct additional research on factors affecting vital rates for this species, and would expand monitoring of colonial nesting waterbird nesting and fledgling success at a managed site on McFaddin NWR.

Surveys and monitoring and research activities are useful for tracking and documenting the impacts of various management strategies on fish and wildlife populations, distribution, movements and habitat utilization. This information facilitates implementation of an adaptive management approach which allows continual refinement and improvement of management activities. In some cases, monitoring activities are providing baseline information, previously not available. Under Refuge Management Alternative B, the USFWS would focus additional monitoring and research activities on Mottled Ducks in order to gain information needed for the long-term conservation of this important species and in light of growing concern for declining populations of Mottled Ducks on national wildlife refuges in Texas.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative B, the USFWS would continue to manage oil and gas exploration and development activities on the Refuge Complex through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to fish and wildlife resources, including timing of activities to avoid major periods of utilization, required use of specialized equipment, location and size of facilities, and required pollution controls.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex would be a reduced impact on fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative B, the USFWS would increase efforts to develop partnerships with private land owners to restore and enhance wetland and upland habitats on private lands by:

1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project; and 3) holding workshops for landowners to demonstrate habitat enhancement methods and techniques. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands.

The USFWS would also continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, Texas General Land Office and Galveston Bay Estuary Program, conservation organizations such as the Galveston Bay Foundation, Ducks Unlimited and local Audubon Society chapters, community organizations and Refuge volunteers. These partnerships support and greatly enhance a variety of refuge management programs.

It is anticipated that expanded outreach and partnership efforts under Refuge Management Alternative B would result in increased benefits to fish and wildlife resources as important habitats are restored and enhanced. Projects such as those implemented to date would enhance wetland habitats for wintering waterfowl, Mottled Ducks and other wetland-dependent migratory birds, and for resident wildlife including several species of reptiles and amphibians which depend on freshwater habitat. Ongoing partnerships with the Refuge Friends groups, conservation organizations and volunteers would support a variety of habitat restoration and biological program activities on the Refuge Complex, contributing directly to conservation of fish and wildlife resources.

B. Socioeconomic Resources Section

1. Economic Impacts

Economic impacts from management activities on the Refuge Complex occur in the regional economy in two different ways.

First, there are the direct economic impacts that occur as a result of the economic stimulus of three elements:
1) Direct expenditures made by USFWS to manage operations at the Refuge Complex,
2) Value of production from agricultural programs on the Refuge Complex, and
3) Expenditures made by recreational visitors to the Refuge Complex.

Second, there are **indirect and induced economic** impacts which are additional economic activity that occur as a result of the re-spending of these direct economic elements. The indirect and induced economic impacts are measured as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the direct economic elements. Total economic impacts (direct, indirect and induced) of for this management alternative were estimated using the data and methods discussed below. The analysis compares the impacts from this management alternative to the "No Action" management alternative, which would continue current activities.

The study area for purposes of estimating economic impacts is all of Jefferson and Chambers Counties along with a small portion of Galveston County, which includes the eastern portion of the Bolivar Peninsula east of Rollover Pass.

a. Direct Economic Impacts

(1). Value of Refuge Operations (Direct Expenditures)

Based on information about the activities proposed under Refuge Management Alternative B, an estimate of the operational expenditures was prepared. The estimate is broken out into five-year periods because it is expected that the amounts within certain cost categories would change with time under this Refuge Management Alternative. Because projects would occur throughout the study period, project costs will

vary by year. In addition, changes in staffing would occur throughout the study period so salary costs vary annually as well. The estimate of the annual average cost, per five-year period, for Alternative B is summarized in Table 4-13. The estimate of Refuge Operation's direct expenditures under this alternative shows a modest increase [no more than 10%] compared to the $2,695,184 estimate under the Refuge Management Alternative A (No Action).

Table 4-13
Average Annual Operational Costs for the Refuge Complex – Refuge Management Alternative B (Direct Expenditures)

Cost Category	**Annual Average Expenditures**		
	Year 1 – 5	**Year 5 - 10**	**Year 10 - 15**
Staff Salaries	$1,736,727	$1,775,894	$1,819,561
Utilities	$38,500	$38,500	$38,500
Travel	$43,035	$43,035	$43,035
Heavy Equip. Rental and Replacement	$77,000	$77,000	$77,000
Annual and Deferred Maintenance	$1,065,217	$940,883	$944,217
Special Programs	$16,500	$16,500	$16,500
Total Average Annual Expenditures	**$2,976,980**	**$2,891,813**	**$2,938,813**

(2). Value of Production from Refuge Agricultural Programs

(a). Cattle Grazing

The estimate for the value of grazing included some development assumptions regarding the annual average number of AUMs expected to occur under Refuge Management Alternative B. The annual average AUMs are expected to increase from 23,900 under the Refuge Management Alternative A (No Action) to about 29,875 under this Alternative. Using the estimated value of $88.02/AUM determined in the analysis for the Alternative A, there is an increase in the estimate of the production value of grazing in excess of $500,000. A summary comparing the changes in AUMs and value of production between Refuge Management Alternatives A and B is contained in Table 4-14.

Table 4-14
Estimated Production Value of Grazing Activities On Refuge Complex - Refuge Management Alternative B

Alternative	Annual Average AUMS	Value of Annual Production
No Action Alternative	23,900	$2,103,678
Refuge Mgmt. Alternative B	29,875	$2,629,598

(b). Rice Production

Under the development assumptions for this alternative the annual acreage in rice production is expected to increase from 600 acres under Refuge Management Alternative A (No Action) to approximately 1000 acres under Refuge Management Alternative B. Using the estimated value for rice production of $416.45/acre determined in the "No Action" alternative, there is about a ⅔ increase in the estimate of value for rice production on the Refuge Complex. A summary comparing the changes in annual average acreage produced and value of production between Refuge Management Alternatives A and B is contained in Table 4-15.

Table 4-15 Estimated Value of Rice Production On Refuge Complex - Refuge Management Alternative B		
Alternative	Annual Average Acreage Produced	Value of Annual Production
No Action Alternative	600	$249,867
Refuge Mgmt. Alternative B	1000	$416,450

(3) Value of Refuge Recreational Programs

For each Refuge Management Alternative, assumptions were made on how proposed management changes would affect visitation during the study period. These changes are expressed as increases or decreases in the number of non-resident recreational visitors under the "No Action" alternative. The estimated changes in recreational visitors under this alternative are broken out by recreational activity as follows:

Activity	**Change**
Waterfowl Hunting	10% Increase
Upland Bird Hunting	New activity - 100 hunter/days per year
Fishing	No change
Wildlife Observation	5% Increase

These changes were then applied to the estimate of annual non-resident visits and the estimates of itemized expenditures by recreational activity which were developed for Refuge Management Alternative A (No Action). Table 4-16 contains a summary of the comparison of the annual direct expenditures associated with Recreational visitors to the Refuge Complex between Refuge Management Alternatives A and B.

Table 4-16 Annual Direct Expenditures Associated with Recreational Visitors on Refuge Complex - RM Alternative B		
Alternative	Annual Non-resident Visitors	Total Recreational Expenditures
No Action Alternative	35,010	$1,098,923
Refuge Mgmt. Alternative B	36,682	$1,189,014

b. Indirect and Induced Economic Impacts

Indirect and Induced economic impacts are described as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the following three elements: direct expenditures made by the USFWS to manage operations at the Refuge Complex, value of agricultural production on the Refuge Complex, and the direct expenditures made by recreational visitors to the Refuge Complex. These direct expenditures create additional economic activity, the indirect and induced impacts, as re-spending of the direct expenditures occur. The indirect and induced impacts are estimated by using a series of economic multipliers applied to the estimates of the direct economic impacts of USFWS activities. IMPLAN was used to apply economic multipliers to the direct economic elements valued above to arrive at an estimate of the indirect and induced impacts to employment, income and indirect business taxes in the study area that can be attributable these USFWS activities.

The indirect and induced economic impacts are measured in the four following areas:

Employment: The annual average estimated employment is measured as Full-Time Equivalents (FTEs). Full-time equivalent employees equal the number of employees on full-time schedules plus the number of

employees on part time schedules converted to a full-time basis. This includes direct employment at the Refuge Complex (Approximately 30 FTEs at this time) as well as the additional employment supported in the surrounding area.

Labor Income: Labor income includes employee compensation and proprietary income. Employee compensation is the total wages and salaries of workers who are paid by employers, as well as the value of benefits such as health care, life insurance, retirement payments, and non-cash compensation. Proprietary income consists of payments received by self-employed individuals as income.

Other Property Type Income: This type of income is payments in the form of rents, royalties, dividends, and includes corporate profits.

Indirect Business Taxes: Indirect business taxes include excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses.

1). Refuge Operations

The comparison between the indirect and induced economic impacts attributable to Refuge Operations for Alternative B and the "No Action" alternative is summarized in Table 4-17.

Table 4-17
Indirect & Induced Economic Impacts of Refuge Operations at Refuge Complex – Refuge Management Alternative B

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	45	45	45
Refuge Management Alternative B	48	47	47
Labor Income			
No Action Alternative	$1,066,457	$1,066,457	$1,066,457
Refuge Management Alternative B	$1,199,076	$1,157,810	$1,171,821
Other Property Type Income			
No Action Alternative	$222,664	$222,664	$222,664
Refuge Management Alternative B	$272,669	$257,929	$257,417
Indirect Business Taxes			
No Action Alternative	$493,149	$493,149	$493,149
Refuge Management Alternative B	$502,252	$511,181	$522,302

(2). Refuge Agricultural Program

The comparison between the indirect and induced economic impacts attributable to agricultural activities, cattle grazing and rice farming, on the Refuge Complex for Refuge Management Alternatives A (No Action) and B is summarized in Table 4-18.

Table 4-18. Indirect and Induced Economic Impacts of Agricultural Activities at Refuge Complex - Refuge Management (RM) Alternative B

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	20	20	20
Refuge Management Alternative B	27	27	27
Labor Income			
No Action Alternative	$587,382	$587,382	$587,382
Refuge Management Alternative B	$785,861	$785,861	$785,861
Other Property Type Income			
No Action Alternative	$272,759	$272,759	$272,759
Refuge Management Alternative B	$371,550	$371,550	$371,550
Indirect Business Taxes			
No Action Alternative	$87,668	$87,668	$87,668
Refuge Management Alternative B	$118,065	$118,065	$118,065

Table 4-19 Indirect and Induced Economic Impacts of Recreational Activities at Refuge Complex - RM Alternative B

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	25	26	26
RM Alternative B	26	27	27
Labor Income			
No Action Alternative	$609,908	$621,374	$629,040
RM Alternative B	$634,780	$647,953	$656,417
Other Property Type Income			
No Action Alternative	$224,963	$229,144	$231,939
RM Alternative B	$234,159	$238,962	$242,048
Indirect Business Taxes			
No Action Alternative	$136,816	$139,559	$141,394
RM Alternative B	$142,266	$145,414	$147,438

(3). Refuge Recreational Programs

The comparison between the indirect and induced economic impacts attributable to expenditures by recreational visitors at the Refuge Complex for Refuge Management Alternative B and the "No Action" alternative is summarized in Table 4-19.

2. Population Impacts

Management actions associated with the Refuge Complex are not expected to have notable impacts on population trends within the study area. Population trends in Jefferson and Chambers counties have shown increases in recent years though these increases are likely not influenced by activities at the Refuge Complex. Any population change that could be associated with implementation of alternatives under consideration in the EIS would likely be linked to employment changes. Although the Refuge Complex under this management alternative is expected to continue to support in excess of 90 FTEs per year, the Refuge Complex is not considered a major employer in the area and thus would not support a significant proportion of the population.

3. Fiscal Impacts on Local Governments

Refuge management has the potential to impact the fiscal conditions of local government entities. This fiscal effect could be on revenues and/or expenditures. The "Economics Impacts" section above has already evaluated impacts from the various current refuge management activities on indirect business taxes. In addition to the increased indirect business taxes, the USFWS makes substantial payments to local governmental entities under the Refuge Revenue Sharing Act.

Changes in demand for government services could vary with changes in population tied to the Refuge Complex and could cause undue strain on infrastructure (e.g. roads, utilities, schools, etc). As discussed above, since notable population changes are not expected, identifiable changes in demand for government services due to changes in population are not expected. Changes in recreation activities could also cause some impacts to local government services through changes in demand though they are not expected to be notable under current management or any of the other Refuge Management Alternatives.

Management actions can also affect local government services directly. For instance, the USFWS purchases water from the Chambers-Liberty Counties Navigation District (District) to support its management activities. This provides positive impacts to this local District that has experienced a decrease in water purchases due to a decline in rice production in the area.

4. Social Impacts

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, ecosystem management actions such as those made by the USFWS within the Refuge Complex. Additionally, Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them)
- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions)
- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability)
- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others)

The interactions between USFWS activities and people are already evident in the area. Current direct and indirect interactions between the USFWS and the local and regional population base include visitation to the refuges (e.g., recreation opportunities), participation in USFWS volunteer programs, an awareness of refuge activities (but not direct participation in these activities), or simply driving by the Refuge Complex land holdings. These interactions would basically remain the same for the vast majority of the nearby population under any of the Refuge Management Alternatives being considered in this EIS, and there would be a relatively small magnitude and frequency of "new" impacts since the USFWS has been managing lands within the Refuge Complex for many years.

Additionally, implementation of any of the Refuge Management Alternatives would not lead to substantial new population or changes in the demographic or other characteristics of the existing population. One of the most important causes of potentially significant social effects is a new population that is 1) relatively large in relation to the existing population, and/or 2) demographically or socially different than the existing population. Since there would be little change in population or demographics directly or indirectly from any of the alternatives, this cause/effect relationship is not of concern in this EIS analysis.

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Issues would

arise when management activities are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships between the USFWS and Stakeholder Groups

General categories of stakeholder groups describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A summary of potential future relationships between the USFWS and stakeholder groups follows. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole. The following is a list of local stakeholder groups who could be affected by USFWS management activities on the Refuge Complex:

- Residents and/or Employees
- Landowners
- Recreationalists
- Governmental or Quasi-Governmental Agencies
- Businesspersons and/or Business Owners
- Conservation or Environmental Protection Advocates

Overall, USFWS management activities and objectives under all the Refuge Management Alternatives may in some cases conflict with some of the goals, beliefs, and objectives of many of the local stakeholders. This situation will lead to the continued need for the USFWS to interact with the public (see next section) and to find a proper balance to its activities. However, socioeconomic issues would continue to exist among the various stakeholder groups with regard to their opinion of the USFWS role, responsibilities, and actions; many of these issues would remain unresolved in the future as discussed later in this section.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. Under Refuge Management Alternative B, current USFWS public outreach efforts would continue and be expanded.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

The following is a summary of socioeconomic issues associated with USFWS activities at the Refuge Complex. The proposed USFWS management actions under the Refuge Management Alternatives would have no major effect on the existence or resolution of these current issues. Under any of the alternatives for potential management actions:

- There would be points that continue to be in dispute or unsettled between different parties regarding the existence and/or management of the Refuge Complex

- Different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions

- Some people would continue to think positively about the role of the USFWS in the area; others would continue to think negatively about this role; and others would continue to have no opinion or be neutral about the USFWS role and activities within the area

- As with existing conditions, issues would be unresolved and one party could not be determined to be "right" and the other party "wrong" with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future.

Under Refuge Management Alternatives B through E, management philosophies and priorities would change from current conditions. The USFWS management of the Refuge Complex would continue to be primarily oriented to support wildlife habitat management and enhance fish and wildlife values; however, the philosophy of the primary management approach would differ for each Refuge Management Alternative. These different management approaches and philosophies have a relationship with social structures and lifestyle, but the differences among alternatives from a specific social structure/lifestyle perspective would not be substantial except on a localized or case-specific basis. Under all Refuge Management Alternatives, the USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however the "appropriateness" of any chosen alternative would depend on individual and group values, beliefs, and goals.

While the Refuge Management Alternatives support different philosophies and priorities, and the differences among alternatives may be identifiable on a localized basis, the social structure and lifestyle conditions and trends within the Refuge Complex would generally remain the same as current conditions.

d. Environmental Justice

The need to conduct an environmental justice analysis for the Texas Chenier Plain Refuge Complex EIS/CCP/LPP is based on Executive Order (EO) 12898. Several areas have been identified as having potential minority or low-income populations within the primary or secondary study areas. EO 12898 requires an assessment as to whether these populations might be disproportionately affected by the management alternatives.

Based on the results of the socioeconomic and environmental impact analysis conducted for this project, it can be concluded that those persons who reside in and around the Refuge Complex would bear both some adverse effects and some beneficial effects by the continued operation and/or expansion of the Refuge Complex. However, any identified socioeconomic or environmental impacts from continued operation of the Refuge Complex by the USFWS would not be localized nor be placed primarily on the identified minority and/or low-income population components. Overall, the identified minority and/or low-income populations would not be disproportionately affected compared to other segments of the general population in the area.

Additionally, persons of all races and income levels were invited to participate in the public participation process for the EIS, and comments or input into the process from any minority or low-income persons were considered equally with all other persons. Therefore, implementation of any of the Refuge Management Alternatives would be in compliance with EO 12898.

III. IMPACT ANALYSIS FOR REFUGE MANAGEMENT ALTERNATIVE C: EMPHASIS ON NATIVE HABITAT RESTORATION AND ADDRESSING MAJOR THREATS TO THE ECOSYSTEM

Overview

Under this Alternative, the Refuge Complex would focus its management efforts on restoring wetlands, native prairie and woodlots, and on reversing trends of loss and degradation of these native habitats by increasing efforts to address ongoing and future threats from relative sea level rise and altered hydrological regimes. Restoration of native prairie and prairie wetlands would occur on all suitable upland sites. A portion of the historic fresh and intermediate component of the Refuge Complex's coastal marshes would be restored. Efforts to address coastal habitat loss and degradation resulting from shoreline erosion along the Gulf, Galveston Bay and the GIWW and to restore emergent marshes would be intensified by increasing coordination among agencies and other stakeholders. Goals would include implementing a major barrier beach/dune restoration project on McFaddin NWR and marsh restoration on Texas Point NWR through the beneficial use of dredge material. Ongoing interior marsh loss would also be addressed by working with agencies and other stakeholders on major hydrologic restoration projects that restore freshwater inflows and further restrict saltwater intrusion for entire watersheds, and through several smaller hydrologic restoration projects on the refuges. Management efforts to control exotic and invasive plant and animal species would be expanded. The Refuge Complex would continue to provide the current level of opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses.

A. Natural Resources Section

1. Impacts to Air Quality

The USFWS fire management program on the Refuge Complex has the greatest potential of all refuge management actions to impact the region's air quality. Fire management activities include both the suppression of unplanned wildland fires and prescribed burning. Smoke from unplanned wildland fires and from planned prescribed burning can be transported by prevailing winds and affect air quality and transportation safety over a large area which includes the cities of Houston, Beaumont and Port Arthur and numerous smaller local communities.

Under Refuge Management Alternative C, suppression of wildland fires would continue as prescribed in the Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Whenever feasible, natural fires ignited by lightning would be allowed to burn.

Under Refuge Management Alternative C, the USFWS' prescribed burning program on the Refuge Complex would be substantially modified relative to Refuge Management Alternative A. The USFWS would use prescribed burning on the Refuge Complex primarily to reduce accumulations of hazardous fuels and to restore and enhance native marsh and prairie habitats. The annual burning objective under this Alternative would be 5,000 to 6,000 acres (compared to 12,000 – 15,000 acres under Refuge Management Alternative A), and most prescribed burning would occur during spring and summer to mimic the historic fire regime.

Although prescribed burning under Refuge Management Alternative C would continue to be beneficial to the Refuge Complex's habitats and wildlife (as discussed under *Section III.A.4. Impacts to Vegetation and Habitats and Section III.A.5. Impacts to Fish and Wildlife Resources below*); this management action could also negatively impact local air quality, primarily through the production of smoke. The scope of this impact would decrease relative to Refuge Management Alternative A because of the reduced amount

of smoke produced from decreased prescribed burning activities. Prevailing wind directions and other climatic parameters are generally unfavorable for conducting prescribed burns during the spring and summer, and smoke management issues would limit the USFWS' ability to meet annual goals under this Alternative. In addition, the prevalence of unfavorable conditions during spring and summer would increase the potential for unintentional smoke management impacts.

Decreased prescribed burning activities on the Refuge Complex under Refuge Management Alternative C would also result in larger areas with higher vegetative fuel loads. Most lightning-caused wildland fires on the Refuge Complex occur during the months of June through October, when prevailing winds typically include a southerly component which transports smoke towards communities and other smoke-sensitive areas. Wildland fires would be more likely to start in areas with higher fuel loads, and fires that did start would burn with higher intensity, produce more smoke, and would be more difficult to suppress than in areas where prescribed burning reduced accumulations of hazardous fuels.

2. Impacts to Geology and Soils

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

As under Refuge Management Alternative A, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss under this Alternative. On McFaddin and Texas Point NWRs, these partnerships have focused on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Structural erosion abatement projects involving construction of rock breakwaters and shoreline armoring with rip rap along the GIWW on McFaddin NWR have also been implemented. On Anahuac NWR, these efforts have focused on protecting the East Galveston Bay shoreline through offshore breakwater construction and restoration of salt marsh along the shoreline.

Under Refuge Management Alternative C, the USFWS would expand coordination efforts with a goal of substantially increasing the scope and extent of these projects, including implementing a major project to restore the barrier beach/dune system on McFaddin NWR and large-scale structural erosion abatement projects using rock breakwaters along the GIWW and East Galveston Bay shorelines. The USFWS would also implement several small-scale erosion abatement projects on the Refuge Complex.

Although shoreline erosion and retreat and along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has accelerated rates of shoreline retreat along the Gulf shoreline. This reduced sand supply has led to loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges.

The historic barrier beach/dune system has been almost entirely lost on both the Texas Point and McFaddin NWRs. Shoreline erosion and retreat along the Gulf on these refuges is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. Morton *et al*. (2004) found beach erosion between Sabine Pass and High Island to be among the highest in Texas. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and much of the

McFaddin NWR shoreline is eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of habitat, loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of plant productivity may decrease the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water (DeLaune *et al*. 1983, Nyman *et al*. 1993). (On McFaddin NWR, coastal erosion and damage from storm tidal surges have destroyed a portion of Texas State Highway 87, a coastal highway that has been closed since 1989.)

Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels have caused erosional loss of organic marsh soils, also leading to conversion of vegetated marshes to open water. Conversion of vegetated marshes to open water has also occurred throughout the region in areas where rapid land subsidence has resulted in submergence of wetlands. Conversion of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et a*l. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). It is likely that conversion of vegetated marshes to open water have been greatest in areas subject to both saltwater intrusion and rapid subsidence.

Relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

Restoration of the barrier beach/dune system on McFaddin NWR and increased use of dredged material on Texas Point NWR would contribute to increasing coarse sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994). If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR could substantially reduce current rates of land loss. These projects would also restore historic elevations along the shoreline and protect inland marshes, and plant productivity therein, by reducing saltwater intrusion. Offshore rock breakwaters and shoreline armoring would also reduce the erosion of shoreline. Restoring emergent marsh by planting smooth cordgrass along shorelines will reduce land loss and increase sedimentation and vertical accretion within vegetation stands.

Other USFWS management activities on the Refuge Complex under Refuge Management Alternative C would also impact soils and soil formation. Under this Alternative, the USFWS would coordinate with other Federal and State agencies to implement major watershed-based hydrological restoration projects to restore freshwater inflows and restrict saltwater intrusion. Once these projects were implemented, the USWS would replace intensively-manipulated water control structures in some marsh semi-impoundments with more passive rock weir structures. Structural marsh management techniques, such as weirs and impoundments, may affect marsh vertical accretion (Nyman *et al*. 1993). In a survey in Louisiana regarding the effects of weir management on marsh loss, Nyman *et al*. (1993) concluded that weirs did not affect marsh loss or accretion, but that weirs may have different effects under different

hydrological conditions, and that the effects of herbivore activity (muskrats) were important. Bryant and Chabreck (1998) found three structurally managed marshes in the Chenier Plain of Louisiana had significantly lower accretion than adjacent unmanaged marshes, while the fourth managed marsh had higher accretion than the adjacent unmanaged marsh. The managed marsh with higher accretion rates remained permanently flooded, while the three managed marshes with lower accretion underwent frequent drainage. It was hypothesized that structurally managed marshes are hydrologically isolated from tidal sediment subsidies and that frequent forced drying oxidized organic material in the soil. Gabrey and Afton (2001) found that belowground biomass was higher in unimpounded than impounded marshes. Perez and Cahoon (2005) did not find any difference in marsh accretion between structurally managed marshes on McFaddin NWR and adjacent unmanaged marsh.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al.* 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Marsh accretion in the Chenier Plain region's fresher marshes is very dependent on the accumulation of organic matter from plant productivity, as opposed to mineral sediment deposition which is very important in the deltaic marshes of southeastern Louisiana.

Watershed-scale hydrologic restoration projects would reduce saltwater intrusion and increase freshwater and sediment inflows to marshes, resulting in increased plant productivity important to soil formation and marsh surface elevation gain. Hydrologic restoration at a watershed scale will likely be necessary to effectively counter the future effects of relative sea level rise on the region's coastal wetlands. Conversion to more passive water management infrastructure on the Refuge Complex would reduce overall water level and salinity management capabilities in individual managed units, but this may be mitigated by the larger projects.

Prescribed burning could also affect soils and vertical accretion in marshes. Insufficient data exists to adequately address the effects of fire on marsh accretion. Evidence exists suggesting root mass is a significant contributor to vertical accretion via peat formation (DeLaune *et al*. 1983, Nyman *et al*. 1993). In a study on the McFaddin NWR, both root volume and sediment elevation recovered faster in a burned area relative to an unburned area after salt water flooding (M. Ford and D. Cahoon, unpubl. data). Gabrey and Afton (2001) found that unburned and cover-burned Chenier plain marshes showed no differences in belowground biomass. Fire has been shown to increase primary productivity in some Gulf coast marshes (Hackney and Cruz 1981, Gabrey and Afton 2001). While these studies examined the effects of cover burns (burns conducted when sufficient water is present in the marsh to restrict biomass consumption to aerial plant material), root and peat burns can have a profound impact on marsh accretion. Root fires consume the litter layer and shallow root systems, while peat fires burn deeper into the soil consuming available organic matter (Lynch 1941). In most situations, root and peat fires are avoided by carefully monitoring water levels and soil moisture. Nyman and Chabreck (1995) concluded that fire should be used with caution until its effects on marsh accretion is better understood.

The USFWS would also coordinate and support expanded monitoring and scientific research under Refuge Management Alternative C to determine impacts of shoreline and marsh restoration efforts and the effects of habitat management activities such as structural marsh management and prescribed burning on marsh soils and vertical accretion. This would lead to a greater understanding of how to reduce the impacts of ongoing and future relative sea level rise and altered hydrological regimes. For example, monitoring and research would help ensure that structural marsh management and prescribed burning programs are being conducted in a way to maximize marsh accretion while meeting short-term habitat objectives.

3. Impacts to Hydrology and Water Quality

a. Hydrology

Under Refuge Management Alternative C, the USFWS would continue to coordinate with State and Federal agencies on a large-scale hydrological restoration project for marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass, and would expand coordination with stakeholders to evaluate ways to provide additional freshwater inflows to marshes south of the GIWW in Jefferson County. Once these projects were implemented, the USFWS would replace some traditional water control structures on the Refuge Complex with more passive rock weir structures. Under this Alternative, the USFWS would also conduct the following hydrologic restoration activities on the Refuge Complex: 1) acquire additional water rights in order to provide additional freshwater inflows, 2) restore natural channels to historical dimensions and several constructed channels to marsh, 3) restore surface hydrology by removing abandoned agricultural and oil and gas infrastructure, and 4) coordinate local agencies and other partners to repair saltwater barriers.

Hydrologic management and restoration activities would reduce saltwater intrusion, reduce tidal energies in formerly non-tidal or micro-tidal marshes, establish freshwater and sediment inflows and manage water levels to mimic historic hydroperiods (wetting and drying cycles). All would help maintain the historic continuum of fresh to saline marshes, and the diverse plant and animal communities associated with these habitats. All would help to prevent the conversion of vegetated marsh to open water. By promoting plant productivity, hydrological management and restoration activities may also contribute to marsh soil formation and surface elevation gain (marsh accretion). Hydrologic restoration on a watershed scale will likely be necessary to effectively counter the future effects of relative sea level rise on the region's coastal wetlands.

b. Water Quality

Under Refuge Management Alternative C, the USFWS would expand efforts to protect water quality on the Refuge Complex. In addition to activities under Alternative A, this would involve developing enhanced spill response capabilities, supporting additional water quality monitoring, and assessing threats from abandoned oil and gas infrastructure and accumulations of lead shot pellets and remediation of any known problem areas. Overall, these activities would reduce the impacts of point and non-point source pollution sources and accidental spills on water quality, habitats and fish and wildlife resources.

4. Impacts to Vegetation and Habitats

USFWS management activities affecting vegetation and habitats on the Refuge Complex under Refuge Management Alternative C would include all of the habitat management and restoration activities in wetland and upland habitats described under Alternative A. Changes from Alternative A would include a long-term transition to less intensive water management in coastal marsh habitats following completion of watershed-scale hydrologic restoration projects, phasing out of the cooperative rice farming and moist soil management programs, modified use of prescribed burning and controlled grazing, and expanded restoration of native coastal prairie on suitable upland sites.

Public uses on the Refuge Complex, including hunting, fishing, wildlife observation and photography, environmental education and interpretation, would continue under Refuge Management Alternative C. Impacts to vegetation and habitats would be similar to those described for these uses under Refuge Management Alternative A.

Systematic monitoring of vegetation and habitats under the Refuge Complex Biological Program would be expanded under Refuge Management Alternative C.

Management of oil and gas activities through issuance of Special Use Permits would continue as under Alternative A, and would be aimed at minimizing and mitigating for the impacts of these activities on habitats and fish and wildlife resources.

a. Impacts to Vegetation and Habitats from Habitat Management and Restoration Activities

(1). Wetland Specific Management and Restoration

Wetland management and restoration activities under Refuge Management Alternative C would influence the vegetative communities found in Refuge Complex coastal marshes and prairie wetland habitats.

(a). Water Management in Coastal Marshes

Under Refuge Management Alternative C, the USFWS would continue to coordinate with State and Federal agencies on a large-scale hydrological restoration project for marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass. The USFWS would expand coordination with stakeholders to evaluate watershed-scale hydrologic restoration projects, including providing additional freshwater inflows to marshes south of the GIWW in Jefferson County. Use of strategically located below-ground siphons to move freshwater beneath the GIWW to these marshes is one option which would be fully assessed. Once these projects were implemented, the USFWS would replace some traditional water control structures on the Refuge Complex with more passive rock weir structures. Under this Alternative, the USFWS would also conduct the following hydrologic restoration activities on the Refuge Complex: 1) acquire additional water rights in order to provide additional freshwater inflows; 2) restore some natural channels to historical dimensions, and restore several constructed channels to marsh; 3) restore surface hydrology by removing abandoned agricultural and oil and gas infrastructure; and 4) coordinate with local agencies and other partners to repair saltwater barriers.

Hydrologic management and restoration activities would reduce saltwater intrusion, reduce tidal energies in formerly non-tidal or micro-tidal marshes, establish freshwater and sediment inflows and manage water levels to mimic historic hydroperiods (wetting and drying cycles). All would help maintain the historic continuum of fresh to saline marshes, and the diverse plant and animal communities associated with these habitats. All would help to prevent the conversion of vegetated marsh to open water. By promoting plant productivity, hydrological management and restoration activities may also contribute to marsh soil formation and surface elevation gain (marsh accretion). Hydrologic restoration on a watershed scale will likely be necessary to effectively counter the future effects of relative sea level rise on the region's coastal wetlands.

(b). Marsh Restoration

Under the Refuge Management Alternative C, the USFWS would expand coordination with State and Federal agencies with a goal of increasing the level and scope of wetland restoration activities through the beneficial use of dredge material from the maintenance and improvement of navigation channels including the GIWW and the Sabine-Neches Ship Channel. All opportunities to use dredge material in this manner will be fully evaluated. Expanded marsh restoration efforts under Refuge Management Alternative C would increase the amount of vegetated emergent marsh in areas which have converted to open water, providing more productive habitat for native fish and wildlife. Beneficially used dredge material would provide a substrate for reestablishment of marsh vegetation, and increase net sediment supply to marshes which would provides nutrients and increase plant productivity (Chabreck 1976, 1994). Increasing mineral sediment input to marshes through the beneficial use of dredge material would contribute to marsh surface elevation gain. This practice may represent the most practical alternative available to augment marsh vertical accretion and ensure the viability of the region's coastal wetlands in the face of projected relative sea level rise.

Under Refuge Management Alternative C, the USFWS would restore approximately 300 acres of shallow freshwater wetlands in areas currently in the cooperative rice farming program's rotation. Restoration would involve removal of rice field levees to restore surface hydrology and earth moving from designated portions of the lower elevation cuts of the fields to recreate these "pothole" wetlands. Freshwater prairie wetlands on the Gulf Coast have been reduced mainly through development and agriculture (Moulton *et al*. 1997). These freshwater habitats would support submerged, floating and emergent plant communities valuable to migratory birds and other wetland-dependent fish and wildlife.

(c). Moist Soil Management

Under Refuge Management Alternative C, the USFWS would continue to conduct moist soil management at current levels. Moist soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). On Anahuac NWR, 300-400 acres of moist soil units would continue to be managed annually, primarily to provide habitat for wintering waterfowl. This would involve continued water management and mechanical soil manipulations timed to promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia. Approximately 150 acres of the Anahuac's NWR's moist soil units would be flooded throughout the summer to provide brood rearing habitat for Mottled Ducks and whistling ducks. This management regime favors the establishment of perennial wetland plants, including several species of floating and submerged aquatic plants, including arrow head, white water lily, and lotus.

(d). Cooperative Rice Farming Program

Under Refuge Management Alternative C, the USFWS would phase out the cooperative rice farming program on Anahuac NWR. Fallowed rice fields would be restored to native prairie and shallow prairie wetlands. Abandoned rice fields would be susceptible to rapid invasion by Chinese tallow, Eastern baccharis, common rush, and deep-rooted sedge, all of which decrease habitat quality for native wildlife. Extensive and expensive restoration of areas impacted by these invasive plants would be required to restore and maintain native habitats.

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Under Refuge Management Alternative C, approximately 4,535 acres would be restored to native coastal prairie on the Anahuac NWR. This would include restoration of existing fallowed former croplands (2223 acres) and newly-fallowed areas (2312 acres) created as the cooperative rice farming program is discontinued. Of the five Refuge Management Alternatives, native prairie restoration would be most extensive under Alternative C. The newly restored sites, along with existing native prairie remnants, previously restored native prairie sites and other grasslands would be managed using the variety of management tools described in Refuge Management Alternative A. Together, the management and restoration activities undertaken under Refuge Management Alternative C would protect and enhance approximately 5,774 acres of non-saline grasslands on the Refuge Complex. Impacts of burning, grazing, invasive species management and mowing/haying to vegetation and habitats are discussed below in *Section C.4.1.c*.

Over 9 million acres of native tallgrass prairie once occurred along the western Gulf Coast in Texas and Louisiana (Smeins *et a*l. 1991). Based on remnant stands of native grasslands, prairies on the upper Texas coast were characterized by little bluestem, brownseed paspalum, and Indiangrass or eastern gammagrass and switchgrass associations, depending on hydrology (Diamond and Smeins 1984). It is now estimated that 99.8% and 99.6% of little bluestem and eastern gamma grass/switchgrass prairies, respectfully, have been lost in Texas (McFarland 1995). The little bluestem/brownseed paspalum community has been identified as a threatened natural community and the eastern gammagrass/switchgrass community has been identified as an endangered natural community by the Texas Organization for Endangered Species (Diamond *et al*. 1992). Both communities are assigned a Global conservation status rank of "Critically Imperiled" (G1) by The Nature Conservancy (2002).

Prairie restoration and management activities on the Refuge Complex would increase the abundance of native prairie grasses and forbs, helping to restore and maintain natural biological diversity. Many management activities would help control invasive weed and woody species infestations. Restoration and management of native prairie habitat on the Refuge Complex would help conserve an increasingly rare component of the western Gulf Coast ecosystem by restoring and maintaining native prairie plant

associations including little bluestem/brownseed paspalum and eastern gamma grass/switchgrass prairie plant communities.

Seed viability in prairie plants is believed to be reduced in highly fragmented prairie landscapes due to loss of genetic variability as remnant stands become smaller and more isolated. Conservation of existing coastal prairie remnants in the project area is critical because they represent reservoirs of genetic material, and are extremely valuable sources of viable local seed and plant materials. Prairie plants on the upper Texas Coast evolved under relatively unique climatic conditions of high annual rainfall and hydric soils, and future restoration of native prairie in the region depends on the protection of existing viable local seed and plant material sources. Native prairie restoration on the Refuge Complex under Refuge Management Alternative C would help maintain a small but potentially important source of native prairie seed.

(b). Woodlot Restoration and Protection

Under Refuge Management Alternative C, the USFWS would continue management activities as described under Alternative A to protect and diversify 127 acres of existing coastal woodlots and riparian woodlands: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts. In, addition the USFWS would create 29 acres of additional woodland habitat on the Anahuac NWR.

Overall, implementation of the USFWS management actions under this Alternative would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging.

(3). General Habitat Management Activities

Under Refuge Management Alternative C, the USFWS would reduce the use of prescribed burning and controlled livestock grazing on the Refuge Complex, depending more on lightning-ignited fires and herbivory by native wildlife to create habitat diversity. Efforts to control and monitor invasive species would be intensified to enhance native habitats. Coordination in interagency efforts to address threats posed by relative sea level rise would be expanded with a goal of implementing major shoreline restoration projects.

(a). Fire Management - Wildland Fire Suppression and Prescribed Burning

Under Refuge Management Alternative C, the USFWS fire management program would continue to involve both suppression of unplanned wildland fires and prescribed burning. Suppression activities would continue as described in the Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of “Appropriate Management Response” to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Whenever feasible under this Alternative, natural fires ignited by lightning would be allowed to burn.

Under Refuge Management Alternative C, the USFWS’ prescribed burning program on the Refuge Complex would be substantially modified relative to Refuge Management Alternative A. The USFWS would use prescribed burning on the Refuge Complex primarily to reduce accumulations of hazardous fuels and to restore and enhance native marsh and prairie habitats. The annual burning objective under this Alternative would be 5,000 to 6,000 acres (compared to 12,000 – 15,000 acres under Refuge Management Alternative A), and most prescribed burning would occur during spring and summer to mimic the historic fire regime.

Beneficial impacts of the prescribed burning program under this Alternative would be similar but less extensive than those described for burning under Refuge Management Alternative A, and include:

- Hazardous fuels would be reduced within immediate proximity to USFWS and private facilities and structures (to protect life and property). Prescribed burning would lessen the potential of uncontrollable wildfires by reducing the accumulation of rank vegetation and litter.

- Habitat for waterfowl and other migratory birds would be enhanced in burned areas by maintaining early successional plant communities which provide important food resources, by increasing production and nutritional quality of these foods, and by enhancing the availability of these foods by creating openings in otherwise dense stands of vegetation.

- Encroachment of undesirable woody shrubs, including Chinese tallow, bigleaf sumpweed, and Eastern baccharis, would be suppressed. Without fire disturbance, both marsh and prairie habitats on the Refuge Complex are subject to invasion by such woody shrubs, which in turn reduces habitat quality for many grassland-dependent avian species and other wildlife.

Prescribed burning (integrated with control livestock grazing and water management) in wetland habitats on the Refuge Complex would promote the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, and seashore saltgrass. Interstitial vegetation, often seed producing annuals such as sprangletops (*Leptochloa* spp.) and millets (*Echinochloa* spp.) and forbs such as purple ammenia and Delta duck potato, increases after a fire, particularly when followed by grazing and suitable hydrology. Under Refuge Management Alternative C, the proportion of marsh habitat with early successional plant communities would decrease on the Refuge Complex relative to current conditions as fewer acres would be burned. Herbivory by native species such as snow geese and muskrats would also decrease, as burning during fall and early winter provides optimal habitat for these species.

The impacts of prescribed burning in upland grassland habitats under Refuge Management Alternative C would remain the same as under Alternative A and include: 1) maintaining and enhancing native prairie plant communities, including several native grasses and forbs, by enhancing conditions which encourage reproduction and growth of these species; and 2) helping to control invasive plants, most notably Chinese tallow and Eastern baccharis, which often outcompete and replace native grasses in areas where fire has been excluded or its frequency decreased. Under this Alternative, increased summer burning would be expected to be more effective in controlling woody plant encroachment.

Prescribed burning can have detrimental impacts to vegetation and habitats, ranging from an undesirable change in plant species composition to actual conversion of emergent marshes to open water when fires occur at the wrong time. Proper timing of burns under appropriate conditions of soil moisture, fuel loads and fuel moisture is essential to minimize negative impacts. For example, burning under excessively dry conditions could result in plant mortality, consume organic matter and decrease marsh soil elevation, which in turn could result in permanent conversion to open water. Fire increases soil erosion potential until plant regrowth occurs. Recently burned areas are especially susceptible to erosion during storm surges from tropical storms and hurricanes. Hot fires occurring without adequate soil moisture can also cause a temporary reduction in microflora and microfauna in wetland soils. Burning cannot restore lost marsh or counter the effects of excessive flooding or salinity (Chabreck 1994). Burning is not as beneficial in more saline marshes, because the resulting subclimax plant community is not as diverse (Spicer *et al*. 1986).

Under Refuge Management Alternative C, the USFWS prescribed burning program would continue to consider factors including soil and vegetative fuel moisture, seasonality and timing, ignition patterns, habitat type and previous burn history to ensure maintenance of diverse and productive at wetland and upland habitats on the Refuge Complex. Potential for some adverse affects to vegetation and habitats to

occur would decrease under this Alternative because of the reduced acreage burned annually and the reduced frequency of burning.

(b). Controlled Livestock Grazing

Controlled grazing on the Refuge Complex is used (integrated with fire management and water management) to maintain and increase diversity (plant species composition and structural attributes) and productivity in wetland and upland habitats.

Under Refuge Management Alternative C, grazing intensity would be decreased in most fresh and intermediate marsh habitats on the Refuge Complex. Controlled grazing would be applied only in recently burned areas following prescribed burns and natural fires, and lower stocking rates would be used. In upland prairie habitats, where feasible more high intensity/short duration grazing treatments would be used.

Controlled grazing can be an effective and inexpensive tool in wetland and grassland management providing habitat components that benefit waterfowl and other wildlife species. The relation of cattle grazing to wildlife varies considerably, depending on stocking rate, seasonality, plant community, and wildlife concerned (Chabreck 1968). Research indicates that dual use of grasslands by wildlife and livestock is often compatible when livestock grazing is carefully managed and wildlife needs are considered (Holechek 1982).

Grazing (integrated with fire and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant species and communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Decreased grazing intensity and duration in marsh habitats under this Alternative would decrease the abundance of these early successional plant communities. The impacts of grazing on the physical structure of vegetation would be reduced. Overall, plant succession would trend toward higher successional plant communities, primarily marshhay cordgrass, and physical structure towards more tall, dense stands of vegetation than under current grazing management practices.

In general, the beneficial impacts of grazing in wetland habitats under this Alternative would be similar but less extensive than those described under Refuge Management Alternative A, and include:

- Rank vegetation would be reduced, enabling migratory birds access to roots and tubers of mature plants and shoots of new plants.
- Competing growth of marshhay cordgrass and other dominant climax plant communities would be reduced, allowing for the growth of subdominant plant species, many of which are preferred foods of ducks and geese.
- Additional open water habitat would be created, which provides loafing areas for birds and allow them to access aquatic invertebrates.
- Marsh burning would be complemented by prolonging the time that new growth is available for goose use as green browse.
- Plant vigor and plant productivity would be increased, nutrient recycling enhanced, and excessive build-up of residual plant material prevented.
- Hazardous fuel loading would be reduced, reducing the amount and intensity of wildfires.

- Capped soils would be broken through hoof action, assisting in seedling establishment of many preferred food plants.

- Vegetation in recently burned areas would be maintained in more palatable stages for wintering waterfowl.

Carefully managed grazing in coastal prairie habitats increases plant vigor of native prairie grasses and increases overall plant species composition and structural diversity.

Prairie ecosystems in North America are adapted to episodic short duration and high intensity grazing, as bison and other native herbivores concentrated on recently burned areas feeding on new growth and moved on to new recently burned areas as the vegetation matured. Fire and grazing regimes generated a mosaic of prairie habitats, ranging from recently burned and heavily grazed areas to areas with mature grassland plant communities with no recent history of fire or grazing. On a landscape level, this diverse habitat mosaic supported a wide variety of grassland-dependent wildlife species. Under this Alternative, a similar regime would be applied on selected upland units. It is expected that this management regime would increase the diversity of upland habitats (structurally and in plant species composition) on the Refuge Complex, and therefore increase natural biological diversity.

Potential detrimental affects of grazing result primarily from overgrazing and include excessive trampling of vegetation, compaction of soils reducing percolation rates, and increased soil erosion. The deposition of excess nutrients in the form of feces in areas where livestock concentrate (USFWS 1994) may negatively impact surface water quality. Fecal coliform from geese and livestock are the main pollutants contaminating the shellfish waters of East Galveston Bay (Galveston Bay Estuary Program 1995). Warm-season grazing of wetland areas can reduce seed production of annual grasses (Chabreck 1968). Overgrazing in prairie habitats, usually caused by prolonged grazing intensity, can reduce native prairie plant diversity. While prairie ecosystems are adapted to short duration high intensity grazing patterns, extended duration grazing can reduce native grasses and some native forbs, particularly those that are more palatable and are preferentially selected by livestock. Soil disturbance by excessive hoof action can provide conditions favorable for establishment of exotic and invasive plant species such as Chinese tallow, and cattle can spread seed of undesirable plant species by physically carrying them or ingesting them.

Under Refuge Management Alternative C, the USFWS would continue to monitor grazing programs and adjust grazing strategies so as to avoid detrimental impacts. The potential for adverse impacts to vegetation and habitats to occur would decrease under this Alternative.

(c). Invasive Species Management

Under Refuge Management Alternative C, the USFWS would expand invasive species management activities on the Refuge Complex, treating additional areas and increasing partnership efforts. Additional field monitoring and research and enhanced GIS capabilities would be utilized to evaluate the effectiveness of ongoing treatments, to map existing infestations, and to quickly discover and initiate control activities on new infestations. The USFWS would continue to invasive plant species to conserve native biological diversity of the Refuge Complex and to maintain habitat quality for migratory birds and other native wildlife. An Integrated Pest Management (IPM) program would be implemented to control the following invasive plant species (USFWS 1996):

- Chinese tallow, Eastern baccharis, willow, and deep-rooted sedge in freshwater marshes, prairies, woodlots and on levees and roadsides.

- Water hyacinth, alligatorweed, Salvinia, common reed and cattail in waterways and managed wetland units.

- Red rice, coffeebean, barnyard grass, and other grasses in rice.

- Broadleaf weeds and King Ranch bluestem in remnant and restored prairies.

In wetland habitats, these activities would result in removal of undesirable invasive plant species including cattail, common reed, and California bulrush that form dense, homogeneous stands which result in loss of open water as ponds close. Control of invasive floating aquatic plants such as water hyacinth, alligatorweed and Salivinia also restores open water habitats, and promotes the growth of native floating and submerged aquatic plant species important to native fish and wildlife.

The control of Chinese tallow and deep-rooted sedge in prairie and woodlots results in increased diversity of native plants. In woodlots, reduction of Chinese tallow and increasing native tree and shrub abundance is likely to increase abundance of forage insects for migrating birds (especially Lepidopteran larvae) (Barrow and Renne 2001).

Under Refuge Management Alternative C, the USFWS would also continue to control exotic animal species on the Refuge Complex to conserve biological diversity and to maintain habitat quality for migratory birds and other native wildlife. Feral hog control would be conducted as described under Alternative A. Control of feral hogs would decrease damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging, and reduce the creation of disturbed areas that enable establishment of Chinese tallow and other undesirable plants. Control activities for nutria under this Alternative would be the same listed for Refuge Management Alternative A and if implemented, would decrease damage to wetland habitats.

(d). Shoreline Protection and Restoration

As under Refuge Management Alternative A, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss under Alternative C. On McFaddin and Texas Point NWRs, these partnerships have focused on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Structural erosion abatement projects involving construction of rock breakwaters and shoreline armoring with rip rap along the GIWW on McFaddin NWR have also been implemented. On Anahuac NWR, these efforts have focused on protecting the East Galveston Bay shoreline through offshore breakwater construction and restoration of salt marsh along the shoreline. Under this Alternative, the USFWS would implement similar projects.

Under Refuge Management Alternative C, the USFWS would expand interagency coordination efforts with a goal of substantially increasing the scope and extent of these projects. Objectives would include implementing major partnership projects to restore the barrier beaches and dunes on McFaddin NWR, beneficially use dredge material along the Gulf shoreline on Texas Point NWR, and construct large-scale structural erosion abatement projects using rock breakwaters along the GIWW and East Galveston Bay shorelines. Potential offshore sand sources for the restoration of the barrier beaches and dunes on McFaddin NWR are currently being investigated through the U.S. Army Corps of Engineers “Sabine Pass to San Luis Pass Shoreline Erosion Feasibility Study.” Preliminary data indicate viable offshore sand sources may be present.

Restoration of barrier beaches and dunes and placement of dredged material along existing shorelines would reduce rates of shoreline retreat and resulting direct loss of coastal habitats. These activities would positively impact vegetation resources and habitats by restoring upland and protecting existing wetland habitats. Restoration of barrier beaches and dunes the Gulf of Mexico would restore an upland native habitat type which has been almost completely lost, and protect interior intermediate marshes and their plant communities from excessive inundation with saltwater during high tidal events. Rock breakwaters in Galveston Bay and the GIWW would also slow erosion and loss of habitat. They would also enhance marine habitat by functioning as an artificial reef, providing opportunities for oyster spat, barnacles, algae, baitfish, and predator fish utilization. Restoring emergent marsh by planting smooth cordgrass between the breakwaters and existing shorelines would restore vegetated wetlands that have

converted to open water. The stands of smooth cordgrass also would provide habitat for snails, shrimp, crabs, insects, and numerous benthic organisms.

(e). Mowing and Haying

Under the Refuge Management Alternative C, approximately 100 acres of upland grassland habitats would be mowed or hayed annually on the Refuge Complex, the same as current levels. Mowing and haying would result in invigorating growth of many native grasses, while reducing vigor of undesirable herbaceous weeds and woody plants including Chinese tallow and Eastern baccharis. Reduction of this herbaceous and woody cover often results in the "release" of native prairie plants.

b. Impacts from Public Use Programs

Assuming only a small overall increase in visitation to the Refuge Complex (decrease in waterfowl hunting, increase for wildlife observation and photography) under Refuge Management Alternative C, impacts to vegetation and habitats described below would remain similar to those described for Alternative A.

The greatest potential for impacts to vegetation resources and habitats on the Refuge Complex due to recreational uses likely comes from motorized boating activities. Many Refuge Complex hunt areas and fishing areas are accessible only or primarily by motorized boat. Wetland vegetation, especially submerged aquatic vegetation, can be impacted by motorboat activity. For example, propeller scarring has been shown to detrimentally impact seagrass beds in the Laguna Madre in South Texas (Pulich *et al*.1997, Dunton *et al.* 1998) and in Florida (Madley *et al*. 2004). Propeller scarring leaving permanent channels in shallow pond and waterway bottoms on the Refuge Complex has also raised concerns about the potential for increased saltwater intrusion, with concurrent negative impacts on emergent and submergent aquatic vegetation.

Foot traffic in areas open to hunting, fishing, wildlife observation and photography, environmental education and interpretation can lead to vegetation trampling, and in heavy use areas, cause plant mortality. On the Refuge Complex, the more extreme impacts occur in areas heavily used for shoreline fishing. Some vegetation trampling and trailing from hunter foot traffic occurs in marsh habitats in Refuge Complex hunt areas, although these impacts tend to be short-term.

Although visitation would increase under this Alternative, administration and management of these uses would continue and impacts to vegetation and habitats would be expected to remain localized and not substantial. Regulations, including horsepower restrictions and area closures to motorized boating would remain in effect to protect wetland habitats and public safety. Permanent sanctuary areas would be maintained throughout the Refuge Complex, which do not permit access by the public. Access for other recreational and educational uses would be restricted to established trails, boardwalks, and observation platforms. Fishing piers constructed in many heavily used shoreline fishing areas would reduce trailing impacts.

Recreational beach uses and associated vehicular traffic on beaches within the McFaddin NWR has led to habitat damage inland of beaches. Motorized vehicles sometimes illegally travel in vegetated habitats inland of the beach, particularly when high water conditions limit or preclude travel on the beach itself. Under Refuge Management Alternative C, the USFWS would continue routine patrols of the Gulf beaches within McFaddin NWR to protect public safety and natural resources.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

No direct impacts to vegetation and habitats would occur as a result of continued implementation of the Refuge Complex biological program under Refuge Management Alternative C. Continued habitat and vegetation monitoring activities and research studies on the Refuge Complex would support an adaptive management approach, by providing information which helps refine and improve exiting management practices.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative C, oil and gas exploration and development activities on the Refuge Complex would continue to be managed through the issuance of Special Use Permits as under Alternative A. Stipulations in the Special Use Permit include those aimed at minimizing impacts to vegetation and habitats, including required use of specialized equipment, location and size of facilities, and required pollution controls. As per federal regulations (50 CFR 29.21), the USFWS would ensure that impacted sites are restored as closely as possible to pre-project conditions upon cessation of activities. Conditions of the Special Use Permit also require mitigation for all impacted habitats. Required mitigation activities include restoration and/or enhancement of habitats on the Refuge Complex which are similar to those impacted by oil and gas activities.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex under this Alternative would be a reduction of impacts to vegetation and habitats from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative C, the USFWS would increase efforts to develop partnerships with private land owners to restore and enhance native prairie and coastal woodlot habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program. It is anticipated that outreach and partnership efforts under Refuge Management Alternative C would result in additional native prairie and coastal woodlot habitat restoration and enhancement throughout the project area.

5. Impacts to Fish and Wildlife Resources

Under Refuge Management Alternative C, habitat management and restoration and biological program activities on the Refuge Complex would be focused on restoring native habitats and addressing threats to biological integrity and biological diversity, with impacts to conservation of the following important fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians
- Invertebrates

The USFWS would continue to administer the six priority recreational uses of the National Wildlife Refuge System on the Refuge Complex: hunting, fishing, wildlife observation and photography, environmental education and interpretation. These uses impact fish and wildlife resources both directly and indirectly.

USFWS management of oil and gas exploration and development and community outreach and partnership programs would also impact fish and wildlife resources.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Under Refuge Management Alternative C, USFWS habitat management and restoration activities would have impacts on wintering and migrating waterfowl populations on the Refuge Complex. Overall and all else being equal, less intensive water level and salinity management, reducing acres of prescribed burning and grazing intensity in marsh habitats, and phasing out of the cooperative rice farming program under this Alternative would be expected to result in a decrease in wintering and migrating waterfowl populations on the Refuge Complex. On a year to year basis, overall habitat quality for waterfowl on the Refuge Complex will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers on the Refuge Complex can also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative C, approximately 30,000 acres of marsh habitats would continue be structurally managed on the Refuge Complex to enhance habitat for wintering waterfowl, utilizing water control structures, levees, and water delivery systems. Following implementation of large-scale watershed hydrologic restoration projects, some water control structures would be replaced with more passively managed rock weir structures. Hydrologic restoration and marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl. Structural management of brackish and intermediate marshes may directly increase the abundance of preferred plant species, such as Olney bulrush and widgeongrass, which provide food resources for wintering and migrating waterfowl (Chabreck 1976, Broome *et al.* 1995). Management of water levels would also provide optimal conditions for foraging and resting waterfowl. Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976).

On Anahuac NWR, the cooperative rice farming program would be phased out under this Alternative. This would result in loss of 500-700 acres of shallow freshwater wetland habitat, and of the nutritious food sources provided by second growth rice and weed seeds in these habitats. Although this would partially be mitigated for by prairie wetland restoration, it is expected that elimination of the rice farming program would result in decreased wintering waterfowl populations on the Refuge Complex.

Under Refuge Management Alternative C, 300 acres of shallow freshwater “prairie wetlands” would be restored in fallowed rice fields, and approximately 300-400 acres of moist soil units would continue to be managed on Anahuac NWR (no change from current levels). Moist soil management provides optimal conditions for germination and growth of preferred waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia.

Marsh restoration and prairie wetland restoration project implemented under this Alternative would create additional emergent marsh and open water habitats and provide additional habitat for wintering and migrating waterfowl.

(b). General Habitat Management and Restoration Activities

The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex promotes optimum habitat conditions for wintering waterfowl and many additional migratory bird species. As compared to current conditions, reduced prescribed burning and less intensive grazing in marsh habitats under Refuge Management

Alternative C would reduce the amount of optimal habitat for wintering waterfowl on the Refuge Complex. Overall under Refuge Management Alternative C, plant succession would trend toward higher successional plant communities, primarily marshhay cordgrass, and physical structure towards more tall, dense stands of vegetation than under current grazing and prescribed burning management practices.

Waterfowl habitat on the Refuge Complex would be enhanced under this Alternative through expanded control efforts for invasive vegetation such as common reed, cattail, and California bulrush which have formed dense homogeneous stands and resulted in loss open water habitats. Infestations of invasive floating plants such as water hyacinth, alligatorweed and Salvinia would also be controlled to restore and maintain open water habitats. Maintaining an interspersion of open water and vegetated emergent wetlands would provide the habitat diversity needed to support wintering waterfowl and other migratory birds. Restoring open water habitats would increases the production of submerged and floating aquatic plants, an important food source for migratory birds. Control of Chinese tallow and deep-rooted sedge in and adjacent to freshwater marshes, moist soil units and rice fields would also enhance waterfowl habitat.

If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and beneficial use of dredge material projects on Texas Point NWR under Refuge Management Alternative C would enhance wetland habitats for wintering waterfowl on these refuges by reducing tidal overwash of the eroding beach ridge into inland marshes. This would eliminate the salinity spikes in these intermediate marshes caused by overwash events, which increase salinities over large areas for extended periods of time and kill submerged and floating aquatic plants and invertebrates which provide important food resources for waterfowl. Smaller shoreline protection and restoration projects implemented on the Refuge Complex under this Alternative would also protect and enhance wetland habitats important to wintering waterfowl.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Under Refuge Management Alternative C, several habitat management and restoration activities currently conducted on the Refuge Complex would be expected to have positive impacts on Mottled Ducks. Conversely, less intensive water level and salinity management, reducing acres of prescribed burning and grazing intensity in marsh habitats, and phasing out of the cooperative rice farming program under this Alternative would be expected to result in a decrease in the amount of optimal Mottled Duck habitat on the Refuge Complex as compared to current conditions.

(a). Wetlands Management and Restoration

Wetland management and restoration activities on the Refuge Complex under Refuge Management Alternative C would provide enhanced habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Large-scale hydrologic restoration projects would restore and maintain fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. Structural marsh management would enhance diversity and productivity of submerged aquatic vegetation in open water habitats, providing an important year-round food sources for Mottled Ducks.

On Anahuac NWR, the cooperative rice farming program would be phased out under this Alternative. This would result in loss of 500-700 acres of shallow freshwater wetland habitat, and of the nutritious food sources provided by second growth rice and weed seeds in these habitats. Although this would partially be mitigated for by prairie wetland restoration, it is expected that elimination of the rice farming program would negatively impact Mottled Ducks on the Refuge Complex. Rice farming provides reliable shallow freshwater wetland habitat throughout the year, including during the key recruitment periods of nesting and brood rearing.

Under Refuge Management Alternative C, 300 acres of shallow freshwater “prairie wetlands” would be restored in fallowed rice fields, and approximately 300-400 acres of moist soil units would continue to be managed on Anahuac NWR (no change from current levels). Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as “sennabean ponds,” as valuable brood rearing habitat. Restoring these natural “prairie wetlands” would provide brood-rearing habitat in close proximity

to quality nesting habitat (see below). Approximately 100-150 acres of moist soil units would be managed each year specifically to provide brood-rearing habitat for Mottled Ducks during summer.

(b). Uplands Management and Restoration

Expanded native prairie restoration and management activities under Refuge Management Alternative C would benefit Mottled Ducks primarily by restoring and enhancing nesting habitat. The USFWS would restore an additional 4,606 acres of native prairie under this Alternative (the most of any Refuge Management Alternative), and use the integrated application of prescribed burning, controlled livestock grazing, herbicide application and mowing and haying to maintain and enhance grassland habitats and reduce brush encroachment (exotic and native plants) in salty and non-saline prairies. All would be expected to improve nesting success of Mottled Ducks and other ground-nesting avian species.

The historical prairie-wetland continuum of the upper Texas coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and mima mounds that are characteristic of coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Protecting extant stands of coastal prairie and restoring adjacent prairie and prairie wetland habitats under Refuge Management Alternative C on the Refuge Complex would increase quality of habitats important to Mottled Duck recruitment and overall reproductive success.

(c). General Habitat Management Activities

The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex promotes optimum habitat conditions for wintering waterfowl and many additional migratory bird species. As compared to current conditions, reduced prescribed burning and less intensive grazing in marsh habitats under Refuge Management Alternative C would reduce the amount of optimal habitat for Mottled Ducks on the Refuge Complex. Overall under Refuge Management Alternative C, plant succession would trend toward higher successional plant communities, primarily marshhay cordgrass, and physical structure towards more tall, dense stands of vegetation than under current grazing and prescribed burning management practices.

Salt prairies occur as a broad zone between coastal prairies and marshes, or more commonly on the Refuge Complex, as a ridge between marshes and bays or the Gulf of Mexico. These cordgrass ridges are dominated by Gulf cordgrass with marshhay cordgrass, knotroot bristlegrass (*Setaria parviflora*) and some brush species typically subdominant. Higher, well drained, salt prairie ridges juxtaposed with lower wetland areas have been identified as important Mottled Duck nesting areas in the Chenier Plain region of Louisiana (Baker 1983) and Texas (Stutzenbaker 1988). Because of the near total loss of coastal prairie, salt prairie is now the most important Mottled Duck nesting habitat on the Refuge Complex.

Fire is necessary in the management of Mottled Duck nesting habitat in salty and non-saline prairies. Fire must be frequent enough to keep brush at low densities, but infrequent enough to maximize years with dense nesting cover for Mottled Ducks. Under Refuge Management Alternative C, increased reliance on natural fire starts to achieve management objectives in prairie habitats would result in a less predictable results than under the current burning regime.

Improper application of fire and grazing has the potential to negatively impact Mottled Ducks. For example, prescribed burning may result in the excessive removal of vegetation reducing suitability as Mottled Duck nesting habitat, and burning at the wrong time of year could destroy nests (Baker 1983). Overgrazing by cattle may reduce desirable nesting habitat for Mottled Duck in marshes and salty prairies, especially after spring burns (Baker 1983, Stutzenbaker 1988). The potential for negative impacts to Mottled Duck nesting habitat would generally decrease under Refuge Management Alternative C due to lower cattle stocking rates and grazing durations and reduced prescribed burning in fresh and intermediate marshes.

Expanded control efforts for invasive plants and exotic animals under this Alternative would enhance wetland and upland habitats for Mottled Ducks.

Marsh habitats being impacted by tidal overwash of the beach ridges on McFaddin and Texas Point NWRS provide important Mottled Duck production and brood rearing habitats. Based on field observations and capture rates during banding efforts, saltwater inundation has reduced Mottled Duck use of affected areas by as much as 50 to 65% over the last 10 years. If implemented under Refuge Management Alternative C, large-scale restoration of the barrier beach/dune system on McFaddin NWR would enhance wetland habitats important to Mottled Ducks by preventing saltwater intrusion currently resulting from frequent tidal overwash from the Gulf into inland marshes. Smaller shoreline protection and restoration project implemented under this Alternative would also protect and enhance marsh and salty prairie habitats important to Mottled Ducks.

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because of the wide diversity of habitat requirements by this category of birds, USFWS habitat management and restoration activities on the Refuge Complex which result in a mosaic of diverse habitat types (plant species composition, structural characteristics, water levels and salinities) is desirable. As such, most of the wetland and upland habitat management and restoration activities to be continued under Refuge Management Alternative C would positively impact the shorebird, wading bird and marsh bird species currently found on the Refuge Complex. Decreased prescribed burning and reduced grazing intensity and duration under this Alternative would reduce the amount of optimal habitat as compared to current conditions for species requiring more open habitats, but increase habitat availability for some species requiring more dense stands of vegetation. Discontinuation of the cooperative rice farming program would eliminate approximately 500-700 acres of shallow freshwater wetland habitat of high importance to many shorebird and wading bird species.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative C, approximately 30,000 acres of marsh habitats would continue be structurally managed on the Refuge Complex. Following implementation of large-scale watershed hydrologic restoration projects, some water control structures would be replaced with more passively managed rock weir structures. Hydrologic restoration and marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities. Structural management of brackish and intermediate marshes may directly increase the abundance of submerged aquatic vegetation, providing habitat for many invertebrates which serve as an important food source. Management of water levels can provide optimal conditions for foraging and resting shorebirds and wading birds.

Shorebirds and wading birds would benefit from continued moist soil management under Refuge Management Alternative C, but discontinuation of the cooperative rice farming program would result in loss of important shallow freshwater wetland habitat. Rice farming and moist soil management result in increased abundance of invertebrates and plants that are a preferred food source for many avian species in this group (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002).

(b). Uplands Management and Restoration

Under Refuge Management Alternative C, expanded restoration and enhancement of native prairie habitats would provide improved habitat for several species of migrating and wintering marsh birds. Three Avian Species of Conservation Concern (USFWS 2005) would benefit from these activities: Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

As compared to current conditions, reduced prescribed burning and less intensive grazing in marsh habitats under Refuge Management Alternative C would reduce the amount of optimal habitat for shorebirds and wading bird species requiring more open habitats, but may provide additional habitat for some marsh bird species which utilize denser stands of vegetation. Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (*Coturnicops noveboracensis*, Mizell 1998), sparrows (Emberizidae) and wrens (Troglodytidae) (Gabrey *et al*. 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et al*. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al*. 2000). Not surprisingly, these secretive marshland bird species decline in the first year post fire. Other bird species such as Icterids (Gabrey *et al*. 2001) and Wilson's Snipe (*Gallinago delicata*) (USFWS unpublished data) increase immediately post-burn. Overall, species requiring denser stands of vegetation in marsh habitats would benefit from burning and grazing regimes under Refuge Management Alternative C, while the amount of habitat for species requiring more open habitats would decrease.

Expanded invasive plant and exotic animal control activities under Refuge Management Alternative C would enhance wetland and upland habitats for many avian species in this group. The removal of invasive vegetation that forms dense, homogeneous stands resulting in pond closure (such as common reed, cattail, and California bulrush), would improve habitat conditions for wading bird and marsh and waterbird species that utilize open water habitats. Shoreline restoration activities including beach/dune restoration and creation of emergent marsh and mudflats in intertidal zones behind breakwaters would benefit many shorebird and wading bird species.

Under Refuge Management Alternative C, the USFWS would continue to maintain a 1-acre nesting site for Least Terns and Black Skimmers on McFaddin NWR. This site is intensively managed to promote increased nesting success for these species, including providing ideal nesting substrate, excluding mammalian predators, and minimizing disturbance.

(4). Impacts to Landbirds

Landbird species found on the Refuge Complex require a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf coast (Mueller 1981, Barrow *et al.* 2000). Some raptor species prefer intermingled field and forested areas (e.g., red-tailed hawks and owls). Other land bird species prefer grassland habitats including marshes and prairies (Peterson *et al*. 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

All habitat management and restoration activities conducted on the Refuge Complex under Refuge Management Alternative C would benefit avian species in this group. Although comprising a relatively small portion of the overall habitats on the Refuge Complex, restoration, management and protection of native prairies and coastal woodlots are of particular significance because of the importance of these habitats to many passerine species, including many neotropical migratory songbirds.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative C, wetland management and restoration activities including large-scale hydrologic restoration, structural marsh management and marsh and prairie wetlands restoration would have positive impacts on several land bird species. Several land bird species listed as Avian Species of Conservation Concern (USFWS 2005), including the Seaside Sparrow, Nelson's Sharptailed Sparrow and Sprague's Pipit, would benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Under Refuge Management Alternative C, 4,606 acres of existing and newly-fallowed rice fields and other upland areas would be restored to native coastal prairie. This Alternative includes restoration of greatest amount of native prairie of the five Refuge Management Alternatives. The newly restored sites, along with existing native prairie remnants, previously restored native prairie sites and other grasslands would be managed using the variety of management tools described in Refuge Management Alternative A. Together, the management and restoration activities undertaken under Refuge Management Alternative C would protect and enhance approximately 5,774 acres of grassland habitats on the Refuge Complex.

Native prairie remnants, restored sites and other upland grassland habitats on the Refuge Complex provide wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow, and nesting habitat for species including Dicksissel and Eastern Meadowlark. These are also important nesting habitats for Mottled Ducks. Several species of raptors commonly observed on the Refuge Complex include Red-tailed Hawk, Red-shouldered Hawk, Turkey Vulture, American Kestrel, White-tailed Kite, Northern Harrier, and Short-eared Owl (USFWS 1997a). Many other raptor species are observed during spring and fall migrations. Many of the landbirds that would benefit from protection and management of native coastal prairie habitats under Refuge Management Alternative C are species that are declining in the Coastal Prairies Region of Texas (Shackelford and Lockwood 2000), and/or are among several species recently listed by the USFWS as Avian Species of Conservation Concern in the Gulf Prairies Bird Conservation Region (USFWS 2005). White-tailed Hawk, Loggerhead Shrike, Northern Bobwhite, Yellow and Black Rail, Buff-breasted Sandpiper, Short-eared Owl, Sedge Wren, Henslow's Sparrow, and LeConte's Sparrow are all Avian Species of Conservation Concern that would benefit from restoration and management of prairie habitats on the Refuge Complex under this Alternative.

Woodlot Restoration and Management

Under Refuge Management Alternative C, the USFWS would continue management activities as described under Alternative A to protects and diversify 127 acres of existing coastal woodlots and riparian woodlands: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts. In, addition the USFWS would create 29 acres of additional woodland habitat on the Anahuac NWR.

Overall, implementation of the USFWS management actions under this Alternative would have similar impacts to those described under Alternative A, with additional benefits provided by the new woodland habitats. These activities would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging. Species to benefit would include three neotropical migratory birds considered Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler

(c). General Habitat Management Activities

Under Refuge Management Alternative C, the USFWS would reduce prescribed burning and decrease grazing intensity and duration. Seaside Sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al*. (2001) reported that breeding Seaside Sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested. Gabrey *et a*l. (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first

winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (2005) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife. Decreased burning frequency and increased reliance on natural fire starts to meet habitat objectives under Refuge Management Alternative C has potential to either positively or negatively impact some land bird species.

Under this Alternative, the USFWS would expand invasive plant and exotic animal control activities. Control of Chinese tallow would lead to increased diversity of native woody plants in the coastal woodlots, as well as increased forage insects (especially Lepidopteran larvae) for migrating passerines and other birds. Chinese tallow stands have an ecological trap effect for migrant songbirds that are drawn to the cover of the woodlots, but then find insufficient food resources to replenish depleted energy reserves (Barrow and Renne 2001).

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Under Refuge Management Alternative C, the USFWS would expand its coordination with other agencies in support of implementing large-scale hydrologic restoration projects, continue to structurally manage marshes, restore coastal wetlands, and conduct vegetative management activities including prescribed burning, controlled livestock grazing, and exotic plant and animal control. The USFWS would implement additional shoreline restoration and protection, and increase interagency coordination with a goal of implementing major barrier beach/dune restoration on McFaddin and Texas Point NWRs. These activities would protect, restore and enhance estuarine wetlands, and ensure wetland habitat diversity and productivity important to a variety of fish and shellfish species. The continuum of fresh to saline aquatic environments on the Refuge Complex supports highly diverse aquatic vertebrate and invertebrate communities.

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et a*l. 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et a*l. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al.* 1990, Kneib 1991, Rozas 1995).

Structural marsh management using water control structures and levees in managed marsh units can restrict access to managed areas for some aquatic organisms, such as fish and crustaceans (Rogers *et al*. 1992, Kuhn *et al*. 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a natural stable or deteriorating deltaic marsh (Peterson *et al.* 1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown.

Impacts of structural marsh management to fisheries resources have been reduced on the Refuge Complex by incorporating design features into existing water control structures such as vertical slots which allow passage of estuarine organisms, managing structures to facilitate ingress and egress by opening gates during key movement periods, and utilizing rock weirs to counter erosion and enlargement

of tidal waterways (as opposed to traditional fixed crest weirs). These design features and management regimes would be also be incorporated under Refuge Management Alternative C. Increased use of rock weirs under this Alternative may further enhance fisheries access as these structures are semi-permeable and typically contain larger openings than traditional water control structures.

Much of the work on fisheries use of flooded marshes has focused on saline marshes with a high component of *Spartina alternaflora* (Zimmerman *et al.* 1990, Baltz *et a*l. 1993, Peterson and Turner 1994, Knieb and Wagner 1994, Minello *et al*. 1994, Rozas *et al*. 1998, Zimmerman *et a*l. 2000). Brown shrimp, white shrimp, and blue crabs are associated with salt marsh dominated estuaries (Weinstein 1979, Wenner and Beatty 1993). Many of the salt marshes of the western Gulf coast are experiencing rapid subsidence, saltwater intrusion and conversion to open water. Research has suggested that marsh conversion to open water will reach a point beyond which fisheries will decline due to a reduction of total marsh edge (Browder *et al*. 1989). Further, fisheries habitat gained due to marsh breakup is not sustainable in the long term (Browder *et a*l. 1989, Condrey and Fuller 1992). Under this Alternative, activities which restore productive wetland habitats and help reduce rates of marsh loss (hydrologic restoration, marsh restoration using dredge material, structural marsh management and shoreline restoration and protection) would help sustain healthy fisheries resources in the long-term.

(6). Impacts to Threatened and Endangered Species

Three avian species occurring on the Refuge Complex are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon, Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Under Refuge Management Alternative C, protection, restoration and management of coastal wetland habitats on the Refuge Complex would benefit the three avian T&E species. Bald Eagles observed on the Refuge Complex are usually associated with large concentrations of wintering waterfowl. Brown Pelicans utilize shorelines tidal saline ponds for resting and foraging. Shoreline restoration and protection activities would provide improved habitat for Piping Plover and Brown Pelican. Conservation and management of both wetland and upland habitats aimed at ensuring biological integrity and biological diversity under Refuge Management Alternative C would benefit Threatened and Endangered species and many other sensitive or declining native fish and wildlife species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found on the Refuge Complex include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species on the Refuge Complex. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic animals.

In general, habitat management and restoration activities under Refuge Management Alternative C which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of wildlife species.

USFWS management activities under Refuge Management Alternative C which maintain and restore freshwater wetland habitats (major hydrologic restoration projects, structural management of marshes, moist soil management, and restoration of freshwater prairie wetlands) would be particularly beneficial to amphibians and reptiles. Conversely, loss of freshwater wetland habitat provided by rice farming under this Alternative would reduce this habitat type on Anahuac NWR. Freshwater habitat is critical for most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas.

Expanded control of invasive woody species in wetland and upland habitats under this Alternative may decrease habitat quality for certain mammals such as raccoon and striped skunk. Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, and some reptiles, and invertebrates.

Under Refuge Management Alternative C, the USFWS would prescribe burn fewer acres annually, burn primarily in the spring and summer, and depend more on natural fire starts to meet habitat objectives. Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et al*. 1989) summarizes by saying "Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil litter stabilize." Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data). It appears that fire management practices that favor desired vegetation conditions seem to be compatible with maximizing arthropod diversity as long as a mosaic of burned an unburned habitats is maintained.

b. Impacts from Public Use Programs

Assuming a slight increase in visitation to the Refuge Complex under Refuge Management Alternative C, overall impacts to fish and wildlife resources would likely increase slightly over current levels described under Alternative A. Visitation for waterfowl hunting is projected to decrease slightly under this Alternative, while visitation for wildlife observation, photography, environmental education and interpretation is expected to increase.

(1). Impacts to Waterfowl

(a). Waterfowl Hunting

The most direct effect of hunting on the Refuge Complex is the mortality of harvested waterfowl species resulting from the hunting activities. However, because regulations governing harvest in the Central and Mississippi Flyways are developed annually under the USFWS migratory bird hunting regulation frameworks, and are designed to ensure that viable waterfowl populations are sustained over the long-term, continuation of the waterfowl hunting program on the Refuge Complex under Refuge Management Alternative C will not have any measurable effect on overall populations and the long-term viability of these populations.

Many studies have documented the effects of hunting on intensity on the number of birds utilizing an area (Reichholf 1976, Madsen *et al.* 1992 as cited by Fox and Madsen 1997, Wolder 1993). These studies have shown that relatively light hunting pressure can reduce waterfowl abundance in hunted areas. Distribution and habitat use, feeding patterns, and the nutritional status of waterfowl have also been

shown to be affected by hunting activities. Hunting activity can cause birds to alter habitat use, change feeding locations (Madsen 1995), feed more at night (Morton *et al.* 1989) and reduce the amount of time spent feeding (Korschgen *et al.* 1985, Madsen 1995). Collectively, these changes in behavior have the potential to adversely impact the nutritional status of waterfowl (Belanger and Bedard 1995).
Means of access to and within Refuge Complex hunt areas would remain the same as under Refuge Management Alternative A and would include motorized boating (primarily in Oyster, Onion and East Bay bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake and hunt area access ditches on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), non-motorized boating, motorized vehicles, and walking. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use, but these impacts are likely less than those caused by motorized boating.

The continued maintenance of sanctuary areas on the Refuge Complex would be required to mitigate for disturbance impacts from hunting activities under Refuge Management Alternative C. Maintaining existing regulations under this Alternative would also be necessary to help mitigate the impacts of hunting activity-related disturbance to waterfowl. It is possible that hunting activities under Alternative C would result in reduced abundance of wintering waterfowl on the Refuge Complex in years of poor habitat quality due to climatic extremes or tidal flooding from tropical disturbances

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation

Under Refuge Management Alternative C, existing visitor facilities on the Refuge Complex would be maintained and several new facilities would be developed to support these uses on Anahuac, McFaddin and Texas Point NWRs. Means of access for these uses and the presence of visitors result in disturbance impacts to waterfowl, as described under Refuge Management Alternative A. Increased visitation and the presence of new facilities would increase these impacts and expand the areas within which impacts would occur.

Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et a*l. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use.

Disturbance of waterfowl by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993). In wetland habitats, disturbance from “out of vehicle” approaches can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). While some species of waterfowl appear to acclimate to vehicular traffic, and even presence of visitors on trails, boardwalks, and observation platforms, other species are less tolerant of disturbance. Overall it is likely that species composition and abundance of waterfowl is decreased in areas supporting these recreational uses.

(2). Impacts to other Migratory Birds, Shorebirds, Wading Birds, other Marsh and Waterbirds, and Landbirds

(a). Waterfowl Hunting

Although the disturbance impacts of waterfowl hunting under Refuge Management Alternative C on other wetland-dependent migratory and resident birds which are not hunted is likely less than for waterfowl, studies have demonstrated that hunting (including accessing hunt areas) does affect abundance and distribution of these other avian species. The noise associated with shooting likely reduces habitat utilization by shorebirds, wading birds, other marsh and waterbirds, and landbirds using wetland habitats within hunt areas, at least while hunting is occurring. Motorized boating disturbs and displaces many waterbird species (Dahlgren and Korschgen 1992, Knight and Cole 1995), as will non-motorized boats, vehicles and walking through the marsh.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

Under Refuge Management Alternative C, existing visitor facilities on the Refuge Complex would be maintained and several new facilities would be developed to support these uses on Anahuac, McFaddin and Texas Point NWRs. As described under Refuge Management Alternative A, means of access and the presence of visitors result in disturbance impacts to migratory birds. Under Alternative C, increased visitation and the presence of new facilities would increase these impacts and expand the areas within which impacts would occur.

Disturbance of migratory birds by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993) and shoreline areas regularly used for fishing. Along roads through wetland habitats, disturbance from "out of vehicle" approaches for observation and photography can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). Walking on trails tends to displace birds and can cause declines in species richness and abundance (Riffell *et a*l. 1996). Some generalist avian species such as house finches tend to increase near trails, while specialist species such as solitary vireo move away from trails. The zone of influence around trails appears to be approximately 75m for woodland areas adjacent to grasslands (Miller *et al*. 1998).

Disturbance impacts to birds from visitation are often magnified during the breeding season. Color of clothing worn can attract or repel different passerine species based on breeding plumages of those species (Gutzwiller and Marcum 1997). Primary song occurrence and consistency of certain passerines can be impacted by a single visitor (Gutzwiller *et al*. 1994), which could limit the number of breeding pairs and production by those species in disturbed areas (Reijnen and Foppen 1994). Predation on songbird, raptors, colonial nesting species, and waterfowl nests tends to increase near more frequently visited areas (Glinski 1976, Buckley and Buckley 1978, Boyle and Samson 1985, Miller *et al*. 1998).

(3). Impacts to Fisheries

(a). Fishing

The most direct effect of fishing on the Refuge Complex is the mortality of harvested freshwater and saltwater fish, blue crabs, and several fish and shellfish species caught for use as bait. Fishing and crabbing on the Refuge Complex occur under regulations promulgated by the Texas Parks and Wildlife Department. These regulations are designed to ensure that viable fish and shellfish populations are sustained over the long-term.

Continuation of fishing and crabbing on the Refuge Complex under Refuge Management Alternative C should not have any measurable effect on overall populations and the long-term viability of these species' populations.

b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

No impacts to fisheries resources are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative C.

(4). Impacts to Threatened and Endangered Species

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that Bald Eagles, Brown Pelicans and Piping Plovers using Refuge Complex habitats would be subject to the some level of disturbance by public use activities under Alternative C. These impacts are expected to be negligible. Bald Eagles are usually associated with large concentrations of wintering waterfowl that occur in refuge sanctuary areas which are not open to the public. Piping Plovers utilize beach, shoreline and intertidal mudflat habitats primarily during fall and winter, when use of these habitats by the public is lightest. Brown Pelicans readily forage and roost adjacent to human activity and infrastructure. The three T&E avian species do not nest on the Refuge Complex, their presence is transient in nature, and they are highly mobile and able to move to undisturbed areas. Overall, no impacts to Federally-listed or State-listed Threatened and Endangered species are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative C.

(5). Impacts to other Fish and Wildlife Species – Mammals, Amphibians, Reptiles, and Invertebrates

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that mammals and amphibians and reptiles would be subject to some level of disturbance from public use activities occurring on the Refuge Complex under Alternative C. These impacts are expected to be negligible. Vehicles would occasionally strike and kill mammals such as Virginia opossum, armadillo, raccoon and striped skunk, and reptiles and amphibians including alligators, snakes and frogs.

(b). Commercial Alligator Harvest

Under Refuge Management Alternative C, the current adult alligator harvest program would continue to be administered as an economic use on the Refuge Complex. This program is administered under regulations promulgated by Texas Parks and Wildlife Department, and these regulations are designed to ensure that viable alligator populations are sustained over the long-term. In addition, the USFWS regulates the alligator harvest program on the Refuge Complex through issuance of a Special Use Permit which contains stipulations also designed to conserve alligator populations. For example, special regulations are in place to restrict harvest of reproductive-aged alligators and maintain a natural age structure within the Refuge Complex alligator population. Continuation of the commercial alligator harvest program under Alternative B should not have any measurable effect on the long-term viability of alligator populations on the Refuge Complex.

(c). Control of Muskrat Populations

Under Refuge Management Alternative C, muskrat populations could be controlled in specific locations as deemed necessary to protect wetland habitats on the Refuge Complex through issuance of Special Use Permits for trapping and removal by qualified individuals. Herbivory in areas of high density muskrat populations can cause or exacerbate conditions resulting in permanent conversion of vegetated marsh to open water. This is likely to be most prevalent in areas affected by saltwater intrusion or other factors contributing to marsh loss. Trapping and removal of muskrats under this program would have negligible if any impacts on overall muskrat populations and the long-term viability of these populations.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

Under Refuge Management Alternative C, all current surveys, monitoring and research activities for migratory birds, resident wildlife, fisheries and T&E species (described under Refuge Management Alternative A) would continue.

Surveys and monitoring and research activities are useful for tracking and documenting the impacts of various management strategies on fish and wildlife populations, distribution, movements and habitat utilization. This information facilitates implementation of an adaptive management approach which allows continual refinement and improvement of management activities. In some cases, monitoring activities are providing baseline information, previously not available.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative C, the USFWS would continue to manage oil and gas exploration and development activities on the Refuge Complex through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to fish and wildlife resources, including timing of activities to avoid major periods of utilization, required use of specialized equipment, location and size of facilities, and required pollution controls.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex would be a reduced impact on fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative C, the USFWS would increase efforts to develop partnerships with private land owners to restore and enhance native prairie and coastal woodland habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program. It is anticipated that expanded outreach and partnership efforts under Refuge Management Alternative C would result in increased benefits to fish and wildlife resources, and in particular those species dependent upon coastal prairie and woodland habitats.

B. Socioeconomic Resources Section

1. Economic Impacts

Economic impacts from management activities on the Refuge Complex occur in the regional economy in two different ways.

First, there are the direct economic impacts that occur as a result of the economic stimulus of three elements: 1) direct expenditures made by the USFWS to manage operations at the Refuge Complex, 2) value of production from agricultural programs on the Refuge Complex; and 3) expenditures made by recreational visitors to the Refuge Complex.

Second, there are indirect and induced economic impacts which are additional economic activity that occur as a result of the re-spending of these direct economic elements. The indirect and induced economic impacts are measured as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the direct economic elements.. Total economic impacts (direct, indirect and induced) of for this Refuge Management Alternative were estimated using the data and methods discussed below. The analysis compares the impacts from this management alternative to the "No Action" management alternative, which would continue current activities.

The study area for purposes of estimating economic impacts is all of Jefferson and Chambers Counties along with a small portion of Galveston County, which includes the eastern portion of the Bolivar Peninsula east of Rollover Pass.

a. Direct Economic Impacts

(1). Value of Refuge Operations (Direct Expenditures)[14]

Based on information about the activities proposed under Refuge Management Alternative C, an estimate of the operational expenditures was prepared. The estimate is broken out into five-year periods because it is expected that the amounts within certain cost categories would change with time under this Refuge Management Alternative. Because projects would occur throughout the study period, project costs will vary by year. In addition, changes in staffing would occur throughout the study period so salary costs vary annually as well. The estimate of the annual average cost, per five-year period, for Alternative C is summarized in Table 4-20.

The estimate of Refuge Operation's direct expenditures under Refuge Management Alternative C shows a moderate increase [approximately 25%] compared to the $2,695,184 estimate under the "No Action" alternative.

Table 4-20
Average Annual Operational Costs for the Refuge Complex - Alternative C (Direct Expenditures)

Cost Category	Annual Average Expenditures		
	Year 1 – 5	Year 5 - 10	Year 10 - 15
Annual Staff Salaries	$1,768,527	$1,814,394	$1,867,894
Utilities	$43,750	$43,750	$43,750
Travel	$46,948	$46,948	$46,948
Water Purchases	$16,000	$0	$0
Heavy Equip. Rental and Replacement	$93,900	$84,500	$84,500
Annual and Deferred Maintenance	$1,409,283	$1,325,257	$1,332,693
Special Programs	$18,000	$18,000	$18,000
Total Average Expenditures	$3,396,409	$3,332,849	$3,393,785

(2). Value of Production from Refuge Agricultural Programs

(a). Cattle Grazing

The estimate for the value of grazing included some development assumptions regarding the annual average number of AUMs expected to occur under this management scenario. The annual average AUMs are expected to decrease from 23,900 under Refuge Management Alternative A (No Action) alternative to about 11,950 under Refuge Management Alternative C. Using the estimated value of $88.02/AUM determined in the analysis for Refuge Management Alternative A, there is about a 50% decrease in the estimate of the production value of grazing. A summary comparing the changes in AUMs and value of production between Refuge Management Alternatives A and C is contained in Table 4-21.

14 The Value of USFWS Operations Table is essentially done for Refuge Management Alternative A (No Acton). Under the remaining Refuge Management Alternatives (B through E), the USFWS will change the magnitude and intensity of management activities on the Refuge Complex. These actions will show increases or decreases from the baseline direct expenditures by the USFWS in the local economy as indicated in the Value Table above.

Table 4-21
Estimated Production Value of Grazing Activities On Refuge Complex – Refuge Management Alternative C

Alternative	Annual Average AUMS	Value of Annual Production
No Action Alternative	23,900	$2,103,678
Refuge Mgmt. Alternative C	11,950	$1,051,839

(b). Rice Production

Under the development assumptions for this alternative the annual acreage in rice production is will decrease from 600 acres under Refuge Management Alternative A (No Action) to ultimately 0 acres as the cooperative farming program is phased out under Refuge Management Alternative C. The estimated annual value for current rice production of $249,867 determined in the "No Action" alternative would be completely eliminated by the end of the 15-year planning period. A summary comparing the changes in annual average acreage produced and value of production between Refuge Management Alternatives A and C is contained in Table 4-22.

Table 4-22
Estimated Value of Rice Production On Refuge Complex – Refuge Management Alternative C

Alternative	Annual Average Acreage Produced	Value of Annual Production
No Action Alternative	600	$249,867
Refuge Mgmt. Alternative C	0	0

(3) Value of Refuge Recreational Programs

For each management alternative, assumptions were made on how proposed management changes would affect visitation during the study period. These changes are expressed as increases or decreases in the number of non-resident recreational visitors under Refuge Management Alternative A (No Action). The estimated changes in recreational visitors under this alternative are broken out by recreational activity as follows:

Activity	**Change**
Waterfowl Hunting	5% Decrease
Upland Bird Hunting	No change
Fishing	No change
Wildlife Observation	5% Increase

These changes were then applied to the estimate of annual non-resident visits and the estimates of itemized expenditures by recreational activity which were developed for Refuge Management Alternative A (No Action). Table 4-23 contains a summary of the comparison of the annual direct expenditures associated with Recreational visitors to the Refuge Complex between Refuge Management Alternatives A and C.

Table 4-23
Annual Direct Expenditures Associated with Recreational Visitors on Refuge Complex - RM Alternative C

Alternative	Annual Non-resident Visitors	Total Recreational Expenditures
No Action Alternative	35,010	$1,098,923
Refuge Mgmt. Alternative C	36,407	$1,168,996

b. Indirect and Induced Economic Impacts

Indirect and Induced economic impacts are described as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the following three elements: direct expenditures made by USFWS to manage operations at the Refuge Complex, value of agricultural production on the Refuge Complex, and the direct expenditures made by recreational visitors to the Refuge Complex. These direct expenditures create additional economic activity, the indirect and induced impacts, as re-spending of the direct expenditures occur. The indirect and induced impacts are estimated by using a series of economic multipliers applied to the estimates of the direct economic impacts of USFWS activities. IMPLAN was used to apply economic multipliers to the direct economic elements valued above to estimate the indirect and induced impacts to employment, income and indirect business taxes in the study area that can be attributable these USFWS activities.

The indirect and induced economic impacts are measured in the four following areas:

Employment: The annual average estimated employment is measured as Full-Time Equivalents (FTEs). Full-time equivalent employees equal the number of employees on full-time schedules plus the number of employees on part time schedules converted to a full-time basis. This includes direct employment at the Refuge Complex (Approximately 30 FTEs at this time) as well as the additional employment supported in the surrounding area.

Labor Income: Labor income includes employee compensation and proprietary income. Employee compensation is the total wages and salaries of workers who are paid by employers, as well as the value of benefits such as health care, life insurance, retirement payments, and non-cash compensation. Proprietary income consists of payments received by self-employed individuals as income.

Other Property Type Income: This type of income is payments in the form of rents, royalties, dividends, and includes corporate profits.

Indirect Business Taxes: Indirect business taxes include excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses.

(1). Refuge Operations

The comparison between the indirect and induced economic impacts attributable to Refuge Operations for Refuge Management Alternatives A and C is summarized in Table 4-24.

Table 4-24
Economic Impacts of USFWS Operations at Chenier Plain NWR Complex

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	45	45	45
Refuge Management Alternative C	56	54	54
Labor Income			
No Action Alternative	$1,066,457	$1,066,457	$1,066,457
Refuge Management Alternative C	$1,398,105	$1,364,523	$1,383,730
Other Property Type Income			
No Action Alternative	$222,664	$222,664	$222,664
Refuge Management Alternative C	$380,427	$360,019	$361,088
Indirect Business Taxes			
No Action Alternative	$493,149	$493,149	$493,149
Refuge Management Alternative C	$527,874	$537,309	$551,526

2). Refuge Agricultural Program

The comparison between the indirect and induced economic impacts attributable to agricultural activities, cattle grazing and rice farming, on the Refuge Complex for Refuge Management Alternatives A (No Action) and C is summarized in Table 4-25. These impacts reflect a 50% reduction in cattle grazing and a gradual phasing out of the rice farming over the planning period.

Table 4-25
Indirect and Induced Economic Impacts of Agricultural Activities on Refuge Complex – Alternative C

Impact on:	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	20	20	20
Alternative C	12	11	9
Labor Income			
No Action Alternative	$587,382	$587,382	$587,382
Alternative C	$347,390	$314,345	$273,037
Other Property Type Income			
No Action Alternative	$272,759	$272,759	$272,759
Alternative C	$173,100	$148,620	$124,139
Indirect Business Taxes			
No Action Alternative	$87,668	$87,668	$87,668
Alternative C	$52,653	$47,226	$40,442

(3). Refuge Recreational Programs

The comparison between the indirect and induced economic impacts attributable to expenditures by recreational visitors at the Refuge Complex for Refuge Management Alternative A (No Action) and C is summarized in Table 4-26.

Table 4-26
Indirect and Induced Economic Impacts of Recreational Activities at Refuge Complex - Alternative C

Impact on:	Year 1-5	Year 6 – 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	25	26	26
Alternative C	26	27	27
Labor Income			
No Action Alternative	$609,908	$621,374	$629,040
Alternative C	$631,754	$644,737	$653,076
Other Property Type Income			
No Action Alternative	$224,963	$229,144	$231,939
Alternative C	$233,073	$237,808	$240,849
Indirect Business Taxes			
No Action Alternative	$136,816	$139,559	$141,394
Alternative C	$141,569	$144,674	$146,669

2. Population Impacts

Management actions associated with the Refuge Complex under any of the Refuge Management Alternatives are not expected to have notable impacts on population trends within the study area. Population trends in Jefferson and Chambers counties have shown increases in recent years though these increases are likely not influenced by activities at the Refuge Complex. Any population change that could be associated with implementation of alternatives under consideration in the EIS would likely be linked to employment changes. Although the Refuge Complex under this management alternative is expected to continue to support nearly 90 FTEs per year, the Refuge Complex is not considered a major employer in the area and thus would not support a significant proportion of the population.

3. Fiscal Impacts on Local Governments

Refuge management has the potential to impact the fiscal conditions of local government entities. This fiscal effect could be on revenues and/or expenditures. The "Economics Impacts" section above has already evaluated impacts from the various current refuge management activities on indirect business taxes. In addition to the increased indirect business taxes, the USFWS makes substantial payments to local governmental entities under the Refuge Revenue Sharing Act.

Changes in demand for government services could vary with changes in population tied to the Refuge Complex and could cause undue strain on infrastructure (e.g. roads, utilities, schools, etc). As discussed above, since notable population changes are not expected, identifiable changes in demand for government services due to changes in population are not expected. Changes in recreation activities could also cause some impacts to local government services through changes in demand though they are not expected to be notable under any of the Refuge Management Alternatives.

Management actions can also affect local government services directly. For instance, the USFWS purchases water from the Chambers-Liberty Counties Navigation District (District) to support its management activities. This provides positive impacts to this local District that has experienced a decrease in water purchases due to a decline in rice production in the area. Under Refuge Management Alternative C, purchase of water from the District would likely cease with the phasing out the cooperative rice program.

4. Social Impacts

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, natural resource management actions such as those made by the USFWS on the Refuge Complex. Additionally, Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them)
- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions)
- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability)

- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others)

The interactions between USFWS activities and people are already evident in the area. Current direct and indirect interactions between the USFWS and the local and regional population base include visitation to the refuges (e.g., recreation opportunities), participation in USFWS volunteer programs, an awareness of refuge activities (but not direct participation in these activities), or simply driving by the Refuge Complex land holdings. These interactions would basically remain the same for the vast majority of the nearby population under any of the Refuge Management Alternatives being considered in this EIS, and there would be a relatively small magnitude and frequency of "new" impacts since the USFWS has been managing lands within the Refuge Complex for many years.

Additionally, implementation of any of the Refuge Management Alternatives would not lead to substantial new population or changes in the demographic or other characteristics of the existing population. One of the most important causes of potentially significant social effects is a new population that is 1) relatively large in relation to the existing population, and/or 2) demographically or socially different than the existing population. Since there would be little change in population or demographics directly or indirectly from any of the alternatives, this cause/effect relationship is not of concern in this EIS analysis.

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Issues would arise when management activities are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships between the USFWS and Stakeholder Groups

General categories of stakeholder groups describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A summary of potential future relationships between the USFWS and stakeholder groups follows. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole. The following is a list of local stakeholder groups who could be affected by USFWS management activities on the Refuge Complex:

- Residents and/or Employees
- Landowners
- Recreationalists
- Governmental or Quasi-Governmental Agencies
- Businesspersons and/or Business Owners
- Conservation or Environmental Protection Advocates

Overall, USFWS management activities and objectives under all the Refuge Management Alternatives may in some cases conflict with some of the goals, beliefs, and objectives of many of the local stakeholders. This situation will lead to the continued need for the USFWS to interact with the public (see next section) and to find a proper balance to its activities.. However, socioeconomic issues would continue to exist among the various stakeholder groups with regard to their opinion of the USFWS role, responsibilities, and actions; many of these issues would remain unresolved in the future as discussed later in this section.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. Under Refuge Management Alternative C, current USFWS public outreach efforts would continue and be expanded.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

The following is a summary of socioeconomic issues associated with USFWS activities at the Refuge Complex. The proposed USFWS management actions under the Refuge Management Alternatives would have no major effect on the existence or resolution of these current issues.. Under any of the Refuge Management Alternatives:

- There would be points that continue to be in dispute or unsettled between different parties regarding the existence and/or management of the Refuge Complex

- Different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions

- Some people would continue to think positively about the role of the USFWS in the area; others would continue to think negatively about this role; and others would continue to have no opinion or be neutral about the USFWS role and activities within the area

- As with existing conditions, issues would be unresolved and one party could not be determined to be “right” and the other party “wrong” with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future.

Under Refuge Management Alternatives B through E, management philosophies and priorities would change from current conditions. The USFWS management of the Refuge Complex would continue to be primarily oriented to support wildlife habitat management and enhance fish and wildlife values; however, the philosophy of the primary management approach would differ for each Refuge Management Alternative. These different management approaches and philosophies have a relationship with social structures and lifestyle, but the differences among alternatives from a specific social structure/lifestyle perspective would not be substantial except on a localized or case-specific basis. Under all Refuge Management Alternatives, the USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however, the “appropriateness” of any chosen alternative would depend on individual and group values, beliefs, and goals.

While the Refuge Management Alternatives support different philosophies and priorities, and the differences among Alternatives may be identifiable on a localized basis, the social structure and lifestyle conditions and trends within the Refuge Complex would generally remain the same as current conditions.

d. Environmental Justice

The need to conduct an environmental justice analysis for the Texas Chenier Plain Refuge Complex EIS/CCP/LPP is based on Executive Order (EO) 12898. Several areas have been identified as having potential minority or low-income populations within the primary or secondary study areas. EO 12898 requires an assessment as to whether these populations might be disproportionately affected by the management alternatives.

Based on the results of the socioeconomic and environmental impact analysis conducted for this project, it can be concluded that those persons who reside in and around the Refuge Complex would bear both some adverse and some beneficial effects by the continued operation and/or expansion of the Refuge Complex. However, any identified socioeconomic or environmental impacts from continued operation of the Refuge Complex by the USFWS would not be localized nor be placed primarily on the identified minority and/or low-income population components. Overall, the identified minority and/or low-income populations would not be disproportionately affected compared to other segments of the general population in the area.

Additionally, persons of all races and income levels were invited to participate in the public participation process for the EIS, and comments or input into the process from any minority or low-income persons were considered equally with all other persons. Therefore, implementation of any of the Refuge Management Alternatives would be in compliance with EO 12898.

IV. IMPACT ANALYSIS FOR REFUGE MANAGEMENT ALTERNATIVE D – PREFERRED ALTERNATIVE: EMPHASIS ON AN INTEGRATED MANAGEMENT APPROACH COMBINING: 1) EXPANDED HABITAT MANAGEMENT AND RESTORATION PROGRAMS, 2) NEW RESEARCH AND WILDLIFE POPULATION MONITORING, AND 3) INCREASED EFFORTS TO ADDRESS MAJOR THREATS TO THE ECOSYSTEM

Overview

Under this Alternative, the Refuge Complex would continue and expand current habitat management and native habitat restoration programs, with increased monitoring and research to assess management actions and facilitate a more effective adaptive management approach. Wetland habitat management activities for waterfowl, shorebirds and other wetland-dependent migratory birds including structural water management in marshes, prescribed burning, controlled grazing, and moist soil management would be refined and enhanced, and in some cases expanded through development of new infrastructure. Concurrently, additional restoration of native habitats including wetlands, prairie and woodlots would be undertaken to benefit a variety of native fauna, with a focus on priority species identified as in need of conservation through national and international conservation initiatives.

Efforts to address coastal habitat loss and degradation resulting from shoreline erosion along the Gulf, Galveston Bay and the GIWW and to restore emergent marshes would be intensified by increasing coordination among agencies and other stakeholders. Goals would include implementing large-scale partnership projects including barrier beach/dune restoration on McFaddin NWR, marsh and shoreline restoration on Texas Point NWR through the beneficial use of dredge material, and structural shoreline protection along the GIWW and East Galveston Bay. Ongoing interior marsh loss would be addressed by working with agencies and other stakeholders on watershed-scale hydrologic restoration projects that restore freshwater inflows and further restrict saltwater intrusion. The USFWS would also implement several smaller hydrologic restoration and shoreline protection projects on the Refuge Complex. Management efforts to control exotic and invasive plant and animal species would be expanded, and additional efforts implemented to monitor and reduce impacts of contaminants.

Through new partnerships with universities and other agencies, additional research and monitoring would be conducted to better assess impacts of relative sea level rise and to support future conservation planning to address these impacts. Additional monitoring of exotic/invasive plant species, including research to assess the efficacy of ongoing and new control techniques, would be conducted. Additional baseline data on fish and wildlife populations and habitat use would also be collected, with an emphasis on documenting the status of several sensitive or declining species.

The Refuge Complex would also continue to provide and promote opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses: hunting, fishing, wildlife observation and photography, environmental education and interpretation. The Refuge Complex would seek to provide additional recreational opportunities and improve the quality of visitor services and of the visitor experience through construction of additional public use facilities, expanding law enforcement efforts to protect public safety and natural resources, providing additional hunting and fishing opportunities, and developing additional educational programs. Expanded outreach to local communities and private landowners would be aimed at developing new partnerships to further conservation and promote awareness of the region's natural resources.

A. Natural Resources Section

1. Impacts to Air Quality

The USFWS fire management program on the Refuge Complex activities include both the suppression of unplanned wildland fires and prescribed burning. Under Refuge Management Alternative D, suppression of wildland fires would continue as described in the Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Under Refuge Management Alternative D, the USFWS would continue to implement a rotational prescribed burning program on the Refuge Complex. Burning would be conducted in emergent marsh habitats during fall and early winter, and burning in upland grassland habitats during late winter and early spring. Limited summer burning would be initiated where needed to control invasive woody vegetation. The overall annual burning objective would remain unchanged from current levels of 12,000 - 15,000 acres.

The USFWS fire management program has the greatest potential of all refuge management actions to impact the region's air quality. Smoke from unplanned wildland fires and from planned prescribed burning can be transported by prevailing winds and affect air quality and transportation safety over a large area which includes the cities of Houston, Beaumont and Port Arthur and numerous smaller local communities.

Smoke is made up primarily of carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons and other organics, nitrogen oxides, and trace minerals. The composition of smoke varies with fuel type. In general, particulate matter is the major pollutant of concern from wildland fire and prescribed fire smoke. Particulate matter is a general term for a mixture of solid particles and liquid droplets found in the air. Particulate matter from smoke tends to be very small (less than one micron in diameter) and, as a result, is more of a health concern than the coarser particles that typically make up road dust. Because of their size range, particulates scatter light effectively and therefore, reduce visibility easily.

The human health effects from smoke run from irritation of the eyes and respiratory tract to more serious disorders including asthma, bronchitis, reduced lung function, and premature death. Particulate matter is the main source of health effects, but carbon dioxide and toxic air pollutants from wildfires can also cause health concerns (Therriault 2001).

The atmospheric conditions that affect the movement and dispersal of smoke include the following: wind direction, wind speed, mixing height (the elevation in the atmosphere that the smoke mixes and disperses), transport wind speed and direction (the direction and speed of upper level winds responsible for moving the smoke from the immediate area), and Category day/dispersion (a combination of mixing height and transport wind speed to give an over all indicator of smoke dispersion potential). The Category Day 1, 2, 3, 4 or 5 equates to poor, fair, good, very good and excellent smoke dispersal (USFWS 2003).

The USFWS uses prescribed burning on the Refuge Complex primarily to maintain and improve habitat for wintering and migrating waterfowl and other migratory birds and to reduce accumulations of hazardous fuels. Prescribed burning under Refuge Management Alternative D would continue to be beneficial to the Refuge Complex's habitats and wildlife (as discussed under *Section IV.A.4 Impacts to Vegetationand Habitats* and *Section IV.A.5 Impacts to Fish and Wildlife Resources* below).

Prescribed burning has the potential to negatively impact local air quality through the production of smoke. Because prescribed burning is conducted on the Refuge Complex under strict prescriptions which include implementing smoke management measures, impacts to local and regional air quality from the USFWS fire management program will be minimal. Prescription parameters which must be met prior to ignition and for the predicted duration of a prescribed burn specifically aimed at preventing smoke

impacts include surface and transport wind direction and speed, mixing height, ambient air temperature and humidity, and fuel moisture. Both current and predicted climatic conditions are considered when deciding whether to proceed with a burn, and are regularly monitored during the burns as a further safeguard. Reducing smoke impacts to surrounding communities is also an important consideration in planning and implementing suppression actions on all wildland fires occurring on the Refuge Complex**.**

Prescribed burning on the Refuge Complex under these controlled conditions also reduces the potential for smoke impacts to air quality from unplanned wildland fires by effectively managing vegetative fuels. Most lightning-caused wildland fires on the Refuge Complex occur during the months of June through October, when prevailing winds typically include a southerly component which transports smoke towards communities and other smoke-sensitive areas. Wildland fires are less likely to start in areas with reduced fuel loads because of prescribed burning, and fires that do start burn with less intensity, produce less smoke, and are easier to suppress than in unburned areas with excessive accumulations of hazardous fuels.

Wildlife can also be negatively impacted by smoke, particularly where large areas are ignited in a short period of time. The USFWS utilizes techniques to minimize air quality hazards for wildlife on the Refuge Complex, specifically by conducting ignition in a way that provides interspersions of clean air for wildlife to escape to.

Under Refuge Management Alternative D, the USFWS would use updated technologies associated with predictive modeling of climatic conditions and smoke dispersal and movement. The USFWS would conduct additional monitoring of fire behavior, fuel loading, fuel and soil moisture, and climatic conditions and research on the relationship of these variables with smoke production. These tools and information would help to further reduce risks of adverse impacts to local and regional air quality from USFWS fire management program activities.

2. Impacts to Geology and Soils

As under Refuge Management Alternative A, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations under Refuge Management Alternative D to address threats which are resulting in ongoing coastal land loss. On McFaddin and Texas Point NWRs, these partnerships have focused on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Structural erosion abatement projects involving construction of rock breakwaters and shoreline armoring with rip rap along the GIWW on McFaddin NWR have also been implemented. On Anahuac NWR, these efforts have focused on protecting the East Galveston Bay shoreline through offshore breakwater construction and restoration of salt marsh along the shoreline. Under Refuge Management Alternative D, the USFWS would expand coordination efforts with a goal of substantially increasing the scope and extent of these projects, including implementing a major project to restore the barrier beach/dune system on McFaddin NWR, expanded beneficial use of dredge material on Texas Point NWR, and large-scale structural erosion abatement projects using rock breakwaters along the GIWW and East Galveston Bay shorelines. The USFWS would also implement several smaller scale projects on the Refuge Complex.

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

Relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent

scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise may be underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

Although shoreline erosion and retreat and along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has accelerated rates of shoreline retreat along the Gulf shoreline. This reduced sand supply has led to loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges.

The historic barrier beach/dune system has been almost entirely lost on both the Texas Point and McFaddin NWRs. Shoreline erosion and retreat along the Gulf on these refuges is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. Morton *et al*. (1998) found beach erosion between Sabine Pass and High Island to be among the highest in Texas. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and significant portions of the McFaddin NWR shoreline is eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of habitat, loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of plant productivity may decrease the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water (DeLaune *et al*. 1983, Nyman *et al*. 1993). (On McFaddin NWR, coastal erosion and damage from storm tidal surges have destroyed a portion of Texas State Highway 87, a coastal highway that has been closed since 1989.)

Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels have caused erosional loss of organic marsh soils, also leading to conversion of vegetated marshes to open water. Conversion of vegetated marshes to open water has also occurred throughout the region in areas where rapid land subsidence has resulted in submergence of wetlands. Conversion of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et al*. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). It is likely that conversion of vegetated marshes to open water have been greatest in areas subject to both saltwater intrusion and rapid subsidence.

Restoration of the barrier beach/dune system on McFaddin NWR and increased use of dredged material on Texas Point NWR under Refuge Management Alternative D would contribute to increasing coarse sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994). If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR could substantially reduce current rates of land loss. These projects would also restore historic elevations along the shoreline and protect inland

marshes, and plant productivity therein, by reducing saltwater intrusion. Offshore rock breakwaters and shoreline armoring would also reduce the erosion of shoreline. Restoring emergent marsh by planting smooth cordgrass along shorelines will reduce land loss and increase sedimentation and vertical accretion within vegetation stands.

Other USFWS management activities on the Refuge Complex under Refuge Management Alternative D would also impact soils and soil formation. Under this Alternative, the USFWS would enhance hydrologic management in several existing marsh units by developing additional infrastructure. Structural marsh management techniques, such as weirs and impoundments, may affect marsh vertical accretion (Nyman *et al.* 1993). In a survey in Louisiana regarding the effects of weir management on marsh loss, Nyman *et al.* (1993) concluded that weirs did not affect marsh loss or accretion, but that weirs may have different effects under different hydrological conditions, and that the effects of herbivore activity (muskrats) were important. Bryant and Chabreck (1998) found three structurally managed marshes in the Chenier Plain of Louisiana had significantly lower accretion than adjacent unmanaged marshes, while the fourth managed marsh had higher accretion than the adjacent unmanaged marsh. The managed marsh with higher accretion rates remained permanently flooded, while the three managed marshes with lower accretion underwent frequent drainage. It was hypothesized that structurally managed marshes are hydrologically isolated from tidal sediment subsidies and that frequent forced drying oxidized organic material in the soil. Gabrey and Afton (2001) found that belowground biomass was higher in unimpounded than impounded marshes. Perez and Cahoon (2005) did not find any difference in marsh accretion between structurally managed marshes on McFaddin NWR and adjacent unmanaged marsh.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Marsh accretion in the Chenier Plain region's fresher marshes is very dependent on the accumulation of organic matter from plant productivity, as opposed to mineral sediment deposition which is very important in the deltaic marshes of southeastern Louisiana.

Large and small hydrologic restoration projects implemented under Refuge Management Alternative D would reduce saltwater intrusion and/or increase freshwater inflows to marshes on the Refuge Complex, resulting in increased plant productivity important to soil formation and marsh surface elevation gain.

Prescribed burning could also affect soils and vertical accretion in marshes. Insufficient data exists to adequately address the effects of fire on marsh accretion. Evidence exists suggesting root mass is a significant contributor to vertical accretion via peat formation (DeLaune *et al.* 1983, Nyman *et al*. 1993). In a study on the McFaddin NWR, both root volume and sediment elevation recovered faster in a burned area relative to an unburned area after salt water flooding (M. Ford and D. Cahoon, unpubl. data). Gabrey and Afton (2001) found that unburned and cover-burned Chenier plain marshes showed no differences in belowground biomass. Fire has been shown to increase primary productivity in some Gulf coast marshes (Hackney and Cruz 1981, Gabrey and Afton 2001). While these studies examined the effects of cover burns (burns conducted when sufficient water is present in the marsh to restrict biomass consumption to aerial plant material), root and peat burns can have a profound impact on marsh accretion. Root fires consume the litter layer and shallow root systems, while peat fires burn deeper into the soil consuming available organic matter (Lynch 1941). In most situations, root and peat fires are avoided by carefully monitoring water levels and soil moisture. Nyman and Chabreck (1995) concluded that fire should be used with caution until its effects on marsh accretion is better understood.

The USFWS would also coordinate and support expanded monitoring and scientific research through partnerships with the U.S. Geological Survey and universities under Refuge Management Alternative D to determine impacts of shoreline and marsh restoration efforts and the effects of habitat management activities such as structural marsh management and prescribed burning on marsh soils and vertical

accretion. This would lead to a greater understanding of how to reduce the impacts of ongoing and future relative sea level rise and altered hydrological regimes. For example, monitoring and research would help ensure that structural marsh management and prescribed burning programs are being conducted in a way to maximize marsh accretion while meeting short-term habitat objectives.

3. Impacts to Hydrology and Water Quality

a. Hydrology

Under Refuge Management Alternative D, the USFWS would expand current wetland management and restoration activities aimed at minimizing or mitigating impacts of altered hydrological regimes on plant, fish and wildlife resources. Under this Alternative, the USFWS would improve water management capabilities in managed marsh units by installing new infrastructure, attempt to adjudicate additional water rights in order to provide additional freshwater inflows, develop on-refuge capabilities to deliver additional freshwater inflows, reduce saltwater intrusion by restoring man-made channels and by working with partners to repair several off-refuge saltwater barriers, and restore surface hydrology by removing abandoned agricultural and oil and gas infrastructure, and restore hydrology by restoring natural channels to historical dimensions. The USFWS would also continue to coordinate with State and Federal agencies on a large-scale hydrological restoration project for marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass and on projects to reestablish freshwater inflows to the marshes south of the GIWW in Jefferson County.

Watershed-scale and refuge-specific hydrologic management and restoration projects implemented under Refuge Management Alternative D would help maintain and/or restore the region's historic continuum of fresh, intermediate, brackish and saline marshes. In turn, these habitats would support a natural diversity of native plant, fish and animal communities. Restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) in coastal marshes would also help to prevent the conversion of vegetated marsh to open water, promote plant productivity and contribute to marsh surface elevation gain.

b. Water Quality

Under Refuge Management Alternative D, the USFWS would expand efforts to protect water quality on the Refuge Complex. In addition to activities under Alternative A, this would involve developing enhanced spill response capabilities, supporting additional water quality monitoring, assessing threats from abandoned oil and gas infrastructure and accumulations of lead shot pellets, and remediation of any known problem areas. Overall, these activities would reduce the impacts of point and non-point source pollution sources and accidental spills on water quality, habitats and fish and wildlife resources.

4. Impacts to Vegetation and Habitats

USFWS management activities affecting vegetation and habitats on the Refuge Complex under Refuge Management Alternative D would include all of the habitat management and restoration activities in wetland and upland habitats described under Refuge Management Alternative A. The USFWS would refine and in some cases expand these programs, as directed by new research and monitoring programs aimed at facilitating an adaptive approach to management.

Public uses on the Refuge Complex, including hunting, fishing, wildlife observation and photography, environmental education and interpretation, would continue under Refuge Management Alternative D. The USFWS would seek to provide additional recreational opportunities and improve the quality of visitor services and of the visitor experience through construction of additional public use facilities, expanding law enforcement efforts to protect public safety and natural resources, providing additional hunting and fishing opportunities, and developing additional educational programs. Impacts to vegetation and habitats would be similar to those described for these uses under Refuge Management Alternative A.

Systematic monitoring of vegetation and habitats under the Refuge Complex Biological Program would be expanded under Refuge Management Alternative D.

Management of oil and gas activities through issuance of Special Use Permits would continue as under Alternative A, and would be aimed at minimizing and mitigating for the impacts of these activities on habitats and fish and wildlife resources.

a. Impacts to Vegetation and Habitats from Habitat Management and Restoration Activities

(1). Wetland Specific Management and Restoration

As discussed under *Sections IV.A.2 Impacts to Geology and Soils* and *IV.A.3. Impacts to Hydrology and Water Quality*, wetlands management and restoration activities on the Refuge Complex impact geology, soils and hydrologic regimes. Such activities also strongly influence the vegetative communities found in Refuge Complex coastal marshes and prairie wetland habitats.

(a). Water Management in Coastal Marshes

Under Refuge Management Alternative D, the USFWS would expand current wetland management and restoration activities aimed at minimizing or mitigating impacts of altered hydrological regimes on plant, fish and wildlife resources. The USFWS would continue to coordinate with State and Federal agencies on watershed-scale hydrological restoration projects including projects to reestablish freshwater inflows to the marshes south of the GIWW in Jefferson County. A second major project would reduce saltwater intruision in marshes in the eastern Salt Bayou watershed affected by the Keith Lake Fish Pass. Use of strategically located below-ground siphons to move freshwater beneath the GIWW to these marshes is one option which would be fully assessed. Under Refuge Management Alternative D, the USFWS would expand use of GIS and remote sensing technologies to detect and track changes in emergent marsh to open water ratios and in vegetative communities relative to hydrologic management and restoration activities.

The USFWS would continue to structurally manage approximately 12,000 and 18,000 acres of marsh habitats on the Anahuac NWR and McFaddin NWR, respectively. Water management on Texas Point NWR would continue to be conducted in a passive manner, primarily using rock weirs in man-made ditches and canals. The USFWS would improve water management capabilities in managed marsh units by installing new infrastructure. Under this Alternative, the USFWS would also conduct the following hydrologic restoration activities on the Refuge Complex: 1) adjudicate additional water rights in order to provide additional freshwater inflows; 2) restore some natural channels to historical dimensions, and restore several constructed channels to marsh; 3) restore surface hydrology by removing abandoned agricultural and oil and gas infrastructure; and 4) coordinate with partners to repair saltwater barriers.

Coastal marshes provide important food resources and cover to a diversity of wetland-dependent resident and migratory fish and wildlife species. These marshes also provide buffering of tidal storm surge, reduce flooding, and filter excessive nutrients and other contaminants. Threats to the Chenier Plain region's coastal marshes include altered hydrology resulting in increased saltwater intrusion and loss of freshwater and sediment inflows, and rising sea levels and land subsidence. These processes are resulting in coastal land loss as shorelines are eroded and recede and as inland vegetated wetlands convert to open water, which in turn is decreasing habitat quantity and quality for native fish and wildlife.

Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976). Merino *et al*. (2005) found that managed areas, particularly those without complete levees, had more submerged aquatic vegetation than unmanaged areas. Marsh restoration using semi-impoundments in Louisiana reversed the deleterious effects of excessive tidal exchange caused by channelization (Hess *et al.* 1989). This restoration project caused both emergent and submergent vegetation to flourish. Monitoring efforts on and around McFaddin NWR indicated that diversity indices for both emergent and submergent plants were higher within structurally managed marshes compared to adjacent unmanaged marshes (USFWS 2006). This was largely due to the presence of plants with lower

salinity tolerances, indicating that this marsh management program is at least partially meeting objectives. Chabreck (1994) stresses that careful planning and implementation is required in order for structural marsh management to reverse the negative effects of hydrological alterations and maintain critical wetland functions.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al.* 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al.* 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exacerbate flooding, further reducing plant vigor. USFWS water management activities in fresh to brackish coastal marshes on the Refuge Complex reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying. These management activities therefore benefit soil formation and vertical accretion by increasing plant productivity and preventing oxidation of marsh soils.

Hydrologic management and restoration activities on the Refuge Complex under this Alternative would help to maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes and the native plant, fish and animal communities that depend on these habitats. On a watershed scale, restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater and sediment inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) in coastal marshes would also help to prevent the conversion of vegetated marsh to open water. By promoting plant productivity, these activities may also contribute to marsh soil formation and surface elevation gain (marsh accretion). Hydrologic restoration on a watershed scale will likely be necessary to effectively counter the future effects of relative sea level rise on the region's coastal wetlands.

(b). Marsh Restoration

Under the Refuge Management Alternative D, the USFWS would expand coordination with State and Federal agencies with a goal of increasing the level and scope of wetland restoration activities through the beneficial use of dredge material from the maintenance and improvement of navigation channels including the GIWW and the Sabine-Neches Ship Channel. All opportunities to use dredge material in this manner will be fully evaluated. Expanded marsh restoration efforts under Refuge Management Alternative D would increase the amount of vegetated emergent marsh in areas which have converted to open water, providing more productive habitat for native fish and wildlife. Beneficially used dredge material would provide a substrate for reestablishment of marsh vegetation, and increase net sediment supply to marshes which would provides nutrients and increase plant productivity (Chabreck 1976, 1994). Increasing mineral sediment input to marshes would contribute to marsh surface elevation gain. This practice may represent the most practical alternative available to augment marsh vertical accretion and ensure the viability of the region's coastal wetlands in the face of projected relative sea level rise.

Under Refuge Management Alternative D, the USFWS would restore approximately 100 acres of shallow freshwater wetlands. Restoration would involve removal of rice field levees to restore surface hydrology and earth moving from designated portions of the lower elevation cuts of the fields to recreate these "pothole" wetlands. Freshwater prairie wetlands on the Gulf Coast have been reduced mainly through development and agriculture (Moulton *et al.* 1997). These freshwater habitats would support submerged, floating and emergent plant communities valuable to migratory birds and other wetland-dependent fish and wildlife.

(c). Moist Soil Management

Approximately 690 additional acres of moist soil units would be developed on the Refuge Complex under Refuge Management Alternative D (590 acres on Anahuac NWR, 100 acres on McFaddin NWR).

Expanded moist soil management would increase biological diversity on the Refuge Complex. Moist-soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). Water management and mechanical soil manipulations in new moist soil units would promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia. Additional moist soil units would be flooded throughout the summer to provide brood rearing habitat for Mottled Ducks and whistling ducks. This management regime would favor the establishment of perennial wetland plants, including several species of floating and submerged aquatic plants, including arrow head, white water lily, and lotus.

(d). Cooperative Rice Farming Program

Under the Refuge Management Alternative D, the USFWS would continue to implement a cooperative rice farming program on Anahuac NWR to provide shallow freshwater wetland habitat and nutritious food resources for wintering and migrating waterfowl, resident Mottled Ducks, shorebirds, and wading birds. Rice farming would continue on 500 to 700 acres annually on a three-year rotation, leaving approximately 1,000 to 1,200 acres of the Refuge farm as “maintenance” acreage. Almost 80% of the rice produced on the Refuge is now organically grown. Under this Alternative, the USFWS would continue the trend towards increased use of organic farming in the cooperative farming program.

Continuation of the cooperative rice farming program on Anahuac NWR under Refuge Management Alternative D would provide shallow freshwater wetland habitat and serve several management outcomes for migratory bird management on the Refuge Complex: creating forage for migrating and wintering waterfowl, habitat for migrating shorebirds, and freshwater habitat for breeding and brood rearing Mottled Ducks and fulvous and black-bellied whistling ducks. Flooding after harvest makes existing waste grain available to waterfowl and often produces a second crop of rice, which is also left for wildlife. Fall and winter flooding allows migratory waterfowl to exploit waste rice and other weeds found in the fields. During migration and wintering periods, waterfowl and waterbirds extensively use post-harvest ricefields that were cultivated and at least partially flooded (Czech and Parsons 2002). Managed rice fields on the Refuge Complex provide wintering and migrational habitat for Blue-winged Teal, Northern Pintail, Green-winged Teal and Snow Geese, several shorebird species including Long-billed Dowitchers and Semi-palmated, Western, Least, White-rumped, Baird’s, Pectoral, Stilt and Buff-breasted sandpipers, and for several wading bird species. Mottled Ducks also heavily use habitats adjacent to rice fields for nesting (Stutzenbaker 1988). Rice farming also helps to offset waterfowl consumption of crops on adjacent privately-owned croplands.

Rice production has declined during the last decade in counties surrounding the Refuge Complex, reducing this type of agricultural wetland habitat for waterfowl, shorebirds and other wetland-dependent species. Other changes in rice cultivation practices may also have deleterious effects on waterbird populations. Abandoned rice fields and pasturelands are susceptible to invasion by Chinese tallow, eastern baccharis, common rush, and deep-rooted sedge, all of which decrease habitat quality and will require extensive restoration efforts.

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Under Refuge Management Alternative D, approximately 2,223 acres of native prairie would be restored on fallowed former croplands on Anahuac NWR. The USFWS would continue to protect and manage newly and previously restored sites, existing prairie remnants and other grasslands using an integrated program which includes: 1) conducting a rotational prescribed burning program on remnant and restored prairies which includes initiation of summer burning where needed to control invasive woody species; 2) conduct a rotational livestock grazing program on upland grassland habitats which includes more short duration, high intensity grazing applications; 3) utilize an integrated pest management program, consisting of herbicide application, mechanical removal, burning and controlled livestock grazing to

manage invasive plant species such as Chinese tallow and deep-rooted sedge which are negatively impacting upland habitats; and 5) mow or hay approximately 100 acres annually. In addition, the USFWS would develop a 5-acre native prairie propagation area to increase availability viable seeds for future restoration efforts.

Over 9 million acres of native tallgrass prairie once occurred along the western Gulf Coast in Texas and Louisiana (Smeins *et al*. 1991). Based on remnant stands of native grasslands, prairies on the upper Texas coast were characterized by little bluestem, brownseed paspalum, and Indiangrass or eastern gammagrass and switchgrass associations, depending on hydrology (Diamond and Smeins 1984). It is now estimated that 99.8% and 99.6% of little bluestem and eastern gamma grass/switchgrass prairies, respectfully, have been lost in Texas (McFarland 1995). The little bluestem/brownseed paspalum community has been identified as a threatened natural community and the eastern gammagrass/switchgrass community has been identified as an endangered natural community by the Texas Organization for Endangered Species (Diamond *et al.* 1992). Both communities are assigned a Global conservation status rank of "Critically Imperiled" (G1) by The Nature Conservancy (2002).

Together, the management and restoration activities undertaken under Refuge Management Alternative D would protect and enhance approximately 5,774 acres of non-saline grasslands on the Refuge Complex. Impacts of burning, grazing, exotic/invasive species management and mowing and haying to vegetation and habitats are discussed below in *Section IV.A.4.(3) Other Habitat Management Activities*. Overall, prairie restoration and management activities on the Refuge Complex would increase the abundance of native prairie grasses and forbs, helping to restore and maintain natural biological diversity. Many management activities would help control invasive weed and woody species infestations. Management and restoration of native prairie habitat on the Refuge Complex would help conserve an increasingly rare component of the western Gulf Coast ecosystem by restoring and maintaining native prairie plant associations including little bluestem/brownseed paspalum and eastern gamma grass/switchgrass prairie plant communities.

Seed viability in prairie plants is believed to be reduced in highly fragmented prairie landscapes due to loss of genetic variability as remnant stands become smaller and more isolated. Conservation of existing coastal prairie remnants in the project area is critical because they represent reservoirs of genetic material, and are extremely valuable sources of viable local seed and plant materials. Prairie plants on the upper Texas Coast evolved under relatively unique climatic conditions of high annual rainfall and hydric soils, and future restoration of native prairie in the region depends on the protection of existing viable local seed and plant material sources. Native prairie restoration on the Refuge Complex under Refuge Management Alternative D would help maintain a small but potentially important source of native prairie seed.

(b). Woodlot Restoration and Protection

Under Refuge Management Alternative D, the USFWS would continue management activities as described under Alternative A to protects and diversify 127 acres of existing coastal woodlots and riparian woodlands: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts. In, addition the USFWS would create 29 acres of additional woodland habitat on the Anahuac NWR under this Alternative, and assess site suitabitlity for woodlot restoration throughout the Refuge Complex.

Overall, implementation of the USFWS management actions under this Alternative would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging.

(3). Other Habitat Management Activities

Under Refuge Management Alternative D, the USFWS would refine and enhance prescribed burning and controlled livestock grazing programs to increase benefits to migratory birds and other wildlife. The integrated combination of burning, grazing and water management on the Refuge Complex maintains a diverse mosaic of wetland vegetative communities, both in plant species composition and structural attributes. Efforts to control and monitor invasive species would be intensified to enhance native habitats. Coordination in interagency efforts to address threats posed by relative sea level rise would be expanded with a goal of implementing major shoreline restoration projects.

(a). Fire Management - Wildland Fire Suppression and Prescribed Burning

Under Refuge Management Alternative D, the USFWS fire management program would continue to involve both suppression of unplanned wildland fires and prescribed burning. Suppression activities would continue as described in the Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources.

Under Refuge Management Alternative D, the USFWS would initiate summer prescribed burning in wetland and upland habitats on the Refuge Complex. The USFWS would continue to use prescribed burning on the Refuge Complex primarily to reduce accumulations of hazardous fuels and to restore and enhance native marsh and prairie habitats. The annual burning objective under this Alternative would remain at current levels of 12,000 to 15,000 acres annually.

Beneficial impacts of the prescribed burning program under this Alternative would be similar to those described for burning under Refuge Management Alternative A, and include:

- Hazardous fuels would be reduced within immediate proximity to USFWS and private facilities and structures (to protect life and property). Prescribed burning would lessen the potential of uncontrollable wildfires by reducing the accumulation of rank vegetation and litter.

- Habitat for waterfowl and other migratory birds would be enhanced in burned areas by maintaining early successional plant communities which provide important food resources, by increasing production and nutritional quality of these foods, and by enhancing the availability of these foods by creating openings in otherwise dense stands of vegetation.

- Encroachment of undesirable woody shrubs, including Chinese tallow, bigleaf sumpweed, and Eastern baccharis, would be suppressed. Without fire disturbance, both marsh and prairie habitats on the Refuge Complex are subject to invasion by such woody shrubs, which in turn reduces habitat quality for many grassland-dependent avian species and other wildlife.

Prescribed burning (integrated with control livestock grazing and water management) in wetland habitats on the Refuge Complex would promote the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, and seashore saltgrass. Interstitial vegetation, often seed producing annuals such as sprangletops (*Leptochloa* spp.) and millets (*Echinochloa* spp.) and forbs such as purple ammenia and Delta duck potato, increases after a fire, particularly when followed by grazing and suitable hydrology. Under Refuge Management Alternative D, the proportion of marsh habitat with early successional plant communities would increase over current conditions due the application of more intensive grazing in some areas. Initiation of summer burning under this Alternative would be expected to be more effective in controlling woody plant encroachment.

The impacts of prescribed burning in upland grassland habitats under Refuge Management Alternative D would remain the same as under Alternative A and include: 1) maintaining and enhancing native prairie plant communities, including several native grasses and forbs, by enhancing conditions which encourage reproduction and growth of these species; and 2) helping to control invasive plants, most notably Chinese tallow and Eastern baccharis, which often outcompete and replace native grasses in areas where fire has been excluded or its frequency decreased. Under this Alternative, initiation of summer burning would be expected to be more effective in controlling woody plant encroachment. An example of an adaptive management approach likely to be implemented in prairie habitats under this Alternative is as follows. Once healthy stands of native warm-season grass cover has been established through late dormant-season burning, growing season burning would be initiated to reduce Chinese tallow and Eastern baccharis and increase diversity of native prairie grasses and forbs. It is expected that healthy stands of native prairie grasses would provide sufficient fuels to induce fire behavior and intensity capable of reducing infestations of invasive woody vegetation. A complete change to growing season burning is not anticipated. The frequency and seasonality of burning would be adjusted based on continuous monitoring of habitat conditions.

Under Refuge Management Alternative D, the USFWS would establish partnerships with the U.S. Geological Survey and universities to conduct research to further define the relationship between seasonality of fire and its effects on Chinese tallow and native grasses. Winter and early spring burning promotes warm-season grasses, but the overall diversity is low compared to the nearly 600 species that are found in prairie remnants in Texas and Louisiana (Allain and Johnson 1997). Ideally, burn regimes should be varied to promote greater overall species diversity and simulate the conditions under which these grasslands evolved (Howe 1994). However, while summer fires may increase overall species diversity in coastal prairies, they might also reduce the cover of native warm-season grasses and thus increase the competitive advantage of invasive species such as Chinese tallow. Native grasses contribute greatly to fuel loading and continuity. If summer burning reduces the relative abundance of warm season grasses, it may compromise the ability to control Chinese tallow with fire.

Prescribed burning can have detrimental impacts to vegetation and habitats, ranging from an undesirable change in plant species composition to actual conversion of emergent marshes to open water when fires occur at the wrong time. Proper timing of burns under appropriate conditions of soil moisture, fuel loads and fuel moisture is essential to minimize negative impacts. For example, burning under excessively dry conditions could result in destruction of desirable vegetation, consume organic matter and decrease marsh soil elevation, which in turn could result in permanent conversion to open water. Hot fires may result in root burns, which can cause mortality of desirable marsh plant species. Fire increases the soil erosion potential until regrowth occurs. Recently burned areas are especially susceptible to erosion during storm surges from tropical storms and hurricanes. Hot fires occurring without adequate soil moisture can also cause a temporary reduction in microflora and microfauna in wetland soils. Burning cannot restore lost marsh or counter the effects of excessive flooding or salinity (Chabreck 1994). Burning is not as beneficial in more saline marshes, because the resulting subclimax plant community is not as diverse (Spicer *et al*. 1986).

Under Refuge Management Alternative D, the USFWS prescribed burning program would continue to consider factors including soil and vegetative fuel moisture, seasonality and timing, ignition patterns, habitat type and previous burn history to ensure maintenance of diverse and productive wetland and upland habitats on the Refuge Complex. Potential for some adverse affects to vegetation and habitats would remain under this Alternative. The USFWS would conduct short- and long-term fire effects monitoring to more clearly define relationships between fire and vegetation communities.

(b). Controlled Livestock Grazing

Under Refuge Management Alternative D, the USFWS would continue a rotational controlled grazing program on approximately 41,000 acres of the Refuge Complex. Grazing intensity would be increased in selected fresh and intermediate marsh habitats and applications of short-duration, high-intensity grazing would be initiated in selected upland units. To effectively implement these changes, additional infrastructure including fencing and watering sources would be developed.

Controlled grazing on the Refuge Complex is used (integrated with fire management and water management) to maintain and increase diversity (plant species composition and structural attributes) and productivity in wetland and upland habitats. Controlled grazing can be an effective and inexpensive tool in wetland and grassland management providing habitat components that benefit waterfowl and other wildlife species. The relation of cattle grazing to wildlife varies considerably, depending on stocking rate, seasonality, plant community, and wildlife concerned (Chabreck 1968). Research indicates that dual use of grasslands by wildlife and livestock is often compatible when livestock grazing is carefully managed and wildlife needs are considered (Holechek 1982).

Grazing (integrated with fire and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Target plant species and communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Grazing also helps provide optimal physical structure of vegetation for waterfowl utilization in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining plant communities such as seashore paspalum which grow low to the ground. When shallowly flooded, stands of low-growing seashore paspalum and seashore saltgrass interspersed with ponds provide ideal habitat conditions for many waterfowl, shorebird and wading bird species. These conditions also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Increased grazing intensity and duration in selected fresh and intermediate marsh habitats under this Alternative would increase the abundance of early successional plant communities. The impacts of grazing on the physical structure of vegetation would be increased in areas grazed more intensively. Overall, plant succession in marshes would trend toward more area with lower successional plant communities, and physical structure towards more openings and more stands of low-growing plants such as seashore paspalum.

Studies conducted on Sabine National Wildlife Refuge in Cameron Parish, Louisiana (Valentine 1961) determined that increased grazing can change tall climax marshhay cordgrass stands to more diverse community such as seashore paspalum, Setaria, and longtom (*Paspalum lividum*), that are more beneficial to certain types of wildlife. Depending on site conditions (elevation, soil, and hydrology) annual grasses and forbs (including millets, fall Panicum (*Panicum dichotomiflorum*), sprangletop, and Setaria) can be produced through proper grazing.

Pate (2001) found that grazed marshes remained in a sub-climax state, while habitat within grazing exclosures reverted to marshhay cordgrass. At the onset of the study Spartina spp. made up 20% of the plant community, while seashore paspalum comprised 80%. By the end of the study, communities within grazing exclosures changed to 65% *Spartina* spp. and 25% seashore paspalum. In contrast, the grazed area maintained high cover of seashore paspalum throughout the study. Seashore paspalum provides habitat for many species of waterfowl, wading birds and shorebirds, depending on hydrology, while marshhay cordgrass largely precludes these species.

In general, the beneficial impacts of grazing in wetland habitats under this Alternative would be similar to those described under Refuge Management Alternative A, and include:

- Rank vegetation would be reduced, enabling migratory birds access to roots and tubers of mature plants and shoots of new plants.

- Competing growth of marshhay cordgrass and other dominant climax plant communities would be reduced, allowing for the growth of subdominant plant species, many of which are preferred foods of ducks and geese.

- Additional open water habitat would be created, which provides loafing areas for birds and allow them to access aquatic invertebrates.

- Marsh burning would be complemented by prolonging the time that browse is available for goose use.

- Plant vigor and plant productivity would be increased, nutrient recycling enhanced, and excessive build-up of residual plant material prevented.

- Hazardous fuel loading would be reduced, reducing the amount and intensity of wildfires.

- Capped soils would be broken through hoof action, assisting in seedling establishment of many preferred food plants.

- Vegetation in recently burned areas would be maintained in more palatable stages for wintering waterfowl.

Prairie ecosystems in North America are adapted to episodic short duration and high intensity grazing, as bison and other native herbivores concentrated on recently burned areas feeding on new growth and moved on to new recently burned areas as the vegetation matured. Fire and grazing regimes generated a mosaic of prairie habitats, ranging from recently burned and heavily grazed areas to areas with mature grassland plant communities with no recent history of fire or grazing. On a landscape level, this diverse habitat mosaic supported a wide variety of grassland-dependent wildlife species. Under this Alternative, a similar regime would be applied on selected upland units. It is expected that this management regime would increase the diversity of upland habitats (structurally and in plant species composition) on the Refuge Complex, and therefore increase natural biological diversity.

Potential detrimental affects of grazing includes the risk of overgrazing, excessive trampling of vegetation, compaction of soils reducing percolation rates, and increased soil erosion. The deposition of excess nutrients in the form of feces in areas where livestock concentrate (USFWS 1994) may negatively impact surface water quality. Fecal coliform from geese and livestock are the main pollutants contaminating the shellfish waters of East Galveston Bay (Galveston Bay National Estuary Program 1992). Warm-season grazing of wetland areas can reduce seed production of annual grasses (Chabreck 1968). Overgrazing in prairie habitats, usually caused by prolonged grazing, can reduce native prairie plant diversity. While prairie ecosystems are adapted to short duration high intensity grazing patterns, extended duration grazing can reduce native grasses and some native forbs, particularly those that are more palatable and are preferentially selected by livestock. Soil disturbance by excessive hoof action can provide conditions favorable for establishment of exotic and invasive plant species such as Chinese tallow, and cattle can spread seed of undesirable plant species by physically carrying them or ingesting them.

Under Refuge Management Alternative D, the USFWS would expand monitoring of grazing programs and adjust grazing strategies as needed. The potential for detrimental impacts should decrease as management is refined in response to monitoring information.

(c). Invasive Species Management

Under Refuge Management Alternative D, the USFWS would expand invasive species management activities on the Refuge Complex, treating additional areas and increasing partnership efforts. Additional field monitoring and research and enhanced GIS capabilities would be used to evaluate the effectiveness of ongoing treatments, to map existing infestations, and to quickly discover and initiate control activities on new infestations. The USFWS would continue to control invasive plant species to conserve native biological diversity of the Refuge Complex and to maintain habitat quality for migratory birds and other native wildlife. An Integrated Pest Management (IPM) program would be implemented to control the following invasive plant species (USFWS 1996):

- Chinese tallow, Eastern baccharis, willow, and deep-rooted sedge in freshwater marshes, prairies, woodlots and on levees and roadsides.

- Water hyacinth, alligatorweed, Salvinia, common reed and cattail in waterways and managed wetland units.

- Red rice, coffeebean, barnyard grass, and other grasses in rice.

- Broadleaf weeds and King Ranch bluestem in remnant and restored prairies.

Under Refuge Management Alternative D, the IPM program would include evaluating the use of approved and permitted biological control agents for control of particularly problematic invasive species including Salvinia and water hyacinth.

In wetland habitats, these activities would result in removal of undesirable invasive plant species including cattail, common reed, and California bulrush that form dense, homogeneous stands which result in loss of open water as ponds close. Control of exotic floating aquatic plants such as water hyacinth, alligatorweed and Salivinia also restores open water habitats, and promotes the growth of native floating and submerged aquatic plant species important to native fish and wildlife.

The control of Chinese tallow and deep-rooted sedge in prairie and woodlots results in increased diversity of native plants. In woodlots, reduction of Chinese tallow and increasing native tree and shrub abundance is likely to increase abundance of forage insects for migrating birds (especially Lepidopteran larvae) (Barrow and Renne 2001).

Under Refuge Management Alternative D, the USFWS would also continue to control exotic animal species on the Refuge Complex to conserve native biological diversity and to maintain habitat quality for migratory birds and other native wildlife. Feral hog control would be expanded under this Alternative.. Control of feral hogs would decrease damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging, and reduce the creation of disturbed areas that enable establishment of Chinese tallow and other undesirable plants. Control activities for nutria under this Alternative could be implemented if populations reach levels which threaten wetland habitats.

(d). Shoreline Protection and Restoration

As under Refuge Management Alternative A, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss under Alternative D. On McFaddin and Texas Point NWRs, these partnerships have focused on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Structural erosion abatement projects involving construction of rock breakwaters and shoreline armoring with rip rap along the GIWW on McFaddin NWR have also been implemented. On Anahuac NWR, these efforts have focused on protecting the East Galveston Bay shoreline through offshore breakwater construction and restoration of salt marsh along the shoreline. Under this Alternative, the USFWS would continue to implement similar projects.

Under Refuge Management Alternative D, the USFWS would expand interagency coordination efforts with a goal of substantially increasing the scope and extent of these projects. Objectives would include implementing major partnership projects to restore the barrier beaches and dunes on McFaddin NWR, beneficially use dredge material along the Gulf shoreline on Texas Point NWR, and construct large-scale structural erosion abatement projects using rock breakwaters along the GIWW and East Galveston Bay shorelines. Potential offshore sand sources for the restoration of the barrier beaches and dunes on McFaddin NWR are currently being investigated through the U.S. Army Corps of Engineers “Sabine Pass

to San Luis Pass Shoreline Erosion Feasibility Study." Preliminary data indicate viable offshore sand sources may be present.

Restoration of barrier beaches and dunes and placement of dredged material along existing shorelines would reduce rates of shoreline retreat and resulting direct loss of coastal habitats. These activities would positively impact vegetation resources and habitats by restoring upland and protecting existing wetland habitats. Restoration of barrier beaches and dunes along the Gulf of Mexico would restore an upland native habitat type which has been almost completely lost, and .protect interior intermediate marshes and their plant communities from excessive inundation with saltwater during high tidal events. Rock breakwaters in Galveston Bay and the GIWW would also slow erosion and loss of habitat. They would also enhance marine habitat by functioning as an artificial reef, providing opportunities for oyster spat, barnacles, algae, baitfish, and predator fish utilization. Restoring emergent marsh by planting smooth cordgrass between the breakwaters and existing shorelines would restore vegetated wetlands that have converted to open water. The stands of smooth cordgrass also would provide habitat for snails, shrimp, crabs, insects, and numerous benthic organisms.

(e). Mowing and Haying

Under Refuge Management Alternative D, approximately 100 acres of upland grassland habitats would be mowed or hayed annually on the Refuge Complex, the same as current levels. Mowing and haying would result in invigorating growth of many native grasses, while reducing vigor of undesirable herbaceous weeds and woody plants including Chinese tallow and Eastern baccharis. Reduction of this herbaceous and woody cover often results in the "release" of native prairie plants.

b. Impacts from Public Use Programs

Assuming an overall increase in visitation to the Refuge Complex for additional and enhanced opportunities for hunting, fishing, wildlife observation and photography and environmental education and interpretation under Refuge Management Alternative D, impacts to vegetation and habitats described below would remain similar to but have the potential to increase over to those described for Alternative A.

The greatest potential for impacts to vegetation resources and habitats on the Refuge Complex due to recreational uses likely comes from motorized boating activities. Many Refuge Complex hunt areas and fishing areas are accessible only or primarily by motorized boat. Wetland vegetation, especially submerged aquatic vegetation, can be impacted by motorboat activity. For example, propeller scarring has been shown to detrimentally impact seagrass beds in the Laguna Madre in South Texas (Pulich *et al*.1997, Dunton *et al.* 1998) and in Florida (Madley *et al*. 2004). Propeller scarring leaving permanent channels in shallow pond and waterway bottoms on the Refuge Complex has also raised concerns about the potential for increased saltwater intrusion, with concurrent negative impacts on emergent and submergent aquatic vegetation.

Foot traffic in areas open to hunting, fishing, wildlife observation and photography, environmental education and interpretation can lead to vegetation trampling, and in heavy use areas, cause plant mortality. On the Refuge Complex, the more extreme impacts occur in areas heavily used for shoreline fishing. Some vegetation trampling and trailing from hunter foot traffic occurs in marsh habitats in Refuge Complex hunt areas, although these impacts tend to be short-term.

These impacts would be expected to remain localized and minimal under this Alternative. Regulations, including horsepower restrictions and area closures to motorized boating would remain in effect to protect wetland habitats and public safety. Permanent sanctuary areas would be maintained throughout the Refuge Complex, which do not permit access by the public. Access for other recreational and educational uses would be restricted to established trails, boardwalks, and observation platforms. Fishing piers constructed in many heavily used shoreline fishing areas would reduce trailing impacts.

Recreational beach uses and associated vehicular traffic on beaches within the McFaddin NWR has led to habitat damage inland of beaches. Motorized vehicles sometimes illegally travel in vegetated habitats

inland of the beach, particularly when high water conditions limit or preclude travel on the beach itself. Under Refuge Management Alternative D, the USFWS would expand law enforcement efforts on Gulf beaches within McFaddin NWR to provide enhanced protection of public safety and natural resources. The USFWS would also initiate coordination with the Texas General Office and local counties to begin jointly addressing public safety and natural resource issues associated with recreational use of this area.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

No direct impacts to vegetation and habitats would occur as a result of continued implementation of the Refuge Complex biological program under Refuge Management Alternative D.

Under Alternative D, the USFWS would expand systematic habitat monitoring and develop additional partnerships with the U.S. Geological Survey and universities to conduct research on the effects of management activities on habitats. This will include determining effects of fire on marsh accretion and to define the relationship between seasonality of fire and its effects on Chinese tallow and native grasses. The USFWS will also expand the use of GIS technology to track habitat trends such as changes in open water in wetland habitats and in support of invasive/exotic plant management. Expanded habitat and vegetation monitoring activities and research studies on the Refuge Complex would facilitate more effective adaptive management by providing information which helps refine and improve management practices.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative D, oil and gas exploration and development activities on the Refuge Complex would continue to be managed through the issuance of Special Use Permits as under Alternative A. Stipulations in the Special Use Permit include those aimed at minimizing impacts to vegetation and habitats, including required use of specialized equipment, location and size of facilities, and required pollution controls. As per federal regulations (50 CFR 29.21), the USFWS would ensure that impacted sites are restored as closely as possible to pre-project conditions upon cessation of activities. Conditions of the Special Use Permit also require mitigation for all impacted habitats. Required mitigation activities include restoration and/or enhancement of habitats on the Refuge Complex which are similar to those impacted by oil and gas activities. Under this Alternative, the USFWS would develop a comprehensive Oil and Gas Management Plan to enhance management of oil and gas activities on the Refuge Complex.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex under this Alternative would be a reduction of impacts to vegetation and habitats from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative D, the USFWS would increase efforts to develop partnerships with private land owners to restore and enhance wetland, native prairie and coastal woodlot habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project; and 3) holding workshops for landowners to demonstrate habitat enhancement methods and techniques. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands.

The USFWS would also continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, the Texas General Land Office and the Galveston Bay Estuary Program, conservation organizations such as Ducks Unlimited, the Galveston Bay Foundation and local Audubon Society chapters, community

organizations and Refuge volunteers. These partnerships support and greatly enhance a variety of refuge management programs, including native habitat restoration.

It is anticipated that continuation of outreach and partnership efforts under Refuge Management Alternative D would result in additional habitat restoration and enhancement on the Refuge Complex and throughout the project area.

5. Impacts to Fish and Wildlife Resources

Under Refuge Management Alternative D, habitat management and restoration and biological program activities on the Refuge Complex would be focused on conservation of the following important fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians
- Invertebrates

The USFWS also would administer the six priority recreational uses of the National Wildlife Refuge System on the Refuge Complex: hunting, fishing, wildlife observation and photography, environmental education and interpretation. These uses impact fish and wildlife resources both directly and indirectly.

USFWS management of oil and gas exploration and development and community outreach and partnership programs would continue to have positive impacts on fish and wildlife resources.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Coastal habitats in Texas are part of the southern terminus in the U.S. for most of the ducks and geese in the Central Flyway. The 2004 mid-winter waterfowl survey indicated that 7,901,489 waterfowl used the Central Flyway. Of those birds, 5,110,022 waterfowl (65%) wintered in Texas. Available wintering waterfowl habitat in Texas is shrinking due to changes in agricultural uses, industrial and urban development, increased pollutants (Cain 1988), land subsidence, rising sea levels, and man-made hydrological changes such as canals resulting in saltwater intrusion (Michot 1996). Loss or degradation of habitat on landscape scale has increased the importance of public and private lands managed specifically for supporting wintering and migrating waterfowl.

Since the mid-1950s to the early 1990s, approximately 211,000 acres of wetlands were lost on the Texas Gulf coast, to both natural and man-made causes (Moulton *et al.* 1997), with most of the palustrine wetland lost to agriculture (in recent years agricultural lands have decreased by urban development). Palustrine emergent marshes showed the largest decline, primarily by conversion to upland agriculture and other uses; and most estuarine wetlands loss was due to land subsidence. Tacha *et al*. (1992) concluded that between 1976 and 1991 the total ducks in the Chenier Plain of Texas declined by 89%, and these decreases were highly correlated with losses and degradation of wetland habitat.[15] Many wintering and migrating waterfowl along the Texas Coast tend to prefer freshwater coastal marshes and

15 During the 1969 through 1994 period, the Louisiana coastline experienced major wetland losses, similar to the Texas coast. However, there appears to have been no declines in duck populations of coastal Louisiana marshes between 1969 and 1994 (Michot, 1996).

freshwater prairie wetlands. Rice agriculture provided an especially valuable habitat for wintering waterfowl.

Expanding and enhancing wetland management and restoration under Refuge Management Alternative D can be expected to increase wintering and migrating waterfowl populations on the Refuge Complex. On a year to year basis, overall habitat quality for waterfowl on the Refuge Complex will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers on the Refuge Complex can also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure.

Under the Refuge Management Alternative D, the following USFWS management activities would have the greatest impacts on wintering and migrating waterfowl populations on the Refuge Complex.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative D, approximately 30,000 acres of marsh habitats would be structurally managed on the Refuge Complex to enhance habitat for wintering waterfowl, utilizing water control structures, levees, and water delivery systems. Marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl. Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976). Structural management of brackish and intermediate marshes may directly increase the abundance of preferred plant species, such as Olney bulrush and widgeongrass, which provide food resources for wintering and migrating waterfowl (Chabreck 1976, Broome *et al.* 1995). Management of water levels would also provide optimal conditions for foraging and resting waterfowl.

Approximately 590 additional acres of moist soil units would be developed on the Refuge Complex under Refuge Management Alternative D, specifically to provide additional high quality habitat for wintering and migrating waterfowl. Moist soil management would provide optimal conditions for germination and growth of preferred waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia.

On Anahuac NWR, rice production through the cooperative rice farming program would be continue at current levels of 500-700 acres annually under this Alternative to provide habitat for wintering and migrating waterfowl. Management of fallow rice fields would also provide weeds and seed that are heavily utilized by waterfowl.

Marsh restoration and other wetland restoration activities would create additional emergent marsh and open water habitats and provide additional habitat for wintering and migrating waterfowl.

Marsh and wetland restoration activities would create additional emergent marsh and open water habitats and provide additional habitat for wintering and migrating waterfowl.

(b). General Habitat Management and Restoration Activities

Under Refuge Management Alternative D, the USFWS would continue an integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex to create optimal habitat conditions for wintering waterfowl and many additional migratory bird species. As compared to current conditions, enhanced water management capabilities and more intensive grazing in selected marsh units under Refuge Management Alternative D would provide enhanced habitat conditions for wintering waterfowl on the Refuge Complex. Prescribed burning and grazing would promote the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950,

Gosselink *et al*. 1979). Burning and moderate grazing also results in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al.* 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex would include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Burning and grazing would also help provide optimal physical structure of vegetation for waterfowl utilization of emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions would also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Under Alternative D, waterfowl habitat on the Refuge Complex would be enhanced through expanded control programs for invasive vegetation such as common reed, cattail, and California bulrush which have formed dense homogeneous stands and resulted in loss of open water habitats. Infestations of invasive floating plants such as water hyacinth, alligatorweed and Salvinia would also be controlled to restore and maintain open water habitats. Maintaining an interspersion of open water and vegetated emergent wetlands would provide the habitat diversity needed to support wintering waterfowl and other migratory birds. Restoring open water habitats would increase the production of submerged and floating aquatic plants, an important food source. Control of Chinese tallow and deep-rooted sedge in and adjacent to freshwater marshes, moist soil units and rice fields would also enhance waterfowl habitat.

Declines in habitat quality caused by regular tidal overwash are currently adversely affecting migratory waterfowl use, especially on McFaddin and Texas Point NWRs. If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and beneficial use of dredge material projects on Texas Point NWR under Refuge Management Alternative D would significantly enhance wetland habitats for wintering waterfowl on these refuges by reducing tidal overwash of the eroding beach ridge into inland marshes. This would eliminate the salinity spikes in these intermediate marshes caused by overwash events, which increase salinities over large areas for extended periods of time and kill submerged and floating aquatic plants and invertebrates which provide important food resources for waterfowl. Smaller shoreline protection and restoration projects implemented on the Refuge Complex under this Alternative would also protect and enhance wetland habitats important to wintering waterfowl. Implementation of these projects would be expected to increase wintering waterfowl populations on the Refuge Complex.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Mottled ducks are year-round residents of the Chenier Plain region. This species prefers fresh to slightly brackish marshes (Gosselink *et al*. 1979), although a variety of marsh habitats, prairie, and agricultural wetlands (rice fields) are also utilized. Mottled ducks on the Refuge Complex are part of the western Gulf Coast population of Mottled Ducks. Banding studies have indicated that WGC Mottled Ducks do move between Mexico, Texas, Louisiana and Mississippi and Alabama, but no interchange occurs between this population and the Florida population of Mottled Ducks.

Mottled Duck numbers on the Refuge Complex (and other national wildlife refuges on the Texas Coast) have declined precipitously during the last 20 years, as indexed by annual breeding pair surveys and monthly aerial counts conducted September through March (USFWS, Division of Migratory Birds, unpublished reports). Stutzenbaker (1988) reported that the most serious threat facing Mottled Ducks is degradation and loss of habitat. In Texas, factors contributing to loss of habitat include conversion of native habitats for agricultural and urbanization, drainage, marsh subsidence, saltwater intrusion, spread of introduced species (Stutzenbaker 1988, Morton and Paine 1990), as well as increased pollutants (Cain 1988). Saltwater intrusion into wetlands that range from fresh to moderately brackish probably affects growth and survival of ducklings (Moorman *et al*. 1991). Encroachment of Chinese tallow into nesting habitat probably leads to abandonment of nesting areas (Stutzenbaker 1988). Other potential factors influencing Mottled Duck populations in Texas include declines in rice agriculture, extended periods of drought, mortality from predation due to increasing populations of alligators and possible increases in

mammalian predators, a continued high incidence of lead pellet ingestion, and harvest (USFWS Division of Migratory Birds, unpublished reports).

Under Refuge Management Alternative D, many habitat management and restoration activities currently conducted on the Refuge Complex would be continued, and all would be expected to have positive impacts on this species although the landscape level issues described above are likely to control population dynamics of the WGC Mottled Duck population. Several habitat management and restoration activities would be expanded specifically to benefit Mottled Ducks. Management and enhancement of nesting and brood-rearing habitats would be targeted.

(a). Wetlands Management and Restoration

Wetland management and restoration activities on the Refuge Complex under Refuge Management Alternative D would provide additional enhancement of habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Expanded and enhanced structural marsh management would maintain existing and restore additional fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. It would enhance diversity and productivity of submerged aquatic vegetation in open water habitats, providing an important year-round food sources for Mottled Ducks. Moist soil management and cooperative rice farming programs would provide shallow freshwater habitat and nutritious food resources for use by Mottled Ducks year-round. Rice farming would continue to provide 500-700 acres of wetland habitat annually, and moist soil management an additional 690 acres over current levels on the Refuge Complex under this Alternative. Approximately 400 acres of moist soil units would be managed each year specifically to provide brood-rearing habitat for Mottled Ducks during summer.

Under Refuge Management Alternative D, 100 acres of shallow freshwater “prairie wetlands” would be restored in fallowed rice fields. Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as “sennabean ponds,” as valuable brood rearing habitat. Restoring these natural “prairie wetlands” would provide brood-rearing habitat in close proximity to quality nesting habitat (see below).

(b). Uplands Management and Restoration

Expanded native prairie restoration and management activities under Refuge Management Alternative D would benefit Mottled Ducks primarily by restoring and enhancing nesting habitat. The USFWS would restore an additional 2,223 acres of native prairie under this Alternative and use the integrated application of prescribed burning, controlled livestock grazing, herbicide application, and mowing and haying to maintain and enhance grassland habitats and reduce brush encroachment (exotic and native plants) in salty and non-saline prairies. All would be expected to improve nesting success of Mottled Ducks and other ground-nesting avian species.

The historical prairie-wetland continuum of the upper Texas coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and mima mounds that are characteristic of coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Protecting extant stands of coastal prairie and restoring adjacent prairie and prairie wetland habitats under Refuge Management Alternative D on the Refuge Complex would increase quality of habitats important to Mottled Duck recruitment and overall reproductive success.

(c). General Habitat Management Activities

Under Refuge Management Alternative D, prescribed burning would be continued at current levels and grazing intensity (higher stocking rates) and duration in selected fresh and intermediate marshes would be increased. The integrated combination of expanded water level and salinity management, prescribed burning and intensified livestock grazing in wetland habitats on the Refuge Complex under this Alternative

would increase the acreage of optimal wetland habitat for Mottled Ducks. Expanded invasive plant and animal control activities would also enhance wetland and upland habitats for Mottled Ducks, as would shoreline protection and restoration activities.

Salt prairies occur as a broad zone between coastal prairies and marshes, or more commonly on the Refuge Complex, as a ridge between marshes and bays or the Gulf of Mexico. Higher, well drained, salt prairie ridges juxtaposed with lower wetland areas have been identified as important Mottled Duck nesting areas in the Chenier Plain region of Louisiana (Baker 1983) and Texas (Stutzenbaker 1988). Because of the near total loss of coastal prairie, salt prairie is now the most important Mottled Duck nesting habitat on the Refuge Complex. These cordgrass ridges are dominated by gulf cordgrass with marshhay cordgrass, knotroot bristlegrass (*Setaria parviflora*) and some brush species typically subdominant. Baker (1983) found that salt prairie invaded with Sesbania (*Sesbania spp.*) and Baccharis (*Baccharis halimifolia*) were avoided by nesting Mottled Ducks. Burned areas appeared to be undesirable for nesting to three years post-fire. Vegetation heights were comparable to unburned areas by the second year post-fire, but residual senesced vegetation remained low. Fire is necessary in the management of Mottled Duck nesting habitat. Fire must be frequent enough to keep brush at low densities, but infrequent enough to maximize years with dense nesting cover for Mottled Ducks. Initiation of summer burning under this Alternative would be expected to improve nesting habitat in salty prairies by more effectively controlling Eastern baccharis and other woody vegetation.

Improper application of these habitat management practices has the potential to negatively impact Mottled Ducks. For example, prescribed burning may result in the excessive removal of vegetation reducing suitability as Mottled Duck nesting habitat, and burning at the wrong time of year could destroy nests (Baker 1983). Overgrazing by cattle may reduce desirable nesting habitat for Mottled Duck in marshes and salty prairies, especially after spring burns (Baker 1983, Stutzenbaker 1988). The potential for some negative impacts to Mottled Duck nesting habitat would increase under Refuge Management Alternative D. Higher cattle stocking rates and grazing durations in fresh and intermediate marshes could reduce availability of suitable nesting cover in contiguous salty prairies and non-saline grassland habitats under this Alternative.

Marsh habitats currently being impacted by tidal overwash of the beach ridges on McFaddin and Texas Point NWRS provide important Mottled Duck production and brood rearing habitats. Based on field observations and capture rates during banding efforts, saltwater inundation has reduced Mottled Duck use of affected areas by as much as 50 to 65% over the last 10 years. If implemented under Refuge Management Alternative D, large-scale restoration of the barrier beach/dune system on McFaddin NWR would significantly enhance wetland habitats important to Mottled Ducks by preventing saltwater intrusion currently resulting from frequent tidal overwash from the Gulf into inland marshes. Smaller shoreline protection and restoration projects implemented under this Alternative would also protect and enhance marsh and salty prairie habitats important to Mottled Ducks.

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because the category of shorebirds, wading birds, and other marsh and waterbirds consists of a wide variety of species, individual species use microhabitats (e.g., vegetative cover and water depth) differently than other species in the same category (Gosselink *et al*. 1979, Skagen *et al*. 1999). For example, bare to sparse vegetative cover for foraging is preferred by species such as Piping Plover (Federally-listed Threatened) and the Least Tern (State-listed Endangered). Denser vegetation is preferred by other species, for example Little Blue Heron, Black-crowned Night Heron, Yellow-crowned Night Heron, Least Bittern, American Bittern, King Rail, and Clapper Rail. Other species have broad vegetation density requirements, and can utilize areas ranging from relatively bare of vegetation to dense vegetation, for example Reddish Egret (State-listed Threatened) and Wood Stork (State-listed Threatened).

This category of avian species also varies greatly in the amount of soil moisture and water depths they prefer, usually for feeding activities. These requirements range from relatively dry or shallow water (a few centimeters deep), such as the Piping Plover, to slightly deeper (but still relatively shallow) water, such as the Western Sandpiper and Least Sandpiper, to waters about 8-12 cm deep, such as the Black-bellied

Plover and Willet. Other species prefer deeper waters, often within wading depth for long legged birds, such as the White-faced Ibis (State-listed Threatened) and the Least Tern. Some species can utilize deep waters as well as shallower waters (Wilson's Phalarope, Red-necked Phalarope, Olivaceous Cormorant, Double-breasted Cormorant, Laughing Gull, and Forster's Tern). Some species are year-round residents, such as Brown Pelican (Federally listed Endangered), Double-breasted Cormorant, Great Blue Heron, Little Blue heron, Great Egret, and Black Skimmer. Other species are mostly migratory, including Wood Stork, White Ibis, and Forster's Tern.
Because of the wide diversity of habitat requirements by this category of birds, USFWS habitat management and restoration activities on the Refuge Complex which result in a mosaic of diverse habitat types (plant species composition, structural characteristics, water levels and salinities) is desirable. As such, most of the wetland and upland habitat management and restoration activities to be continued under Alternative D would continue to positively impact the shorebird, wading bird and marsh bird species currently found on the Refuge Complex.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative D, expanded and enhanced structural marsh management would improve habitat conditions for many avian species in this group. Water management activities in coastal marshes which maximize the annual production of desirable submerged aquatic plant species provide improved habitat for invertebrates and small vertebrates, which are the primary prey items for many shorebird, wading bird and marsh bird species.

Under Refuge Management Alternative D, cooperative rice farming would continue at current levels and moist soil management programs would be expanded to provide additional shallow freshwater wetland habitat. In total, rice farming would provide approximately 500-700 acres on Anahuac NWR, and Complex-wide moist soil management would provide approximately 1,200 acres under this Alternative. Approximately 300 acres of the Anahuac NWR's moist soil units would be managed specifically to provide wetland and mudflat habitat for shorebirds during spring and fall migrations. Targeted shorebird species would include Long-billed Dowitcher, Semi-palmated Plover, Black-bellied Plover, Black-necked Stilt, Whimbrel, American Avocet, Long-billed Curlew, Hudsonian and Marbled Godwits, and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted Sandpipers. Under this Alternative, 1,200 acres of moist soil units would provide wetland habitat for shorebirds, wading birds, and other marsh and water birds over the winter months. Wading and marsh bird species using moist soil habitats on the Refuge Complex include American Bittern, Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, Tri-colored Heron, Black-crowned and Yellow-crowned Night Herons, White Ibis, White-faced Ibis, and Roseate Spoonbill.

In general, shorebirds and wading birds would also benefit from expanded moist soil management under this Alternative. Rice farming and moist soil management result in increased abundance of invertebrates and plants that are a preferred food source (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002). The timing and depth of flooding on managed agricultural fields influences the type of and intensity of use by such birds (Huner *et al*. 2002).

(b). Uplands Management and Restoration

Under Refuge Management Alternative D, expanded restoration and enhancement of native prairie habitats would provide improved habitat for several species of migrating and wintering marsh birds. Three Avian Species of Conservation Concern (USFWS 2005) would benefit from these activities: Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

Under Refuge Management Alternative D, the USFWS would continue the integrated combination of water level and salinity management, prescribed burning and controlled livestock grazing in wetland habitats on the Refuge Complex. The USFWS would enhance water management capabilities, continue

prescribed burning at current levels and intensify grazing in selected marsh units under this Alternative. These management activities would enhance wetland and upland habitats used by many shorebird, wading bird and marsh bird species.

These management tools would help create optimal physical structure of vegetation for many species of shorebirds and wading birds in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for shorebirds. Conversely, intensified grazing under this Alternative may reduce habitat availability in some refuge units for some marsh bird species which require dense, tall stands of vegetation. Higher grazing intensities would increase the potential for some negative impacts. Grazing could negatively impact some ground-nesting species such as Black-necked Stilts by trampling nests and grazing on emergent pond vegetation used by those birds, and may also disturb nesting pairs (Whyte and Cain 1979). Overall, species requiring less dense, more open marsh habitats would benefit from intensified controlled grazing under Refuge Management Alternative D, while the amount of habitat for species requiring dense stands of vegetation would decrease.

Some species in this group have a relatively narrow range of optimal water depth for feeding and other activities, ranging from almost dry sediment to relatively deeper water (Skagen *et al*. 1999). Management activities that increase water depth may negatively impact those species that prefer shallow or no water, and those that prefer deeper water are negatively impacted when management activities lower water levels. Similar impacts could occur with management of vegetative cover, as some species prefer areas devoid of vegetation, while others prefer heavy vegetative cover. However, most avian species in this group (especially migrants) have evolved with unpredictable available resources, and are able to find suitable microhabitats in an adequately diversified landscape that contains a mosaic of microhabitats, both spatially and temporally. As under Refuge Management Alternative A, overall management under Alternative D would be aimed at maintaining a mosaic of available habitats. This should provide an adequate range of habitats for this group of avian species.

Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (*Coturnicops noveboracensis*, Mizell 1998), sparrows (Emberizidae) and wrens (Troglodytidae, Gabrey *et al.* 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et al*. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al*. 2000). Not surprisingly, these secretive marshland bird species decline in the first year post fire. Other bird species such as Icterids (Gabrey *et al*. 2001) and Wilson's Snipe (*Gallinago delicate)* (USFWS unpublished data) increase immediately post-burn.

The susceptibility of wildlife to mortality during fire events seems to be dependent on weather, fuel characteristics (moisture, loading and continuity), fire characteristics (as influenced by ignition strategies), and the capability and behavior of the species in question. Black rail mortality has been observed where large areas are burned with little unburned escape cover available, while mortality was not observed in a burn containing a mosaic of unburned escape cover (Legare *et al*. 1998). No fire induced mortality was observed for three species of rail during fire operations on the Texas mid-coast, though data were insufficient to draw strong conclusions (Grace *et al*. 2005). Burns conducted under fuel and weather conditions that allow for patches of unburned habitat within the unit may minimize wildlife mortality. Burns ignited in a way that maximizes escape options, primarily through the use of backing and widely spaced strip flanking fires, probably minimizes wildlife mortality while maintaining fire-dependent habitat. The USFWS uses these techniques in prescribed burning operations on the Refuge Complex.

Expanded invasive plant and exotic animal control activities under Refuge Management Alternative D would enhance wetland and upland habitats for many avian species in this group. The removal of invasive vegetation that forms dense, homogeneous stands resulting in pond closure (such as common reed, cattail, and California bulrush), would improve habitat conditions for wading bird and marsh and waterbird species that utilize open water habitats. Shoreline restoration activities including beach/dune

restoration and creation of emergent marsh and mudflats in intertidal zones behind breakwaters would benefit many shorebird and wading bird species.

Under Refuge Management Alternative D, the USFWS would continue to maintain a 1-acre nesting site for Least Terns and Black Skimmers on McFaddin NWR. This site is intensively managed to promote increased nesting success for these species, including providing ideal nesting substrate, excluding mammalian predators, and minimizing disturbance.

(4). Impacts to Landbirds

Landbird species found on the Refuge Complex require a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf coast (Mueller 1981, Barrow *et al*. 2000). Some raptor species prefer intermingled field and forested areas (e.g., Red-tailed Hawks and owls). Other landbird species prefer grassland habitats including marshes and prairies (Peterson *et al*. 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

All habitat management and restoration activities conducted on the Refuge Complex under Refuge Management Alternative D would benefit avian species in this group. Although comprising a relatively small portion of the overall habitats on the Refuge Complex, restoration, management and protection of native prairies and coastal woodlots are of particular significance because of the importance of these habitats to many passerine species, including many neotropical migratory songbirds.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative D, the following wetland management and restoration activities would continue to have positive impacts on several landbird species including managing water levels and salinities in coastal marshes, marsh restoration, moist soil management, and the cooperative rice farming program. Several land bird species listed as Avian Species of Conservation Concern (USFWS 2005), including the Seaside Sparrow, Nelson's Sharptailed Sparrow and Sprague's Pipit, would benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Under Refuge Management Alternative D, 2,223 acres of fallowed rice fields and other upland areas would be restored to native coastal prairie. The newly restored sites, along with existing native prairie remnants, previously restored native prairie sites and other grasslands would be managed using a variety of management tools. Together, the management actions undertaken under Refuge Management Alternative D would protect and enhance approximately 5,774 acres of non-saline grassland habitats on the Refuge Complex.

Many animal species typical of northern prairies, such as Henslow's Sparrows, Smooth Green Snakes, and Prairie Voles, were all found year-round in the Gulf coastal prairies. Dickcissels still nest in these coastal grasslands, and many other avian species utilize Gulf coastal prairies as wintering and/or migratory habitat. Many of the landbirds that would benefit from protection and management of native coastal prairie habitats under Refuge Management Alternative D are species that are declining in the Coastal Prairies Region of Texas (Shackelford and Lockwood 2000), and/or are among several species recently listed by the USFWS as Avian Species of Conservation Concern in the Gulf Prairies Bird Conservation Region (USFWS 2005). For example, White-tailed Hawk, Northern Bobwhite, Yellow and Black Rail, Buff-breasted Sandpiper, Short-eared Owl, Sedge Wren, and LeConte's Sparrow are all Avian Species of Conservation Concern that would benefit from conservation of prairie habitats on the Refuge Complex.

Native prairie remnants and other upland grassland habitats on the Refuge Complex provide wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow, and nesting habitat for species including Dicksissel and Eastern Meadowlark. These are also important nesting habitats for Mottled Ducks. Several species of raptors commonly observed on the Refuge Complex include Red-tailed Hawk, Red-shouldered Hawk, Turkey Vulture, American Kestrel, White-tailed Kite, Northern Harrier, and Short-eared Owl (USFWS 1997a). Many other raptor species are observed during spring and fall migrations. Land birds listed as Avian Species of Conservation Concern utilizing prairie grassland habitats and which would benefit from native prairie restoration and management activities on the Refuge Complex under Refuge Management Alternative D include LeConte's Sparrow, Henslow's Sparrow, Sedge Wren, Loggerhead Shrike, and White-tailed Hawk.

Woodlot Restoration and Management

Under Refuge Management Alternative D, the USFWS would continue management activities as described under Alternative A to protect and diversify 127 acres of existing coastal woodlots and riparian woodlands: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts. In, addition the USFWS would create 29 acres of additional woodland habitat on the Anahuac NWR, and assess opportunities for additional woodlot restoration on suitable sites throughout the Refuge Complex.

Although comprising less than 1 percent of the Refuge Complex acreage, woodlots help support a diverse avian community, which includes several sensitive songbird species. Six of the seven avian species listed as Rare and Declining within the coastal prairies region in Texas are present in the Refuge Complex's coastal woodlots. Migratory birds also depend on coastal woodlots for cover and food. At least 63 species of migratory birds regularly use the wooded habitats of the Chenier Plain region prior to or immediately after crossing the Gulf of Mexico (Barrow *et al*. 2000). Trans-Gulf or circum-Gulf migratory songbirds use Texas Coastal woodlots as stopover habitat (Mueller 1981), which is critical at a time when the birds are depleted of water and energy reserves (Leberg *et al.* 1996).

A primary threat to coastal woodlots is encroachment by the Chinese tallow tree, which provides poor habitat for migratory songbirds. Although the Chinese tallow trees attract birds as frequently as other trees, they provide poorer forage because of sparse insect populations. Specifically, they harbor fewer insects and spiders, especially *Lepidopteron* larvae. Chinese tallow woodlots may thus be an "ecological trap" that provide cover but little food for migrants when they are energy-depleted after migration (Barrow and Renne 2001). Feral hogs can damage understory vegetation and soils, as a result of their rooting habits, and may also cause a shift in plant succession. Such activities can also create disturbed areas that enable easier establishment of some exotic species. Feral hogs may also directly compete with several species of native wildlife for certain foods.

Overall, implementation of the USFWS management actions discussed above under the Refuge Management Alternative D would continue to improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodlot habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging. Species to benefit would include three neotropical migratory birds considered Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler. Since woodlot acreage is small relative to its importance to migrating neotropical migratory birds and other bird species that require trees and/or understory for cover, such positive impacts for each acre protected would be proportionately significant.

(c). General Habitat Management Activities

Prescribed burning, grazing, and invasive species management, and shoreline protection and restoration activities would continue on the Refuge Complex under Refuge Management Alternative D. The integrated combination of water level and salinity management, fire management and controlled livestock

grazing on the Refuge Complex which promotes optimum habitat conditions for wetland-dependent migratory birds also enhances wetland and upland habitats used by many land bird species. Invasive plant and animal control activities would enhance wetland and upland habitats for these species, especially in grassland and coastal woodlot habitats. For example, control of Chinese tallow would lead to increased diversity of native woody plants in the coastal woodlots, as well as increased forage insects (especially Lepidopteran larvae) for migrating passerines and other birds. Chinese tallow stands have an ecological trap effect for migrant songbirds that are drawn to the cover of the woodlots, but then find insufficient food resources to replenish depleted energy reserves (Barrow and Renne 2001).

Seaside Sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al*. (2001) reported that breeding Seaside Sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested.

Gabrey *et al*. (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (2005) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife.

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Under Refuge Management Alternative D, the USFWS would continue to structurally manage marshes, restore coastal wetlands, and conduct management activities including prescribed burning, controlled livestock grazing, invasive plant and animal control, and shoreline restoration and protection. These management activities would protect, restore and enhance estuarine wetlands, and ensure wetland habitat diversity and productivity important to a variety of fish and shellfish species. The continuum of fresh to saline aquatic environments on the Refuge Complex support highly diverse aquatic vertebrate and invertebrate communities. Disruption of salinity gradients would likely cause adverse impacts on blue crabs (Guillory 1996). Many of the refuge marshes would exceed these thresholds without some type of hydrologic management.

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al*. 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al*. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al*. 1990, Kneib 1991, Rozas 1995).

Structural marsh management is employed on portions of the Refuge Complex to reduce impacts of saltwater intrusion and subsequent marsh loss as well as to maintain the historic salinity gradient that characterized coastal marshes of the Chenier Plain.

Managing water levels and salinities using water control structures and levees in managed marsh units may restrict access to managed areas for some aquatic organisms, such as fish and crustaceans (Rogers

et al. 1992, Kuhn *et al*. 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a natural stable or deteriorating deltaic marsh (Peterson *et al.* 1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown. Target salinity ranges typical of structurally managed marshes on the Refuge Complex range from fresh to the low end of brackish, being primarily intermediate (0.5-5.0ppt). While these salinity ranges are used by estuarine species, a study of fisheries use along a salinity gradient in Galveston Bay (Zimmerman *et al*. 1990) found estuarine fisheries were not greatly attracted to intermediate (oligohaline) marshes of the Trinity River delta. This study concluded that the oligohaline environment was not favorable for development of preferred foods, primarily epiphytic algae and peracarid crustaceans. Further, while transient species such as juvenile shrimp, crabs, and fishes had ready access to oligohaline marshes in this area, they did not use them extensively. These data indicate that while water control structures may limit ingress/egress of estuarine organisms, the habitat within may not be optimum for these organisms compared to brackish and saline marshes available on the Refuge Complex.

Impacts of structural marsh management to fisheries resources have been reduced on the Refuge Complex by incorporating design features into existing water control structures such as vertical slots which allow passage of estuarine organisms, managing structures to facilitate ingress and egress by opening gates during key movement periods, and utilizing rock weirs to counter erosion and enlargement of tidal waterways (as opposed to traditional fixed crest weirs). Ingress/egress slots allow more marine organism passage than fixed crest weirs, with larger openings allowing greater fisheries access (Herke *et al.* 1992). These slots provide a means of allowing movement of estuarine organisms in and out of structurally managed marshes, but assist in maintaining the fresher end of the coastal marsh continuum that so many of the Refuge Complex's priority species depend on. Periods of peak ingress and egress movements are associated with water level fluctuations and tidal cycles. Highest peak fisheries resource movements are often related to periods of combined lunar cycles and major tidal movements. Manipulating water control structures during the full moon and new moon of the lunar cycle allows opportunity for the maximum ingress potential of fisheries resources. Holding slight levels of excess water for several days prior to these cycles and releasing during peak ingress periods greatly increases access to the unit from fisheries species dependent on coastal estuaries. Many species will move towards fresher water during incoming tides (Guillory 1996). The USFWS would continue to use these techniques on the Refuge Complex to enhance fisheries utilization of managed marsh units under this Alternative.

Much of the work on fisheries use of flooded marshes has focused on saline marshes with a high component of *Spartina alternaflora* (Zimmerman *et al*. 1990, Baltz *et al*. 1993, Peterson and Turner 1994, Knieb and Wagner 1994, Minello *et al*. 1994, Rozas *et al*. 1998, Zimmerman *et a*l. 2000). Brown shrimp, white shrimp, and blue crabs are associated with salt marsh dominated estuaries (Weinstein 1979, Wenner and Beatty 1993). Many of the salt marshes of the western Gulf coast are experiencing rapid subsidence, saltwater intrusion and conversion to open water. Research has suggested that marsh conversion to open water will reach a point beyond which fisheries will decline due to a reduction of total marsh edge (Browder *et al.* 1989). Further, fisheries habitat gained due to marsh breakup is not sustainable in the long term (Browder *et al.* 1989, Condrey and Fuller 1992). Under this Alternative, activities which restore productive wetland habitats and help reduce rates of marsh loss (hydrologic restoration, marsh restoration using dredge material, structural marsh management and shoreline restoration and protection) would help sustain healthy fisheries resources in the long-term.

(6). Impacts to Threatened and Endangered Species

Three avian species occurring on the Refuge Complex are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon,

Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Under Refuge Management Alternative D, protection, restoration and management of coastal wetland habitats on the Refuge Complex would benefit the three avian T&E species. Bald eagles observed on the Refuge Complex are usually associated with large concentrations of wintering waterfowl. Brown pelicans utilize shorelines and tidal saline ponds for resting and foraging. Shoreline restoration and protection activities would provide improved habitat for Piping Plover and Brown Pelican. Conservation and management of both wetland and upland habitats aimed at ensuring biological integrity and biological diversity under Refuge Management Alternative D would benefit Threatened and Endangered species and many other sensitive or declining native fish and wildlife species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found on the Refuge Complex include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species on the Refuge Complex. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic animals.

In general, habitat management and restoration activities under Refuge Management Alternative D which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of wildlife species.

USFWS management activities under Refuge Management Alternative D which maintain and restore freshwater wetland habitats (structural management of marshes, moist soil management, rice farming) are particularly beneficial to amphibians and reptiles. Reliable freshwater habitat is critical for most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators. Expanded moist soil management and restoration of prairie wetlands would increase available wetland habitat over current levels. Habitat conditions which increase the abundance of insects, crustaceans, and other small prey benefit most species of amphibians and reptiles during at least a portion of their lifecycle. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas.

Expanded control of invasive woody species in wetland and upland habitats may decrease habitat quality for certain mammals such as raccoon and striped skunk. Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, and some reptiles, and invertebrates.

Under Refuge Management Alternative D, suppression of wildland fires and prescribed burning would continue on the Refuge Complex unchanged from current programs. Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et al.* 1989) summarizes by saying "Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in

numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil litter stabilize." Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data). It appears that fire management practices that favor desired vegetation conditions seem to be compatible with maximizing arthropod diversity as long as a mosaic of burned an unburned habitats is maintained.

b. Impacts from Public Use Programs

Assuming an increase in visitation to the Refuge Complex under Refuge Management Alternative D, impacts to fish and wildlife resources would likely increase over current levels described under Alternative A. This assumption is based upon the expanded and enhanced waterfowl hunting opportunities, new hunting programs for doves and the development of new visitor facilities to support and enhance fishing, wildlife observation and photography, and environmental education and interpretation programs provided under this Alternative.

(1). Impacts to Waterfowl

(a). Waterfowl Hunting

Under Refuge Management Alternative D, the USFWS would enhance waterfowl hunting opportunities on the Refuge Complex by improving access facilities, implementing administrative changes aimed at improving quality of the hunting experience, and providing additional services and informational materials to refuge hunters.

The most direct effect of hunting on the Refuge Complex is the mortality of harvested waterfowl species resulting from the hunting activities. However, because regulations governing harvest of migratory birds in the Central and Mississippi Flyways are developed annually under the USFWS national migratory bird hunting regulations frameworks, and are designed to ensure that viable waterfowl populations are sustained over the long-term, the hunting program on the Refuge Complex under Refuge Management Alternative D will not have any measurable effect on overall populations and the long-term viability of these populations.

Many studies have documented the effects of hunting on intensity on the number of birds utilizing an area (Reichholf 1976, Madsen *et al.* 1992 as cited by Fox and Madsen 1997, Wolder 1993). These studies have shown that relatively light hunting pressure can reduce waterfowl abundance in hunted areas. Distribution and habitat use, feeding patterns, and the nutritional status of waterfowl have also been shown to be affected by hunting activities. Hunting activity can cause birds to alter habitat use, change feeding locations (Madsen 1995), feed more at night (Morton *et al.* 1989) and reduce the amount of time spent feeding (Korschgen *et al*. 1985, Madsen 1995). Collectively, these changes in behavior have the potential to adversely impact the nutritional status of waterfowl (Belanger and Bedard 1995).

Means of access to and within Refuge Complex hunt areas would remain the same under this Alternative and include motorized boating (primarily in Oyster, Onion and East Bay bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake and hunt area access ditches on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), non-motorized boating, motorized vehicles, and walking. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use, but these impacts are likely less than those caused by motorized boating.

Monthly aerial surveys of wintering waterfowl on the Refuge Complex have documented the disproportionate use of established sanctuary areas by waterfowl, as compared to the areas open to hunting. This further supports the above studies and indicates that hunting affects the overall distribution of wintering waterfowl on the Refuge Complex. The size, location and habitat quality of sanctuary areas

on the Refuge Complex remains critically important to ensure that migrating and wintering populations of waterfowl maintain sound nutritional and physiological status.

Providing waterfowl with predictable undisturbed sanctuary areas likely increases the ability of birds to meet the obligations of their annual cycle. Waterfowl undergo considerable physiological demands during winter. Heitmeyer (1988) estimated that prebasic molt in female mallards required an additional three grams per day of protein over base metabolic rates. These demands approach the estimated five grams per day associated with reproduction. Pair formation for most North American waterfowl takes place away from the breeding grounds. Waterfowl must accumulate endogenous energy reserves to meet the demands of courtship (Baldassarre and Bolen 1994). Baldassarre and Bolen (1994) proposed that birds that do not accumulate energy reserves may have less time and energy at their disposal to initiate courtship and/or may be unable to maintain previously established pair bonds. Clearly, birds must meet high energy demands to successfully fulfill critical wintering components of their annual cycle. Further, Heitmeyer and Fredrickson (1981) build a scenario where endogenous reserves established on wintering grounds return mallards to breeding areas in better condition to begin nesting, leading to larger clutch sized and earlier nests, which tend to be more successful. Providing sanctuary areas of adequate size, encompassing and/or adjacent to quality feeding areas, may contribute to the ability of birds to meet the physiological demands required during winter and possibly the subsequent nesting cycle.

It has been shown that sanctuary areas on the wintering grounds are effective in maintaining local waterfowl populations in a landscape subject to hunting pressure (Bellrose 1954, Madsen 1998). Heitmeyer and Raveling (1988) found that waterfowl used sanctuaries during the day and local rice fields at night. Similarly, Fleskes *et al*. (2005) found Northern Pintail used areas closed to hunting during the day and dispersed throughout the area at night. These data indicate that while sanctuaries are effective in maintaining local waterfowl populations through the hunting season, birds must disperse at night to feed.

Overall, it is expected that the maintenance of sanctuary areas on the Refuge Complex under Refuge Management Alternative D will mitigate for disturbance impacts from hunting activities. In years of poor habitat quality due to climatic extremes or tidal flooding from tropical disturbances, however, it is possible that hunting activities would result in reduced abundance of wintering waterfowl on the Refuge Complex.

Refuge-specific hunting regulations under Refuge Management Alternative D would also help mitigate the impacts of hunting activity-related disturbance to waterfowl. Waterfowl hunting in hunt areas is allowed three days per week (with the exception of the 1,500-acre Pace Tract on Anahuac NWR which is open for hunting seven days per week), and all hunting activity is curtailed each day at noon. The non-hunted days and afternoon and evening closures provide undisturbed periods within the hunt areas, facilitating waterfowl utilization of hunt area habitats for foraging and resting. Boat use on the Refuge Complex occurs primarily in bayous, canals and ditches, limiting disturbance impacts to these narrow corridors (exceptions are Star Lake and Clam Lake on McFaddin NWR and Pole Lake on Texas Point NWR). The majority of the hunt areas therefore are not impacted by boating activity, being accessible primarily by foot. In addition, a variety of regulations govern means of access to hunt areas, including boat motor and horsepower restrictions, prohibition of airboat and all-terrain vehicle use, and establishment of areas in which only non-motorized boat access is allowed. While these regulations are in place primarily to protect habitats and public safety, they also reduce overall disturbance impacts to waterfowl and other migratory birds.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation

Under Refuge Management Alternative D, existing visitor facilities on the Refuge Complex would be maintained and several new facilities would be developed to support these uses on Anahuac, McFaddin and Texas Point NWRs. Means of access for these uses and the presence of visitors would result in disturbance impacts to waterfowl, as described under Alternative A. Increased visitation and the presence of new facilities would increase these impacts and expand the areas within which impacts would occur.

Primary means of access to areas on the Refuge Complex use for fishing and wildlife observation and photography would include motorized and non-motorized boating (primarily in bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), motorized vehicles on refuge roads open to the public, and walking on trails, boardwalks and observation platforms and along banks and shorelines. A very small number of visitors use bicycles on public roads and levee trails on all three refuges. An even smaller number ride horses on roads at Anahuac NWR and on the Gulf beach at McFaddin NWR. Motorized vehicles and walking are used to access areas used for environmental education and interpretation on Anahuac NWR. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use.

Disturbance of waterfowl by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993). In wetland habitats, disturbance from "out of vehicle" approaches can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). While some species of waterfowl appear to acclimate to vehicular traffic, and even presence of visitors on trails, boardwalks, and observation platforms, other species are less tolerant of disturbance. Overall it is likely that species composition and abundance of waterfowl is decreased in areas supporting these recreational uses.

(2). Impacts to other Migratory Birds Shorebirds, Wading Birds and other Marsh and Waterbirds, Land Birds

(a). Waterfowl Hunting

Although the impacts of waterfowl hunting under Refuge Management Alternative D on other wetland-dependent migratory and resident birds which are not hunted is likely less than for waterfowl, studies have demonstrated that hunting (including accessing hunt areas) does affect abundance and distribution of these other avian species. The noise associated with shooting likely reduces habitat utilization by shorebirds, wading birds, other marsh and waterbirds, and land birds using wetland habitats within hunt areas, at least while hunting is occurring. Motorized boating disturbs and displaces many waterbird species (Dahlgren and Korschgen 1992, Knight and Cole 1995), as will non-motorized boats, vehicles and walking through the marsh.

Under Refuge Management Alternative D, the USFWS would open a portion of Anahuac NWR to hunting of doves. The most direct effect of dove hunting on the Refuge Complex would be the mortality of harvested birds resulting from the hunting activities. However, because regulations governing harvest of migratory birds including doves are developed annually and are designed to ensure that viable populations are sustained over the long-term, this new hunting opportunity should not have any measurable effect on overall populations and the long-term viability of these populations. Disturbance impacts to other wildlife species would be localized and minimal. Refuge-specific regulations for this hunt would be developed to protect wildlife and habitats and public safety, and to minimize conflicts with refuge management activities and other public uses.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

Under Refuge Management Alternative D, existing visitor facilities on the Refuge Complex would be maintained and several new facilities would be developed to support these uses on Anahuac, McFaddin and Texas Point NWRs. As described under Alternative A, means of access and the presence of visitors result in disturbance impacts to migratory birds. Under Alternative D, increased visitation and the presence of new facilities would increase these impacts and expand the areas within which impacts would occur.

Primary means of access to areas on the Refuge Complex for fishing, wildlife observation and photography would include motorized and non-motorized boating (primarily in bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), motorized vehicles on refuge roads open to the public, and walking on trails, boardwalks and observation platforms and along banks and shorelines. A very small number of visitors would use bicycles on public roads and levee trails on all three refuges. An even smaller number would ride horses on roads at Anahuac and McFaddin NWRs. Motorized vehicles and walking would be used to access areas used for environmental education and interpretation on Anahuac NWR.

Disturbance of migratory birds by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993) and shoreline areas regularly used for fishing. Along roads through wetland habitats, disturbance from "out of vehicle" approaches for observation and photography can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). Walking on trails tends to displace birds and can cause declines in species richness and abundance (Riffell *et al*. 1996). Some generalist avian species such as house finches tend to increase near trails, while specialist species such as solitary vireo move away from trails. The zone of influence around trails appears to be approximately 75m for woodland areas adjacent to grasslands (Miller *et al*. 1998).

On Anahuac NWR, visitors would be allowed to access a 10-acre area within the Yellow Rail Prairie Management Unit to attempt to flush and view yellow rails. This is accomplished by walking slowly through the area, and is most successful when groups of people slowly walk parallel to each other dragging a rope in between participants. This activity occurs primarily during the months of March and April, and includes several guided "Yellow Rail Walks" led by refuge staff or trained volunteers. Disturbance of rails flushed during this activity undoubtedly occurs and likely leads to reduced utilization of this area by rails. Suitable undisturbed habitats exist adjacent to this site, and is unlikely that this disturbance results in long-term negative impacts to individual rails or rail populations.

Disturbance impacts to birds from visitation are often magnified during the breeding season. Color of clothing worn can attract or repel different passerine species based on breeding plumages of those species (Gutzwiller and Marcum 1997). Primary song occurrence and consistency of certain passerines can be impacted by a single visitor (Gutzwiller *et al.* 1994), which could limit the number of breeding pairs and production by those species in disturbed areas (Reijnen and Foppen, 1994). Predation on songbird, raptors, colonial nesting species, and waterfowl nests tends to increase near more frequently visited areas (Glinski 1976, Buckley and Buckley 1978, Boyle and Samson 1985, Miller *et al.* 1998).

(3). Impacts to Fisheries

(a). Fishing

Enhancement of fishing and crabbing opportunities on the Refuge Complex under Refuge Management Alternative D would include developing new access facilities and expanding the hours that McFaddin NWR is open to the public.

The most direct effect of fishing on the Refuge Complex is the mortality of harvested freshwater and saltwater fish, blue crabs, and several fish and shellfish species caught for use as bait. Fishing and crabbing on the Refuge Complex occur under regulations promulgated by the Texas Parks and Wildlife Department. These regulations are designed to ensure that viable fish and shellfish populations are sustained over the long-term. Fishing on the Refuge Complex under this Alternative should not have any measurable effect on overall populations and the long-term viability of these species' populations.

(b). Waterfowl Hunting, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach and other Uses

No impacts to fisheries resources are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative D.

(4). Impacts to Threatened and Endangered Species

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that Bald Eagles, Brown Pelicans and Piping Plovers using Refuge Complex habitats would be subject to the some level of disturbance by public use activities on the Refuge Complex under this Alternative. These impacts are expected to be negligible. Bald Eagles are usually associated with large concentrations of wintering waterfowl that occur in refuge sanctuary areas which are not open to the public. Piping Plovers utilize beach, shoreline and intertidal mudflat habitats primarily during fall and winter, when use of these habitats by the public is lightest. Brown Pelicans readily forage and roost adjacent to human activity and infrastructure. The three T&E avian species do not nest on the Refuge Complex, their presence is transient in nature, and they are highly mobile and able to move to undisturbed areas. Overall, no impacts to Federally-listed or State-listed Threatened and Endangered species are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative D.

(5). Impacts to other Fish and Wildlife Species – Mammals, Amphibians, Reptiles, and Invertebrates

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that mammals and amphibians and reptiles would be subject to some level of disturbance from public use activities occurring on the Refuge Complex under this Alternative. These impacts are expected to be negligible. Vehicles would occasionally strike and kill mammals such as Virginia opossum, armadillo, raccoon and striped skunk, and reptiles and amphibians including alligators, snakes and frogs.

(b). Commercial Alligator Harvest

Under Refuge Management Alternative D, an adult alligator harvest program would continue to be administered as an economic use on the Refuge Complex. This program is administered under regulations promulgated by Texas Parks and Wildlife Department, and these regulations are designed to ensure that viable alligator populations are sustained over the long-term. In addition, the USFWS regulates the alligator harvest program on the Refuge Complex through issuance of a Special Use Permit which contains stipulations also designed to conserve alligator populations. For example, special regulations are in place to restrict harvest of reproductive-aged alligators and maintain a natural age structure within the Refuge Complex alligator population. Continuation of the commercial alligator harvest program under Alternative D should not have any measurable effect on the long-term viability of alligator populations on the Refuge Complex.

(c). Control of Muskrat Populations

Under Refuge Management Alternative D, muskrat populations could be controlled in specific locations as deemed necessary to protect wetland habitats on the Refuge Complex through issuance of Special Use Permits for trapping and removal by qualified individuals. Herbivory in areas of high density muskrat populations can cause or exacerbate conditions resulting in permanent conversion of vegetated marsh to open water. This is likely to most prevalent in areas affected by saltwater intrusion or other factors

contributing to marsh loss. Trapping and removal of muskrats under this program would have negligible if any impacts on overall muskrat populations and the long-term viability of these populations.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

Under Refuge Management Alternative D, all current surveys, monitoring and research activities for migratory birds, resident wildlife, fisheries and T&E species (described under Refuge Management Alternative A) would continue. In addition, the USFWS would work with partners to expand the annual Mottled Duck breeding pair survey and to conduct additional research on factors affecting vital rates for this important resident waterfowl species. The USFWS would also expand biological monitoring and research through expanded partnerships for several priority migratory birds (including shorebirds, wading birds, marsh and waterbirds and several migratory and resident land birds) which utilize Refuge Complex habitats and which have been identified as priority species for conservation.

Expanded surveys and monitoring and research activities conducted under Refuge Management Alternative D would be useful for tracking and documenting the impacts of various management strategies on fish and wildlife populations, distribution, movements and habitat utilization. This information will facilitate implementation of an adaptive management approach which allows continual refinement and improvement of management activities on the Refuge Complex. Additional information on Mottled Ducks and other priority migratory birds will enhance conservation efforts for these species.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative D, the USFWS would continue to manage oil and gas exploration and development activities on the Refuge Complex through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to fish and wildlife resources, including timing of activities to avoid major periods of utilization, required use of specialized equipment, location and size of facilities, and required pollution controls. Under this Alternative, the USFWS would develop a comprehensive Oil and Gas Management Plan to enhance management of oil and gas activities on the Refuge Complex.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex would be reduced impacts on fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative D, the USFWS would expand efforts to develop partnerships with private land owners to restore and enhance wetland, native prairie and coastal woodlot habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project; and 3) holding workshops for landowners to demonstrate habitat enhancement methods and techniques. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands. It is anticipated that continuation of outreach and partnership efforts under Refuge Management Alternative D would result in additional habitat restoration and enhancement throughout the project area.

The USFWS would also continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, Texas General Land Office and Galveston Bay Estuary Program, conservation organizations such as Ducks Unlimited, the Galveston Bay Foundation and local Audubon Society chapters, community organizations and Refuge volunteers. These partnerships support and greatly enhance a variety of refuge management programs.

It is anticipated that continuation of outreach and partnership efforts under Refuge Management Alternative D would result in additional habitat restoration and enhancement on the Refuge Complex and throughout the project area.

It is anticipated that expanded outreach and partnership efforts under Refuge Management Alternative D would result in benefits to fish and wildlife resources as important habitats are restored and enhanced. Projects such as those implanted to date would enhance wetland habitats for wintering waterfowl, Mottled Ducks and other wetland-dependent migratory birds, and for resident wildlife including several species of reptiles and amphibians which depend on freshwater habitat. Restoration and enhancement of upland habitats including native prairie and coastal woodlots would benefit many avian species, including many Avian Species of Conservation Concern.

B. Socioeconomic Resources Section

1. Economic Impacts

Economic impacts from management activities on the Refuge Complex occur in the regional economy in two different ways.

First, there are the direct economic impacts that occur as a result of the economic stimulus of three elements: 1) direct expenditures made by USFWS to manage operations at the Refuge Complex, 2) value of production from agricultural programs on the Refuge Complex; and 3) expenditures made by recreational visitors to the Refuge Complex.

Second, there are indirect and induced economic impacts which are additional economic activity that occur as a result of the re-spending of these direct economic elements. The indirect and induced economic impacts are measured as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the direct economic elements. Total economic impacts (direct, indirect and induced) of for this management alternative were estimated using the data and methods discussed below. The analysis compares the impacts from this management alternative to the "No Action" management alternative, which would continue current activities.

The study area for purposes of estimating economic impacts is all of Jefferson and Chambers Counties along with a small portion of Galveston County, which includes the eastern portion of the Bolivar Peninsula east of Rollover Pass.

a. Direct Economic Impacts

(1). Value of Refuge Operations (Direct Expenditures)[16]

Based on information about the activities proposed under Refuge Management Alternative D, an estimate of the operational expenditures was prepared. The estimate is broken out into five-year periods because it is expected that the amounts within certain cost categories would change with time under this management alternative. Because projects would occur throughout the study period, project costs will vary by year. In addition, changes in staffing would occur throughout the study period so salary costs vary annually as well. The estimate of the annual average cost, per five-year period, for Refuge Management Alternative D is summarized in Table 4-27 on the following page.

16 The Value of USFWS Operations Table is essentially done for the No Acton Alternative (Alt. A). Under the remaining management alternatives (B through E), the USFWS will change the magnitude and intensity of management activities on the Refuge Complex. These actions will show increases or decreases from the baseline direct expenditures by the USFWS in the local economy as indicated in the Value Table above.

Table 4-27
Average Annual Operational Costs for the Refuge Complex – Refuge Management Alternative D (Direct Expenditures)

Cost Category	Annual Average Expenditures		
	Year 1 - 5	Year 5 - 10	Year 10 - 15
Annual Staff Salaries	$1,777,927	$1,903,894	$2,060,061
Utilities	$24,500	$17,500	$17,500
Travel	$27,386	$19,562	$19,562
Water Purchases	$66,000	$50,000	$50,000
Heavy Equip. Rental and Replacement	$115,600	$87,333	$86,667
Annual and Deferred Maintenance	$1,707,883	$1,552,050	$1,454,050
Special Programs	$19,500	$19,500	$19,500
Total Average Expenditures	$3,738,797	$3,649,839	$3,707,339

The estimate of Refuge Operation's direct expenditures under this alternative shows an approximate $1,000,000 increase compared to the $2,695,184 estimate under the "No Action" alternative.

(2). Value of Production from Refuge Agricultural Programs

(a). Cattle Grazing

The estimate for the value of grazing included some development assumptions regarding the annual average number of AUMs expected to occur under this management scenario. The annual average AUMs are expected to increase somewhat from 23,900 under the "No Action" alternative to about 27,485 under this management alternative. Using the estimated value of $88.02/AUM determined in the analysis for the "No Action" alternative, there is about a $300,000 increase in the estimate of the production value of grazing. A summary comparing the changes in AUMs and value of production between the "No Action" alternative and Alternative D is contained in Table 4-28.

Table 4-28
Estimated Production Value of Grazing Activities on Refuge Complex - Refuge Management Alternative D

Alternative	Annual Average AUMS	Value of Annual Production
No Action Alternative	23,900	$2,103,678
RM Alternative D	27,485	$2,419,230

(b). Rice Production

Under the development assumptions for this alternative the annual acreage in rice production will stay basically the same as the current 600 acres under the "No Action" alternative. Therefore, the estimated annual value for rice production under this alternative would be the same as the $249,867 determined for the "No Action" alternative. A summary comparing the changes in annual average acreage produced and value of production between the "No Action" alternative and Alternative D is contained in Table 4-29.

Table 4-29
Estimated Value of Rice Production on Refuge Complex - Refuge Management Alternative D

Alternative	Annual Average Acreage Produced	Value of Annual Production
No Action Alternative	600	$249,867
RM Alternative D	600	$249,867

(3) Value of Refuge Recreational Programs

For each management alternative, assumptions were made on how proposed management changes would affect visitation during the study period. These changes are expressed as increases or decreases in the number of non-resident recreational visitors under the "No Action" alternative. The estimated changes in recreational visitors under Refuge Management Alternative are broken out by recreational activity as follows:

Activity	Change
Waterfowl Hunting	5% Increase
Dove Hunting	New activity - 100 hunter/days per year
Fishing	10% Increase
Wildlife Observation	10% Increase

These changes were then applied to the estimate of annual non-resident visits and the estimate of itemized expenditures by recreational activity which were developed for the "No Action" alternative. Table 4-30 contains a summary of the comparison of the annual direct expenditures associated with recreational visitors to the Refuge Complex between the "No Action" alternative and Refuge Management Alternative D.

Table 4-30

Annual Direct Expenditures Associated with Recreational Visitors on Refuge Complex - Alternative D

Alternative	Annual Non-resident Visitors	Total Recreational Expenditures
No Action Alternative	35,010	$1,098,923
RM Alternative D	38,552	$1,278,784

b. Indirect and Induced Economic Impacts

Indirect and induced economic impacts are described as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the following three elements: direct expenditures made by the USFWS to manage operations at the Refuge Complex, value of agricultural production on the Refuge Complex, and the direct expenditures made by recreational visitors to the Refuge Complex. These direct expenditures create additional economic activity, the indirect and induced impacts, as re-spending of the direct expenditures occur. The indirect and induced impacts are estimated by using a series of economic multipliers applied to the estimates of the direct economic impacts of USFWS activities. IMPLAN was used to apply economic multipliers to the direct economic elements valued above to arrive at an estimate of the indirect and induced impacts to employment, income and indirect business taxes in the study area that can be attributable these USFWS activities.

The indirect and induced economic impacts are measured in the four following areas:

Employment: The annual average estimated employment is measured as Full-Time equivalents (FTEs). Full-time equivalent employees equal the number of employees on full-time schedules plus the number of employees on part time schedules converted to a full-time basis. This includes direct employment at the Refuge Complex (Approximately 30 FTEs at this time) as well as the additional employment supported in the surrounding area.

Labor Income: Labor income includes employee compensation and proprietary income. Employee compensation is the total wages and salaries of workers who are paid by employers, as well as the value of benefits such as health care, life insurance, retirement payments, and non-cash compensation. Proprietary income consists of payments received by self-employed individuals as income.

Other Property Type Income: This type of income is payments in the form of rents, royalties, dividends, and includes corporate profits.

Indirect Business Taxes: Indirect business taxes include excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses.

(1). Refuge Operations

The comparison between the indirect and induced economic impacts attributable to Refuge Operations for Alternative D and the "No Action" alternative is summarized in Table 4-31.

Table 4-31
Indirect and Induced Economic Impacts of Operations at Refuge Complex – RM Alternative D

	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	45	45	45
Refuge Management Alternative D	61	59	56
Labor Income			
No Action Alternative	$1,066,457	$1,066,457	$1,066,457
Refuge Management Alternative D	$1,605,157	$1,593,034	$1,554,094
Other Property Type Income			
No Action Alternative	$222,664	$222,664	$222,664
Refuge Management Alternative D	$226,829	$423,406	$401,978
Indirect Business Taxes			
No Action Alternative	$493,149	$493,149	$493,149
Alternative D	$551,300	$578,967	$614,541

(2). Refuge Agricultural Program

The comparison between the indirect and induced economic impacts attributable to agricultural activities, cattle grazing and rice farming, on the Refuge Complex for Refuge Management Alternative D and the "No Action" alternative is summarized on the following page in Table 4-32.

Table 4-32
Indirect and Induced Economic Impacts of Agricultural Activities at Refuge Complex – RM Alternative D

	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	20	20	20
Refuge Management Alternative D	22	22	22
Labor Income			
No Action Alternative	$587,382	$587,382	$587,382
Refuge Management Alternative D	$656,901	$656,901	$656,901
Other Property Type Income			
No Action Alternative	$272,759	$272,759	$272,759
Refuge Management Alternative D	$302,657	$302,657	$302,657
Indirect Business Taxes			
No Action Alternative	$87,668	$87,668	$87,668
Refuge Management Alternative D	$97,766	$97,766	$97,766

(3). Refuge Recreational Programs

The comparison between the indirect and induced economic impacts attributable to expenditures by recreational visitors at the Refuge Complex for Alternative D and the "No Action" alternative is summarized in Table 4-33.

Table 4-33
Indirect and Induced Economic Impacts of Recreational Activities at Refuge Complex – RM Alternative D

	Annual Average		
Employment (FTEs)	Year 1 - 5	Year 6- 10	Year 11 - 15
No Action Alternative	25	26	26
Refuge Management Alternative D	28	29	29
Labor Income			
No Action Alternative	$609,908	$621,374	$629,040
Refuge Management Alternative D	$611,468	$684,011	$692,478
Other Property Type Income			
No Action Alternative	$224,963	$229,144	$231,939
Refuge Management Alternative D	$247,623	$252,244	$255,331
Indirect Business Taxes			
No Action Alternative	$136,816	$139,559	$141,394
Refuge Management Alternative D	$150,623	$153,657	$155,684

2. Population Impacts

Management actions associated with the Refuge Complex are not expected to have notable impacts on population trends within the study area. Population trends in Jefferson and Chambers counties have shown increases in recent years though these increases are likely not influenced by activities at the Refuge Complex. Any population change that could be associated with implementation of alternatives under consideration in the EIS would likely be linked to employment changes. Although the Refuge Complex under this management alternative is expected to support over 100 FTEs per year, the Refuge Complex is not considered a major employer in the area and thus would not support a significant proportion of the population.

3. Fiscal Impacts on Local Governments

Refuge management has the potential to impact the fiscal conditions of local government entities. This fiscal effect could be on revenues and/or expenditures. The "Economics Impacts" section above has already evaluated impacts from the various current refuge management activities on indirect business taxes. In addition to the increased indirect business taxes, the USFWS makes substantial payments to local governmental entities under the Refuge Revenue Sharing Act.

Changes in demand for government services could vary with changes in population tied to the Refuge Complex and could cause undue strain on infrastructure (e.g. roads, utilities, schools, etc). As discussed above, since notable population changes are not expected, identifiable changes in demand for government services due to changes in population are not expected. Changes in recreation activities could also cause some impacts to local government services through changes in demand though they are not expected to be notable under any of the Refuge Management Alternatives.

Management actions can also affect local government services directly. For instance, the USFWS purchases water from the Chambers Liberty Counties Navigation District (District) to support its management activities. This provides positive impacts to this local District that has experienced a decrease in water purchases due to a decline in rice production in the area.

4. Social Impacts

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, natural resource management actions such as those made by the USFWS on the Refuge Complex. Additionally, Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them)
- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions)
- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability)
- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others)

The interactions between USFWS activities and people are already evident in the area. Current direct and indirect interactions between the USFWS and the local and regional population base include visitation to the refuges (e.g., recreation opportunities), participation in USFWS volunteer programs, an awareness of refuge activities (but not direct participation in these activities), or simply driving by the Refuge Complex land holdings. These interactions would basically remain the same for the vast majority of the nearby population under any of the Refuge Management Alternatives being considered in this EIS, and there would be a relatively small magnitude and frequency of "new" impacts since the USFWS has been managing lands within the Refuge Complex for many years.

Additionally, implementation of any of the Refuge Management Alternatives would not lead to substantial new population or changes in the demographic or other characteristics of the existing population. One of the most important causes of potentially significant social effects is a new population that is 1) relatively large in relation to the existing population, and/or 2) demographically or socially different than the existing population. Since there would be little change in population or demographics directly or indirectly from any of the alternatives, this cause/effect relationship is not of concern in this EIS analysis.

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Issues would arise when management activities are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships between the USFWS and Stakeholder Groups

General categories of stakeholder groups describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A summary of potential future relationships between the USFWS and stakeholder groups follows. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole. The following is a list of local stakeholder groups who could be affected by USFWS management activities on the Refuge Complex:

- Residents and/or Employees
- Landowners
- Recreationalists
- Governmental or Quasi-Governmental Agencies
- Businesspersons and/or Business Owners
- Conservation or Environmental Protection Advocates

Overall, USFWS management activities and objectives under all the Refuge Management Alternatives may in some cases conflict with some of the goals, beliefs, and objectives of many of the local stakeholders. This situation will lead to the continued need for the USFWS to interact with the public (see next section) and to find a proper balance to its activities. However, socioeconomic issues would continue to exist among the various stakeholder groups with regard to their opinion of the USFWS role, responsibilities, and actions; many of these issues would remain unresolved in the future as discussed later in this section.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. Under Refuge Management Alternative D, current USFWS public outreach efforts would continue and be expanded.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

The following is a summary of socioeconomic issues associated with USFWS activities at the Refuge Complex. The proposed USFWS management actions under the Refuge Management Alternatives would have no major effect on the existence or resolution of these current issues. Under any of the Refuge Management Alternatives:

- There would be points that continue to be in dispute or unsettled between different parties regarding the existence and/or management of the Refuge Complex
- Different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions
- Some people would continue to think positively about the role of the USFWS in the area; others would continue to think negatively about this role; and others would continue to have no opinion or be neutral about the USFWS role and activities within the area
- As with existing conditions, issues would be unresolved and one party could not be determined to be "right" and the other party "wrong" with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future.

Under Refuge Management Alternatives B through E, management philosophies and priorities would change from current conditions. The USFWS management of the Refuge Complex would continue to be primarily oriented to support wildlife habitat management and enhance fish and wildlife values; however, the philosophy of the primary management approach would differ for each Refuge Management Alternative. These different management approaches and philosophies have a relationship with social structures and lifestyle, but the differences among alternatives from a specific social structure/lifestyle perspective would not be substantial except on a localized or case-specific basis. Under all Refuge Management Alternatives, the USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however the "appropriateness" of any chosen alternative would depend on individual and group values, beliefs, and goals.

While the Refuge Management Alternatives support different philosophies and priorities, and the differences among Alternatives may be identifiable on a localized basis, the social structure and lifestyle conditions and trends within the Refuge Complex would generally remain the same as current conditions.

d. Environmental Justice

The need to conduct an environmental justice analysis for the Texas Chenier Plain Refuge Complex EIS/CCP/LPP is based on Executive Order (EO) 12898. Several areas have been identified as having potential minority or low-income populations within the primary or secondary study areas. EO 12898 requires an assessment as to whether these populations might be disproportionately affected by the management alternatives.

Based on the results of the socioeconomic and environmental impact analysis conducted for this project, it can be concluded that those persons who reside in and around the Refuge Complex would bear both some adverse effects and some beneficial effects by the continued operation and/or expansion of the Refuge Complex. However, any identified socioeconomic or environmental impacts from continued operation of the Refuge Complex by the USFWS would not be localized nor be placed primarily on the identified minority and/or low-income population components. Overall, the identified minority and/or low-

income populations would not be disproportionately affected compared to other segments of the general population in the area.

Additionally, persons of all races and income levels were invited to participate in the public participation process for the EIS, and comments or input into the process from any minority or low-income persons were considered equally with all other persons. Therefore, implementation of any of the Refuge Management Alternatives would be in compliance with EO 12898.

V. IMPACT ANALYSIS FOR REFUGE MANAGEMENT ALTERNATIVE E: EMPHASIS ON A PASSIVE MANAGEMENT APPROACH

Overview

Under this Alternative, the Refuge Complex would change its management focus from active habitat management and restoration to a more passive management approach, in which plant communities and wildlife populations would be influenced primarily by natural events such as lightning-caused fires, herbivory by native wildlife, and tidal or stream flooding. Active habitat management and restoration activities including structural management of water levels and salinities in marshes, prescribed burning, controlled cattle grazing, rice farming, moist soil management and control of invasive species would be discontinued. Efforts to address threats to ecosystem health would focus on monitoring rather than active restoration or protection. The Refuge Complex would continue to provide opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses: hunting, fishing, wildlife observation and photography, environmental education and interpretation, but administrative oversight and management would occur at reduced levels.

A. Natural Resources Section

1. Impacts to Air Quality

The USFWS fire management program on the Refuge Complex has the greatest potential of all refuge management actions to impact the region's air quality. Fire management activities currently include both the suppression of unplanned wildland fires and prescribed burning. Smoke from unplanned wildland fires and from planned prescribed burning can be transported by prevailing winds and affect air quality and transportation safety over a large area which includes the cities of Houston, Beaumont and Port Arthur and numerous smaller local communities.

Under Refuge Management Alternative E, suppression of wildland fires would continue as prescribed in the Refuge Complex Fire Management Plan (USFWS 2001), and the USFWS would discontinue its prescribed burning program on the Refuge Complex. Suppression would involve utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Under this Alternative, whenever feasible, natural fires ignited by lightning would be allowed to burn.

Discontinuation of prescribed burning activities on the Refuge Complex under Refuge Management Alternative E would eliminate potential air quality impacts from smoke generated from these burns. However, lack of prescribed burning would result in rapid accumulation of vegetative fuels over large areas on the Refuge Complex. Most lightning-caused wildland fires on the Refuge Complex occur during the months of June through October, when prevailing winds typically include a southerly component which transports smoke towards communities and other smoke-sensitive areas. Wildland fires would be more likely to start in areas with higher fuel loads, and fires that did start would burn with higher intensity, produce more smoke, and would be more difficult to suppress than in areas where previous fires had reduced accumulations of hazardous fuels. Under this Alternative, the likelihood that smoke from unplanned wildland fires would be transported by prevailing winds and negatively impact air quality and transportation safety in the region would increase, both in terms of increased frequency of events which negatively impact regional air quality and an increase in the amount of smoke and associated particulates during these events.

2. Impacts to Geology and Soils

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

Under Refuge Management Alternative E, the USFWS would discontinue participation in current partnership efforts with other federal and state agencies and conservation organizations aimed at addressing threats which are resulting in ongoing coastal land loss, and would discontinue implementation of small scale shoreline and hydrologic restoration projects on the Refuge Complex. Habitat management activities on the Refuge Complex including structural management of water levels and salinities and prescribed burning which can impact soils and soil formation would be discontinued. Under this Alternative, the USFWS would monitor coastal land loss from shoreline erosion and conversion of vegetated marshes to open water.

Although shoreline erosion and retreat and along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has accelerated rates of shoreline retreat along the Gulf shoreline. This reduced sand supply has led to loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges.

The historic barrier beach/dune system has been almost entirely lost on both the Texas Point and McFaddin NWRs. Shoreline erosion and retreat along the Gulf on these refuges is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. Morton *et al*. (1998) found beach erosion between Sabine Pass and High Island to be among the highest in Texas. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and significant portions of the McFaddin NWR shoreline are eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of habitat, loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of plant productivity may decrease the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water (DeLaune *et al.* 1983, Nyman *et al.* 1993). (On McFaddin NWR, coastal erosion and damage from storm tidal surges have destroyed a portion of Texas State Highway 87, a coastal highway that has been closed since 1989.)

Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels have caused erosional loss of organic marsh soils, also leading to conversion of vegetated marshes to open water. Conversion of vegetated marshes to open water has also occurred throughout the region in areas where rapid land subsidence has resulted in submergence of wetlands. Conversion of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et al*. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). It is likely that

conversion of vegetated marshes to open water have been greatest in areas subject to both saltwater intrusion and rapid subsidence.
Relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

Under Refuge Management Alternative E, the future effects of relative sea level rise and altered hydrological regimes on coastal habitats will likely be substantial. Without efforts to augment coarse sediment supply along the Gulf and to construct breakwaters along the GIWW and East Galveston Bay, rates of shoreline retreat and land loss would likely accelerate. Increased saltwater intrusion would result in decreased plant productivity in fresh and intermediate marshes, reducing soil formation and vertical accretion and leading to submergence and conversion of vegetated marsh to open water. Potential contributions to marsh accretion from mineral sediment supply using dredge material would not be realized. The likelihood of peat burns occurring would increase under this Alternative, with subsequent negative impacts to marsh soils and vertical accretion.

3. Impacts to Hydrology and Water Quality

a. Hydrology

Under Refuge Management Alternative E, the USFWS would discontinue wetland management and restoration activities conducted on the Refuge Complex and aimed at minimizing or mitigating impacts of altered hydrological regimes on plant, fish and wildlife resources. These include structural marsh management, rice farming and moist soil management, marsh and prairie wetland restoration, and shoreline protection and restoration. The USFWS would also discontinue coordination with other State and Federal agencies on a large-scale hydrological restoration projects. Under this Alternative, the USFWS would monitor status and trends of wetland habitats on the Refuge Complex.

Implementation of this Alternative would result in three major hydrological impacts - increased saltwater intrusion, additional loss of freshwater inflows, and permanently altered marsh hydroperiods resulting in rapid drainage and drying and/or excessive flooding and inundation. Fresh and intermediate marshes would be converted to more brackish regimes, resulting in a loss of overall biological diversity. Marshes would be more susceptible to the negative impacts of excessive drying and oxidation of soils and water logging, both of which could lead to conversion to open water.

b. Water Quality

Potential sources of contaminants affecting water quality include accidental releases from oil and gas exploration and production activities on and adjacent to the Refuge Complex, including spills and leaks from wells, production facilities, and pipelines. In addition, a high volume of petrochemicals is transported through the Refuge Complex on a daily basis via the GIWW. Municipal development and agricultural practices may also impact water quality in the Refuge Complex. Non-point pollution sources such as storm drain run-off from local cities and towns are major sources of pollutants entering the Galveston Bay estuarine ecosystem (Galveston Bay Estuary Program 1995). Point source pollution from upstream facilities such as landfills is also of concern. Rice cultivation contributes important freshwater inflows to the Galveston Bay and Sabine Lake estuarine ecosystems, but agricultural practices as a whole may also contribute excess nutrients and toxins to surface waters within these coastal watersheds. Herbicide application is used on rice, soybeans, sorghum, and hay throughout the region. Concentrations of

herbicides are greatest during May, June and July, with the lowest concentrations occurring in the fall and winter. Nitrates from nutrient loading are common in agricultural areas where fertilizer application enters into streams, creeks, and bayous during storm events.

Under Refuge Management Alternative E, the USFWS would continue current water quality monitoring efforts described under Alternative A, but would no longer proactively work to address water quality issues affecting Refuge resources. Impacts of point and non-point source pollution sources and accidental spills on water quality, habitats and fish and wildlife resources on the Refuge Complex would likely increase.

4. Impacts to Vegetation and Habitats

a. Impacts from Habitat Management and Restoration Activities

Under Refuge Management Alternative E, the USFWS would curtail most habitat management and restoration activities on the Refuge Complex. Vegetative communities and habitats would be influenced primarily by events such as lightning-ignited fires, herbivory by native wildlife, and tidal and precipitation-related flooding.

(1). Wetland Specific Management and Restoration

(a). Water Management in Coastal Marshes

Under Refuge Management Alternative E, the USFWS would discontinue structural management of approximately 30,000 acres of coastal marshes on the Refuge Complex.

Structurally managed marshes have been shown to provide quality habitat for migratory birds (Chabreck 1960, 1976). Merino *et al.* (2005) found that managed areas, particularly those without complete levees, had more submerged aquatic vegetation than unmanaged areas. Marsh restoration using semi-impoundments in Louisiana reversed the deleterious effects of excessive tidal exchange caused by channelization, allowing both emergent and submergent vegetation to flourish (Hess *et al*. 1989). Monitoring efforts on and around McFaddin NWR indicated that diversity indices for both emergent and submergent plants were higher within structurally managed marshes compared to adjacent unmanaged marshes (USFWS 2006). This was largely due to the presence of plants with lower salinity tolerances, indicating that this marsh management program is at least partially meeting objectives. Chabreck (1994) stresses that careful planning and implementation is required in order for structural marsh management to reverse the negative effects of hydrological alterations and maintain critical wetland functions.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al.* 1983, Nyman *et al.* 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exacerbate flooding, further reducing plant vigor.

Implementation of this Alternative would result in three major hydrological impacts on the Refuge Complex - increased saltwater intrusion, additional loss of freshwater inflows, and permanently altered marsh hydroperiods resulting in rapid drainage and drying and/or excessive flooding and inundation. The historic continuum of fresh, intermediate, brackish and saline marshes would no longer be maintained. Fresh and intermediate marshes would be converted to more brackish regimes, resulting in a loss of overall biological diversity. Marshes would be more susceptible to the negative impacts of excessive drying and oxidation of soils and water logging, both of which could lead to lack of vertical accretion, submergence, and ultimately to conversion to open water.

(b). Marsh Restoration

Under the Refuge Management Alternative E, the USFWS would discontinue coordination efforts with other agencies to implement wetland restoration on the Refuge Complex through the beneficial use of dredge material and hydrological restoration.

Implementation of this Alternative would result in loss of opportunities to restore vegetated emergent marsh in areas which have converted to open water. It would also result in not implementing what may be the most practical alternative available to augment marsh vertical accretion and ensure the viability of the Refuge Complex' coastal wetlands in the face of projected relative sea level rise, i.e., increasing mineral sediment input to marshes through the beneficial use of dredge material.

(c). Moist Soil Management

Under Refuge Management Alternative E, the USFWS would discontinue moist soil management on the Refuge Complex.

Implementation of this Alternative would result in loss of 500 acres of shallow freshwater wetlands and associated moist soil plants which provide important food resources for waterfowl, shorebirds, wading birds and marsh birds. Abandoned moist soil units would be highly susceptible to rapid encroachment by invasive plant species, including Chinese tallow, deep-rooted sedge, Eastern baccharis and common rush. Invasive plant encroachment would displace native vegetation and reduce biological diversity.

(d). Cooperative Rice Farming Program

Under Refuge Management Alternative E, the USFWS would discontinue rice farming on the Refuge Complex.

Implementation of this Alternative would result in loss of 500-700 acres of shallow freshwater wetlands which provide important food resources for migrating and wintering waterfowl and other migratory birds. Fallowed rice fields would be highly susceptible to rapid encroachment by invasive plant species including Chinese tallow, deep-rooted sedge, Eastern baccharis and common rush. Invasive plant encroachment would displace native vegetation and reduce biological diversity.

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Under Refuge Management Alternative E, the USFWS would discontinue active native prairie restoration and grassland management activities (burning, grazing, invasive plant control, mowing and haying) on the Refuge Complex. The USFWS would monitor plant community changes in upland prairie habitats.

Implementation of this Alternative would allow plant succession to proceed in the 5,774 acres of upland grassland habitats on the Refuge Complex, including former moist soil units and rice fields. Some reversion to grassland habitat would occur in these newly-fallowed areas, although the diversity of native prairie plants would be less than under current management and restoration programs. Fallowed rice fields and abandoned moist soil units would be highly susceptible to rapid encroachment by invasive plant species including Chinese tallow, deep-rooted sedge, Eastern baccharis and common rush. Invasive plant encroachment would displace native vegetation and reduce biological diversity in all grassland habitats on the Refuge Complex.

(b). Woodlot Restoration and Protection

Under Refuge Management Alternative E, the USFWS would discontinue efforts to protect and enhance coastal woodlots on the Refuge Complex. The USFWS would monitor plant community changes in coastal woodlots.

Overall, implementation of this Alternative would be expected to result in decreased abundance and diversity of native canopy and understory plants, and reduced natural regeneration of native woody species in the 127 acres of woodland habitats on the Refuge Complex. Chinese tallow encroachment would occur and would reduce value of woodlots to many avian species.

(3). General Habitat Management Activities

The USFWS uses fire management, controlled livestock grazing and exotic/invasive species management and mowing/haying to enhance habitats for migratory birds and other native fish and wildlife species. The integrated combination of burning, grazing and water management on the Refuge Complex maintains a diverse mosaic of wetland vegetative communities, both in plant species composition and structural attributes. Shoreline restoration and protection activities are being implemented on the Refuge Complex to counter ongoing coastal land loss caused by relative sea level rise, altered hydrological regimes and loss of coarse sediment supply. These management and restoration activities are used to conserve, enhance and restore both wetland and upland habitats on the Refuge Complex.

(a). Fire Management Wildland Fire Suppression and Prescribed Burning

Under Refuge Management Alternative E, suppression of wildland fires would continue as prescribed in the Refuge Complex Fire Management Plan (USFWS 2001), and the USFWS would discontinue its prescribed burning program on the Refuge Complex. Suppression would involve utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Under this Alternative, whenever feasible, natural fires ignited by lightning would be allowed to burn.

Under Refuge Management Alternative E, the proportion of marsh habitat with early successional plant communities would decrease on the Refuge Complex relative to current conditions as fewer acres would be burned annually. Herbivory by native species such as snow geese and muskrats would also decrease, as burning during fall and early winter provides optimal habitat for these species. In combination, the elimination of prescribed burning and controlled grazing under this Alternative would favor a trend toward higher successional plant communities in intermediate and brackish marshes, primarily marshhay cordgrass. The habitat mosaic created by the current integrated use of burning, grazing and water management in Refuge Complex marshes would become less diverse. Discontinuation of prescribed burning in upland prairie habitats would result in more encroachment by woody species including Chinese tallow and Eastern baccharis. Native prairie plant species dependent upon frequent fire would be negatively impacted. Over time, native prairie plant species diversity and relative abundance would decrease.

(b). Controlled Livestock Grazing

Under Refuge Management Alternative E, the USFWS would discontinue use of controlled grazing in marsh and upland habitats.

Grazing (integrated with fire and water management) in wetland habitats on the Refuge Complex promotes the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Elimination of grazing by cattle and prescribed burning under this Alternative would decrease the abundance of these early successional plants in marsh habitats. Overall, plant succession would

trend toward higher successional plant communities, primarily marshhay cordgrass, and physical structure towards tall, dense and rank stands of vegetation. The habitat mosaic created by the current integrated use of burning, grazing and water management in Refuge Complex marshes would become less diverse. In upland habitats, positive impacts of controlled grazing including increased plant vigor, enhanced nutrient recycling and increased plant diversity would not be realized. Encroachment by woody species would increase.

Under this Alternative, the potential for negative impacts of grazing to habitats and water quality on the Refuge Complex would be eliminated. Potential detrimental affects of grazing result primarily from overgrazing and include excessive trampling of vegetation, compaction of soils reducing percolation rates, and increased soil erosion. The deposition of excess nutrients in the form of feces in areas where livestock concentrate (USFWS 1994) may negatively impact surface water quality. Fecal coliform from geese and livestock are the main pollutants contaminating the shellfish waters of East Galveston Bay (Galveston Bay Estuary Program 1995). Warm-season grazing of wetland areas can reduce seed production of annual grasses (Chabreck 1968). Overgrazing in prairie habitats, usually caused by prolonged grazing intensity, can reduce native prairie plant diversity. While prairie ecosystems are adapted to short duration high intensity grazing patterns, extended duration grazing can reduce native grasses and some native forbs, particularly those that are more palatable and are preferentially selected by livestock. Soil disturbance by excessive hoof action can provide conditions favorable for establishment of exotic and invasive plant species such as Chinese tallow, and spread seed of undesirable plant species by physically carrying them or ingesting them.

(c). Invasive Species Management

Under Refuge Management Alternative E, the USFWS would discontinue invasive species management activities on the Refuge Complex. Field monitoring would be conducted to document occurrence and distribution of invasive species, and any changes in occurrence and distribution.

Under this Alternative, abundance and distribution of the following invasive species would likely increase, with concurrent impacts on native habitats and fish and wildlife:

- Chinese tallow, Eastern baccharis, willow, and deep-rooted sedge in freshwater marshes, prairies, fallowed rice fields and moist soil units, woodlots and on levees and roadsides.
- Water hyacinth, alligatorweed, Salvinia, common reed and cattail in fresh and intermediate marshes, managed wetland units and in waterways.
- Red rice, coffeebean, barnyard grass, and other grasses in fallowed rice fields and moist soil units.
- Broadleaf weeds and King Ranch bluestem in remnant and restored prairies.

Monocultures of invasive plants reduce natural biological diversity, increase erosion, alter nutrient cycling and displace macro- and micro-fauna that depend on native plants for habitat and food (Sheley and Petroff 1999). Invasive aquatic plant species such as water hyacinth, common reed, and cattail can form dense, monotypic stands which reduce open water habitats on the Refuge Complex.

Under Alternative E, the USFWS would discontinue control of exotic animal species on the Refuge Complex. Feral hog populations would increase, resulting in increased damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging. Additional soil disturbance would enable establishment of Chinese tallow and other undesirable plants. Potential for damage to wetland habitats due to high populations of nutria would increase.

(d). Shoreline Protection and Restoration

Under Refuge Management Alternative E, the USFWS would discontinue participation in current partnership efforts with other federal and state agencies and conservation organizations to implement shoreline protection and restoration to reduce coastal land loss. Under this Alternative, the USFWS would monitor coastal land loss from shoreline erosion.

Although shoreline erosion and retreat along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has accelerated rates of shoreline retreat along the Gulf shoreline. This reduced sand supply has led to loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges.

The historic barrier beach/dune system has been almost entirely lost on both the Texas Point and McFaddin NWRs. Shoreline erosion and retreat along the Gulf on these refuges is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. Morton *et al.* (1998) found beach erosion between Sabine Pass and High Island to be among the highest in Texas. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and significant portions of the McFaddin NWR shoreline are eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of habitat, loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of plant productivity may decrease the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water (DeLaune *et al.* 1983, Nyman *et al.* 1993).

Under Refuge Management Alternative E, the future effects of relative sea level rise and altered hydrological regimes on coastal habitats will likely be substantial. Without efforts to augment coarse sediment supply along the Gulf and to construct breakwaters along the GIWW and East Galveston Bay, rates of shoreline retreat and land loss would likely accelerate. Increased saltwater intrusion would result in decreased plant productivity in fresh and intermediate marshes, especially on McFaddin and Texas Point NWRs, reducing soil formation and vertical accretion and leading to submergence and conversion of vegetated marsh to open water.

(e). Mowing and Haying

Under the Refuge Management Alternative E, the USFWS would discontinue mowing and haying of upland grassland habitats on the Refuge Complex. Encroachment of Chinese tallow and Eastern baccharis would increase in grassland habitats.

b. Impacts from Public Use Programs

Assuming an overall decrease in visitation to the Refuge Complex under Refuge Management Alternative E, impacts to vegetation and habitats described below would be similar but less extensive than those described for Alternative A.

The greatest potential for impacts to vegetation resources and habitats on the Refuge Complex due to recreational uses likely comes from motorized boating activities. Many Refuge Complex hunt areas and

fishing areas are accessible only or primarily by motorized boat. Wetland vegetation, especially submerged aquatic vegetation, can be impacted by motorboat activity. For example, propeller scarring has been shown to detrimentally impact seagrass beds in the Laguna Madre in South Texas (Pulich *et al.*1997, Dunton *et al.* 1998) and in Florida (Madley *et al.* 2004). Propeller scarring leaving permanent channels in shallow pond and waterway bottoms on the Refuge Complex has also raised concerns about the potential for increased saltwater intrusion, with concurrent negative impacts on emergent and submergent aquatic vegetation.

Foot traffic in areas open to hunting, fishing, wildlife observation and photography, environmental education and interpretation can lead to vegetation trampling, and in heavy use areas, cause plant mortality. On the Refuge Complex, the more extreme impacts occur in areas heavily used for shoreline fishing. Some vegetation trampling and trailing from hunter foot traffic occurs in marsh habitats in Refuge Complex hunt areas, although these impacts tend to be short-term.

These impacts would be expected to remain localized and minimal under this Alternative. Regulations, including horsepower restrictions and area closures to motorized boating would remain in effect to protect wetland habitats and public safety. Permanent sanctuary areas would be maintained throughout the Refuge Complex, which do not permit access by the public. Access for other recreational and educational uses would be restricted to established trails, boardwalks, and observation platforms. Fishing piers constructed in many heavily used shoreline fishing areas would reduce trailing impacts.
Under this Alternative, the USFWS would generally decrease the scope of public use program management and oversight on the Refuge Complex, including field law enforcement. Consequently, the USFWS' ability to protect public safety, habitats and fish and wildlife resources would decline.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

No direct impacts to vegetation and habitats would occur as a result of continued implementation of the Refuge Complex biological program under Refuge Management Alternative E. Surveys and monitoring and research activities would help track and document impacts of a passive management approach on vegetation and habitats on the Refuge Complex.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative E, oil and gas exploration and development activities on the Refuge Complex would continue to be managed through the issuance of Special Use Permits as under Alternative A. Stipulations in the Special Use Permit include those aimed at minimizing impacts to vegetation and habitats, including required use of specialized equipment, location and size of facilities, and required pollution controls. As per federal regulations (50 CFR 29.21), the USFWS would ensure that impacted sites are restored as closely as possible to pre-project conditions upon cessation of activities. Conditions of the Special Use Permit also require mitigation for all impacted habitats. Required mitigation activities include restoration and/or enhancement of habitats on the Refuge Complex which are similar to those impacted by oil and gas activities.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex under this Alternative would be a reduction of impacts to vegetation and habitats from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative E, Refuge staff would no longer coordinate with private landowners on partnership projects to restore and enhance native habitats on private lands. The USFWS would continue to work with Refuge Friends groups, volunteers and other community partners, but at a reduced level. The overall impact would be a reduction in partnership activities aimed at restoring and enhancing native habitats on the Refuge Complex and throughout the project area.

5. Impacts to Fish and Wildlife Resources

Under Refuge Management Alternative E, discontinuation of most habitat management and restoration activities on the Refuge Complex would have impacts to conservation of the following important fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians
- Invertebrates

The USFWS would continue to administer the six priority recreational uses of the National Wildlife Refuge System on the Refuge Complex: hunting, fishing, wildlife observation and photography, environmental education and interpretation. These uses impact fish and wildlife resources both directly and indirectly.

USFWS management of oil and gas exploration and development would also impact fish and wildlife resources.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Under Refuge Management Alternative E, wintering and migrating waterfowl populations on the Refuge Complex would decline as active habitat management and restoration would be curtailed.

On a year to year basis, overall habitat quality for waterfowl on the Refuge Complex will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers on the Refuge Complex can also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative E, structural marsh management and hydrological restoration projects which currently help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl would be curtailed. Habitat values and use by waterfowl would decrease.

On Anahuac NWR, the cooperative rice farming program would be phased out and moist soil management discontinued under this Alternative. This would result in loss of 800-1,000 acres of shallow freshwater wetland habitat, and of the nutritious food sources provided by second growth rice and native moist soil plants in these habitats. Elimination of the rice farming and moist soil management programs would result in decreased wintering waterfowl populations on the Refuge Complex.

No additional wetland habitats would be restored through marsh restoration projects under this Alternative.

(b). General Habitat Management and Restoration Activities

Under Refuge Management Alternative E, the USFWS would discontinue use of an integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats on the Refuge Complex to promote optimum habitat conditions for wintering waterfowl and many additional migratory bird species. As compared to current conditions, discontinuation of prescribed burning and grazing in marsh habitats under Refuge Management Alternative E would reduce habitat quality for and use by wintering waterfowl on the Refuge Complex. Overall, plant succession in intermediate and brackish marshes would trend toward higher successional plant communities, primarily marshhay cordgrass, and physical structure towards tall, dense and rank stands of vegetation.

Stopping control efforts for invasive vegetation such as common reed, cattail, and California bulrush which form dense homogeneous stands would result in loss of open water habitats under this Alternative. Infestations of invasive floating plants such as water hyacinth, alligatorweed and Salvinia would increase and also negatively impact these habitats. Loss of open water and associated submerged and floating plant communities would decrease habitat quality for wintering waterfowl and other migratory birds.

Under Refuge Management Alternative E, the USFWS would discontinue coordination with other agencies aimed at implementing shoreline protection and restoration projects. Tidal overwash of the eroding beach ridge into inland marshes would continue, and likely increase in frequency and magnitude, on McFaddin and Texas Point NWRs. Resulting salinity spikes in intermediate marshes would kill submerged and floating aquatic plants and invertebrates which provide important food resources waterfowl and other migratory birds.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Under Refuge Management Alternative E, discontinuation of habitat management and restoration activities currently conducted on the Refuge Complex would be expected to have negative impacts on Mottled Ducks.

(a). Wetlands Management and Restoration

Current wetland management and restoration activities on the Refuge Complex provide enhanced habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting.

Under Refuge Management Alternative E, structural marsh management and hydrological restoration projects on the Refuge Complex which currently help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl would be curtailed. Habitat values and use by Mottled Ducks would decrease.

On Anahuac NWR, the cooperative rice farming and moist soil management programs would be discontinued under this Alternative. This would result in loss of 800 -1,100 acres of shallow freshwater wetland habitat, and of the nutritious food sources provided by second growth rice and moist soil plants in these habitats. Rice farming and moist soil management provides reliable shallow freshwater wetland habitat throughout the year, including during the key recruitment periods of nesting and brood rearing.

(b). Uplands Management and Restoration

Under Refuge Management Alternative E, curtailment of native prairie restoration and management activities would decrease the quality of nesting habitat for Mottled Ducks on the Refuge Complex. Brush encroachment by exotic and native woody plants in salty and non-saline prairies would reduce the value of these habitats to Mottled Ducks and other ground-nesting avian species.

(c). General Habitat Management Activities

The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats currently used on the Refuge Complex creates a diverse habitat mosaic which provides ideal habitat conditions for Mottled Ducks and many other migratory bird species. As compared to current conditions, discontinuation of prescribed burning and grazing in marsh habitats under Refuge Management Alternative E would reduce the amount of optimal habitat for Mottled Ducks on the Refuge Complex. Overall under Refuge Management Alternative E, plant succession in marshes would trend toward higher successional plant communities, (primarily marshhay cordgrass in brackish and intermediate marshes), and physical structure towards more tall, dense stands of vegetation.

Salt prairies occur as a broad zone between coastal prairies and marshes, or more commonly on the Refuge Complex, as a ridge between marshes and bays or the Gulf of Mexico. These cordgrass ridges are dominated by Gulf cordgrass with marshhay cordgrass, knotroot bristlegrass (*Setaria parviflora*) and some brush species typically subdominant. Higher, well drained, salt prairie ridges juxtaposed with lower wetland areas have been identified as important Mottled Duck nesting areas in the Chenier Plain region of Louisiana (Baker 1983) and Texas (Stutzenbaker 1988). Because of the near total loss of coastal prairie, salt prairie is now the most important Mottled Duck nesting habitat on the Refuge Complex.

Fire is necessary in the management of Mottled Duck nesting habitat in salty and non-saline prairies. Fire must be frequent enough to keep brush at low densities, but infrequent enough to maximize years with dense nesting cover for Mottled Ducks. Under Refuge Management Alternative E, occurrence of lightning-ignited natural fires in salty and non-saline prairies would likely be so infrequent that brush encroachment would be widespread in these important nesting habitats.

Lack of control efforts for invasive plants and exotic animals under this Alternative would also reduce habitat quality for Mottled Ducks in wetland and upland habitats.

Marsh habitats being impacted by tidal overwash of the beach ridges on McFaddin and Texas Point NWRS provide important Mottled Duck production and brood rearing habitats. Based on field observations and capture rates during banding efforts, saltwater inundation has reduced Mottled Duck use of affected areas by as much as 50 to 65% over the last 10 years. Refuge Management Alternative E, increased frequency and magnitude of tidal inundation in these intermediate marshes would continue to negatively impact these habitats and Mottled Ducks.

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because of the wide diversity of habitat requirements by this category of birds, current USFWS habitat management and restoration activities on the Refuge Complex which result in a mosaic of diverse habitat types (plant species composition, structural characteristics, water levels and salinities) is desirable. Discontinuing wetland and upland habitat management and restoration activities under Refuge Management Alternative E would negatively impact many shorebird, wading bird and marsh bird species currently found on the Refuge Complex. Curtailing prescribed burning and grazing under this Alternative would reduce the amount of optimal habitat for species requiring more open habitats, but increase habitat availability for some species requiring more dense stands of vegetation. Discontinuation of the cooperative rice farming and moist soil management programs would eliminate approximately 800-1,100 acres of shallow freshwater wetland habitat of high importance to many shorebird and wading bird species.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative E, structural marsh management and hydrological restoration projects on the Refuge Complex which currently help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl would be curtailed. Habitat values and use by many shorebird, wading bird and marsh and waterbird species would decrease.

Discontinuation of the cooperative rice farming and moist soil management programs would result in loss of 800 to 1,100 acres of important shallow freshwater wetland habitat. Rice farming and moist soil management result in increased abundance of invertebrates and plants that are a preferred food source for many avian species in this group (Chabreck 1976, Broome *et al*.1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002).

(b). Uplands Management and Restoration

Under Refuge Management Alternative E, curtailment of native prairie restoration and management activities would decrease the quality of upland habitats. Brush encroachment by invasive woody plants including Chinese tallow and Eastern baccharis would increase. Habitat quality and use by several species of shorebirds and marsh birds would decline. Impacted species would include three Avian Species of Conservation Concern (USFWS 2005): Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

As compared to current conditions, discontinuing prescribed burning and grazing in marsh habitats under Refuge Management Alternative E would reduce the amount of optimal habitat for shorebirds and wading bird species requiring more open habitats, but may provide additional habitat for some marsh bird species which utilize denser stands of vegetation. Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (*Coturnicops noveboracensis*, Mizell 1998), sparrows (*Emberizidae*) and wrens (*Troglodytidae*, Gabrey *et al.* 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et al*. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al.* 2000). Not surprisingly, these secretive marshland bird species decline in the first year post fire. Other bird species such as Icterids (Gabrey *et al*. 2001) and Wilson's Snipe (*Gallinago delicate*) (USFWS unpublished data) increase immediately post-burn. Overall, species requiring denser stands of vegetation in marsh habitats would benefit Refuge Management Alternative E, while the amount of habitat for species requiring more open habitats would decrease.

Stopping control efforts for invasive vegetation such as common reed, cattail, and California bulrush which form dense homogeneous stands would result in loss of open water habitats under this Alternative. Infestations of exotic invasive floating plants such as water hyacinth, alligatorweed and Salvinia would increase and also negatively impact these habitats. Loss of open water and associated submerged and floating plant communities would decrease habitat quality for many wading bird species.

(4). Impacts to Landbirds

Landbird species found on the Refuge Complex require a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf Coast (Mueller 1981, Barrow *et al.* 2000). Some raptor species prefer intermingled field and forested areas (e.g., Red-tailed Hawks and owls). Other landbird species prefer grassland habitats including marshes and prairies (Peterson *et al.* 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

(a). Wetlands Management and Restoration

Under Refuge Management Alternative E, discontinuing wetland management and restoration activities including hydrological restoration, structural marsh management and marsh restoration would have negative impacts on several land bird species. This include land birds listed as Avian Species of Conservation Concern, the Seaside Sparrow and Sprague's Pipit (USFWS 2005), which currently benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Under Refuge Management Alternative E, discontinuing native prairie restoration and management activities would negatively impact habitat quality for several land bird species. Native prairie remnants and other upland grassland habitats on the Refuge Complex currently provide wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow and Nelson's Sharptailed Sparrow, and nesting habitat for species including Dicksissel and Eastern Meadowlark. These are also important nesting habitats for Mottled Ducks. Several species of raptors commonly observed on the Refuge Complex include Red-tailed Hawk, Red-shouldered Hawk, Turkey Vulture, American Kestrel, White-tailed Kite, Northern Harrier, and Short-eared Owl (USFWS, 1997a). Many other raptor species are observed during spring and fall migrations.

Brush encroachment by invasive woody plants including Chinese tallow and Eastern baccharis would increase under this Alternative. Habitat quality and use by several species of land birds would decline. Impacted species include species that are declining in the Coastal Prairies Region of Texas (Texas Parks and Wildlife Department 2000), and/or are among several species recently listed by the USFWS as Avian Species of Conservation Concern in the Gulf Prairies Bird Conservation Region (USFWS 2005). These include White-tailed Hawk, Loggerhead Shrike, Northern Bobwhite, Short-eared Owl, Sedge Wren, Nelson's Sharptailed Sparrow, Henslow's Sparrow, and LeConte's Sparrow.

Woodlot Restoration and Management

Under Refuge Management Alternative E, the USFWS would discontinue management activities which protect and diversify 60 acres of existing coastal woodlots and riparian woodlands on the Refuge Complex. Encroachment by Chinese tallow would decrease habitat quality for several neotropical migratory birds that require native trees or understory for cover and foraging. Impacted species on the Refuge Complex would include three neotropical migratory birds listed as Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler.

(c). General Habitat Management Activities

Under Refuge Management Alternative E, the USFWS would curtail prescribed burning and grazing on the Refuge Complex. Seaside sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al.* (2001) reported that breeding seaside sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested. Gabrey *et al.* (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (2005) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife. In the short-term, decreased burning frequency under Refuge Management Alternative E could positively impact some species and negatively impact others. In the long-term, reduced habitat diversity under this Alternative will have an overall negative impact on land birds.

Under this Alternative, the USFWS would discontinue invasive plant and animal control activities. Rapid encroachment of Chinese tallow would occur and would lead to decreased diversity of native woody plants in the coastal woodlots, as well as decreased forage insects (especially Lepidopteran larvae) for

migrating passerines and other birds. Chinese tallow stands have an ecological trap effect for migrant songbirds that are drawn to the cover of the woodlots, but then find insufficient food resources to replenish depleted energy reserves (Barrow and Renne 2001).

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Under Refuge Management Alternative E, the USFWS would curtail several wetland management and restoration activities which currently protect, restore and enhance estuarine wetlands and ensure wetland habitat diversity and productivity important to a variety of fish and shellfish species. The present continuum of fresh to saline aquatic environments on the Refuge Complex supports highly diverse aquatic vertebrate and invertebrate communities. Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al.* 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al.* 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al.* 1990, Kneib 1991, Rozas 1995).

Under this Alternative, the USFWS would discontinue structural marsh management. This would have a short-term beneficial impact to certain marine organisms which spend a portion of their lifecycles in estuarine marshes by increasing ingress and egress to these habitats. Structural marsh management using water control structures and levees in managed marsh units can restrict access to managed areas for some aquatic organisms, such as fish and crustaceans (Rogers *et al.* 1992, Kuhn *et al.* 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a natural stable or deteriorating deltaic marsh (Peterson *et al* 1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown.

Much of the work on fisheries use of flooded marshes has focused on saline marshes with a high component of *Spartina alternaflora* (Zimmerman *et al*. 1990, Baltz *et al*. 1993, Peterson and Turner 1994, Knieb and Wagner 1994, Minello *et al.* 1994, Rozas *et al.* 1998, Zimmerman *et al*. 2000). Brown shrimp, white shrimp, and blue crabs are associated with salt marsh dominated estuaries (Weinstein 1979, Wenner and Beatty 1993). Many of the salt marshes of the western Gulf coast are being impacted by rapid subsidence, sea level rise, saltwater intrusion and conversion to open water. Research has suggested that marsh conversion to open water will reach a point beyond which fisheries will decline due to a reduction of total marsh edge (Browder *et al*. 1989). Further, fisheries habitat gained due to marsh breakup is not sustainable in the long term (Browder *et al.* 1989, Condrey and Fuller 1992). Under this Alternative, the USWFS would discontinue hydrologic restoration, marsh restoration using dredge material, structural marsh management and shoreline restoration and protection, all of which restore and protect wetland habitats and help reduce rates of marsh loss. Ultimately, continued habitat loss and degradation would negatively impact fisheries resources.

(6). Impacts to Threatened and Endangered Species

Three avian species occurring on the Refuge Complex are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon, Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth

green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Under Refuge Management Alternative E, protection, restoration and management of coastal wetland habitats on the Refuge Complex which currently benefit the three avian T&E species would be curtailed. Habitat quality and use by T&E species and other declining or sensitive species would decline

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found on the Refuge Complex include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species on the Refuge Complex. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic animals. Under this Alternative, curtailment of habitat management activities would result in invasion of grassland habitats by woody brush species, which may create more favorable habitat for certain mammals.

Current USFWS management activities on the Refuge Complex which maintain and restore freshwater wetland habitats such hydrological restoration, structural management of marshes, moist soil management and rice farming are particularly beneficial to amphibians and reptiles. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas. Conversion of fresh and intermediate marshes to brackish and loss of freshwater wetland habitat provided by rice farming and moist soil management under this Alternative would negatively impact most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators.

Under Refuge Management Alternative E, the USFWS would curtail prescribed burning. Fire frequency would decrease, but natural fires would burn hotter and likely burn larger acres. Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, and some reptiles, and invertebrates. Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et al.* 1989) summarizes by saying "Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil-litter stabilize." Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data).

Under Refuge Management Alternative E, the habitat mosaic created by the current integrated use of burning, grazing and water management in Refuge Complex wetland and upland habitats would become less diverse. Overall, this would have negatively impact resident fish and wildlife.

b. Impacts from Public Use Programs

Assuming a decrease in visitation to the Refuge Complex under Refuge Management Alternative E, overall disturbance impacts to fish and wildlife resources would likely decrease from current levels

described under Alternative A. Under this Alternative, the USFWS would generally decrease the scope of public use program management and oversight on the Refuge Complex, including field law enforcement. Consequently, the USFWS' ability to protect public safety, habitats and fish and wildlife resources would decline.

(1). Impacts to Waterfowl

(a). Waterfowl Hunting

The most direct effect of hunting on the Refuge Complex is the mortality of harvested waterfowl species resulting from the hunting activities. However, because regulations governing harvest in the Central and Mississippi Flyways are developed annually under the USFWS national migratory bird hunting regulation frameworks, and are designed to ensure that viable waterfowl populations are sustained over the long-term, continuation of the waterfowl hunting program on the Refuge Complex under Refuge Management Alternative C will not have any measurable effect on overall populations and the long-term viability of these populations.

Many studies have documented the effects of hunting on intensity on the number of birds utilizing an area (Reichholf 1976, Madsen *et al*. 1992 as cited by Fox and Madsen 1997, Wolder 1993). These studies have shown that relatively light hunting pressure can reduce waterfowl abundance in hunted areas. Distribution and habitat use, feeding patterns, and the nutritional status of waterfowl have also been shown to be affected by hunting activities. Hunting activity can cause birds to alter habitat use, change feeding locations (Madsen 1995), feed more at night (Morton *et al.* 1989) and reduce the amount of time spent feeding (Korschgen *et al.* 1985, Madsen 1995). Collectively, these changes in behavior have the potential to adversely impact the nutritional status of waterfowl (Belanger and Bedard 1995).

Means of access to and within Refuge Complex hunt areas would remain the same as under Alternative A and would include motorized boating (primarily in Oyster, Onion and East Bay bayous and East Galveston Bay on Anahuac NWR, in Salt Bayou, Clam Lake and Star Lake and hunt area access ditches on McFaddin NWR, and in Texas Bayou and its tidal tributaries on Texas Point NWR), non-motorized boating, motorized vehicles, and walking. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use, but these impacts are likely less than those caused by motorized boating. The continued maintenance of sanctuary areas on the Refuge Complex would be required to mitigate for disturbance impacts from hunting activities under Refuge Management Alternative E. Maintaining existing regulations under this Alternative would also be necessary help mitigate the impacts of hunting activity-related disturbance to waterfowl.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation

Under Refuge Management Alternative E, existing visitor facilities on the Refuge Complex would be maintained but no new facilities would be developed. Means of access for these uses and the presence of visitors results in disturbance impacts to waterfowl, as described under Alternative A. Decreased visitation would decrease these impacts.

Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al.* 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use.

Disturbance of waterfowl by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993). In wetland habitats, disturbance from "out of vehicle" approaches can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). While some species of waterfowl appear to acclimate to vehicular traffic, and even presence of visitors on trails, boardwalks, and observation

platforms, other species are less tolerant of disturbance. Overall it is likely that species composition and abundance of waterfowl is decreased in areas supporting these recreational uses.

(2). Impacts to other Migratory Birds - Shorebirds, Wading Birds, other Marsh and Waterbirds, and Landbirds

(a). Waterfowl Hunting

Although the disturbance impacts of waterfowl hunting under Refuge Management Alternative E on other wetland-dependent migratory and resident birds which are not hunted is likely less than for waterfowl, studies have demonstrated that hunting (including accessing hunt areas) does affect abundance and distribution of these other avian species. The noise associated with shooting likely reduces habitat utilization by shorebirds, wading birds, other marsh and waterbirds, and land birds using wetland habitats within hunt areas, at least while hunting is occurring. Motorized boating disturbs and displaces many waterbird species (Dahlgren and Korschgen 1992, Knight and Cole 1995), as will non-motorized boats, vehicles and walking through the marsh.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

Under Refuge Management Alternative E, existing visitor facilities on the Refuge Complex would be maintained but no new facilities would be developed. As described under Alternative A, means of access and the presence of visitors result in disturbance impacts to migratory birds. Under Alternative E, decreased visitation would reduce these impacts.

Disturbance of migratory birds by visitors is likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993) and shoreline areas regularly used for fishing. Along roads through wetland habitats, disturbance from “out of vehicle” approaches for observation and photography can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). Walking on trails tends to displace birds and can cause declines in species richness and abundance (Riffell *et al*. 1996). Some generalist avian species such as house finches tend to increase near trails, while specialist species such as solitary vireo move away from trails. The zone of influence around trails appears to be approximately 75m for woodland areas adjacent to grasslands (Miller *et al*. 1998).

Disturbance impacts to birds from visitation are often magnified during the breeding season. Color of clothing worn can attract or repel different passerine species based on breeding plumages of those species (Gutzwiller and Marcum 1997). Primary song occurrence and consistency of certain passerines can be impacted by a single visitor (Gutzwiller *et al*. 1994), which could limit the number of breeding pairs and production by those species in disturbed areas (Reijnen and Foppen 1994). Predation on songbird, raptors, colonial nesting species, and waterfowl nests tends to increase near more frequently visited areas (Glinski 1976, Buckley and Buckley 1978, Boyle and Samson 1985, Miller *et al.* 1998).

(3). Impacts to Fisheries

(a). Fishing

The most direct effect of fishing on the Refuge Complex is the mortality of harvested freshwater and saltwater fish, blue crabs, and several fish and shellfish species caught for use as bait. Fishing and crabbing on the Refuge Complex occur under regulations promulgated by the Texas Parks and Wildlife Department. These regulations are designed to ensure that viable fish and shellfish populations are sustained over the long-term.

Continuation of fishing and crabbing on the Refuge Complex under Refuge Management Alternative E should not have any measurable effect on overall populations and the long-term viability of these species’ populations.

(b). Hunting, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach and other Uses

No impacts to fisheries resources are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative E.

(4). Impacts to Threatened and Endangered Species

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that Bald Eagles, Brown Pelicans and Piping Plovers using Refuge Complex habitats would be subject to the some level of disturbance by public use activities under Alternative E. These impacts are expected to be negligible. Bald Eagles are usually associated with large concentrations of wintering waterfowl that occur in refuge sanctuary areas which are not open to the public. Piping Plovers utilize beach, shoreline and intertidal mudflat habitats primarily during fall and winter, when use of these habitats by the public is lightest. Brown Pelicans readily forage and roost adjacent to human activity and infrastructure. The three T&E avian species do not nest on the Refuge Complex, their presence is transient in nature, and they are highly mobile and able to move to undisturbed areas. Overall, no impacts to Federally-listed or State-listed Threatened and Endangered species are expected to occur as a result of continued administration of these public uses on the Refuge Complex under Refuge Management Alternative E.

(5). Impacts to other Fish and Wildlife Species – Mammals, Amphibians, Reptiles, and Invertebrates

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

As under Refuge Management Alternative A, it is likely that mammals and amphibians and reptiles would be subject to some level of disturbance from public use activities occurring on the Refuge Complex, under Alternative E. These impacts are expected to be negligible. Vehicles would occasionally strike and kill mammals such as Virginia opossum, armadillo, raccoon and striped skunk, and reptiles and amphibians including alligators, snakes and frogs.

(b). Commercial Alligator Harvest

Under Refuge Management Alternative E, the commercial adult alligator harvest program would no longer be administered as an economic use on the Refuge Complex. Alligator populations would be monitored. The long-term impact of curtailing harvest on alligator populations on the Refuge Complex is unknown. Initially, it is likely that alligator populations would increase. Alligator populations could reach densities at which migratory bird management objectives are compromised due to high levels of predation on Mottled Ducks and other nesting species. Potential impacts would also include increased damage to water management infrastructure and increased conflicts with the public.

(c). Control of Muskrat Populations

Under Refuge Management Alternative E, no active management of muskrat populations would occur. Muskrat populations would be monitored. Herbivory in areas of high density muskrat populations can cause or exacerbate conditions resulting in permanent conversion of vegetated marsh to open water. This is likely to most prevalent in areas affected by saltwater intrusion or other factors contributing to marsh loss. Under this Alternative, the potential for negative impacts to marsh habitats would increase.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

Under Refuge Management Alternative E, current surveys, monitoring and research activities for migratory birds, resident wildlife, fisheries and T&E species (described under Refuge Management Alternative A) would continue. Surveys and monitoring and research activities would help track and document impacts of a passive management approach on fish and wildlife resources on the Refuge Complex.

d. Impacts from Management of Oil and Gas Exploration and Development

Under Refuge Management Alternative E, the USFWS would continue to manage oil and gas exploration and development activities on the Refuge Complex through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to fish and wildlife resources, including timing of activities to avoid major periods of utilization, required use of specialized equipment, location and size of facilities, and required pollution controls.

The net effect of USFWS management of oil and gas exploration and development on the Refuge Complex would be a reduced impact on fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Management Alternative E, Refuge staff would no longer coordinate with private landowners on partnership projects to restore and enhance native habitats on private lands.

The USFWS would continue partnerships with the Friends of Anahuac Refuge and the McFaddin and Texas Point Refuges Alliance, agencies including the Texas Parks and Wildlife Department, Texas General Land Office and Galveston Bay Estuary Program, conservation organizations such as Ducks Unlimited, the Galveston Bay Foundation and local Audubon Society chapters, community organizations and Refuge volunteers. The number and extent of partnership activities and projects would likely be less than current levels, due primarily to the reductions in refuge staff under this Alternative.

It is anticipated that reduced outreach and partnership efforts under Refuge Management Alternative E would result in decreased levels of habitat restoration and enhancement on the Refuge Complex and throughout the project area.

B. Socioeconomic Resources Section

1. Economic Impacts

Economic impacts from management activities on the Refuge Complex occur in the regional economy in two different ways. First, there are the direct economic impacts that occur as a result of the economic stimulus of three elements: 1) direct expenditures made by the USFWS to manage operations at the Refuge Complex, 2) value of production from agricultural programs on the Refuge Complex; and 3) expenditures made by recreational visitors to the Refuge Complex. Second, there are indirect and induced economic impacts which are additional economic activity that occur as a result of the re-spending of these direct economic elements. The indirect and induced economic impacts are measured as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the direct economic elements. Total economic impacts (direct, indirect and induced) of for this management alternative were estimated using the data and methods discussed below. The analysis compares the impacts from Refuge Management Alternative E to the "No Action" management alternative, which would continue current activities.

The study area for purposes of estimating economic impacts is all of Jefferson and Chambers Counties along with a small portion of Galveston County, which includes the eastern portion of the Bolivar Peninsula east of Rollover Pass.

a. Direct Economic Impacts

(1). Value of Refuge Operations (Direct Expenditures)[17]

Table 4-34
Average Annual Operational Costs for the Refuge Complex – RM Alternative E (Direct Expenditures)

Cost Category	Annual Average Expenditures		
	Year 1 - 5	Year 5 - 10	Year 10 - 15
Annual Staff Salaries	$1,614,653	$1,339,986	$1,034,801
Utilities	$35,000	$35,000	$35,000
Travel	$39,123	$39,123	$39,123
Water Purchases	$0	$0	$0
Heavy Equip. Rental and Replacement	$0	$0	$0
Annual and Deferred Maintenance	$28,000	$28,000	$28,000
Special Programs	$0	$0	$0
Total Average Expenditures	**$1,716,776**	**$1,442,110**	**$1,136,924**

Based on information about the activities proposed under this management alternative, an estimate of the operational expenditures was prepared. The estimate is broken out into five-year periods because it is expected that the amounts within certain cost categories would change with time under this management alternative. Because projects would occur throughout the study period, project costs will vary by year. In addition, changes in staffing would occur throughout the study period so salary costs vary annually as well. As the USFWS scales back active management at the Refuge Complex, direct expenditures on habitat management, operations and staffing will be reduced. The estimate of the annual average cost, per five-year period, for Refuge Management Alternative E is summarized in Table 4-34.

The estimate of Refuge Operation's direct expenditures under this alternative shows a decrease by more than half by the end of the planning period compared to the $2,695,184 estimate under the "No Action" alternative.

(2). Value of Production from Refuge Agricultural Programs

(a). Cattle Grazing

Grazing is eliminated in this management scenario along with most other active management strategies. The estimated production value of $2,103,678 for grazing activities under the "No Action" alternative is reduced to 0. A summary comparing the changes in AUMs and value of production between the "No Action" alternative and Refuge Management Alternative E is contained in Table 4-35.

Table 4-35
Estimated Production Value of Grazing Activities on Refuge Complex - RM Alternative E

Alternative	Annual Average AUMS	Value of Annual Production
No Action Alternative	23,900	$2,103,678
Refuge Management Alternative E	0	0

17 The Value of USFWS Operations Table is essentially done for the No Acton Alternative (Alt. A). Under the remaining management alternatives (B through E), the USFWS will change the magnitude and intensity of management activities on the Refuge Complex. These actions will show increases or decreases from the baseline direct expenditures by the USFWS in the local economy as indicated in the Value Table above.

(b). Rice Production

Refuge Management Alternative E will eliminate the cooperative farm program at the beginning of the study period along with the grazing program. Therefore, the estimated annual value for rice production of $249,867 under the "No Action" alternative would be reduced to 0. A summary comparing the changes in annual average acreage produced and value of production between the "No Action" alternative and Refuge Management Alternative E is contained in Table 4-36.

Table 4-36

Estimated Value of Rice Production on Refuge Complex - RM Alternative E

Alternative	Annual Average Acreage Produced	Value of Annual Production
No Action Alternative	600	$249,867
Refuge Management Alternative E	0	0

(3) Value of Refuge Recreational Programs

For each Refuge Management alternative, assumptions were made on how proposed management changes would affect visitation during the study period. These changes are expressed as increases or decreases in the number of non-resident recreational visitors under the "No Action" alternative. The estimated changes in recreational visitors under this alternative are broken out by recreational activity as follows:

Activity	Change
Waterfowl Hunting	10% Decrease
Upland Bird Hunting	No Change
Fishing	No Change
Wildlife Observation	5% Decrease

These changes were then applied to the estimate of annual non-resident visits and the estimate of itemized expenditures by recreational activity which were developed for the "No Action" alternative. Table 4-37 contains a summary of the comparison of the annual direct expenditures associated with recreational visitors to the Refuge Complex between the "No Action" alternative and Refuge Management Alternative E.

Table 4-37

Annual Direct Expenditures Associated with Recreational Visitors on Refuge Complex - RM Alternative E

Alternative	Annual Non-resident Visitors	Total Recreational Expenditures
No Action Alternative	35,010	$1,098,923
Refuge Management Alternative E	33,438	$1,018,007

b. Indirect and Induced Economic Impacts

Indirect and Induced economic impacts are described as the changes in employment, income and indirect business taxes that occur in the regional economy as a result of the economic stimulus of the following three elements: direct expenditures made by the USFWS to manage operations at the Refuge Complex, value of agricultural production on the Refuge Complex, and the direct expenditures made by recreational visitors to the Refuge Complex. These direct expenditures create additional economic activity, the indirect and induced impacts, as re-spending of the direct expenditures occur. The indirect and induced impacts are estimated by using a series of economic multipliers applied to the estimates of the direct economic impacts of USFWS activities. IMPLAN was used to apply economic multipliers to the direct economic elements valued above to arrive at an estimate of the indirect and induced impacts to

employment, income and indirect business taxes in the study area that can be attributable these USFWS activities.

The indirect and induced economic impacts are measured in the four following areas:

Employment: The annual average estimated employment is measured as Full-Time Equivalents (FTEs). Full-time equivalent employees equal the number of employees on full-time schedules plus the number of employees on part time schedules converted to a full-time basis. This includes direct employment at the Refuge Complex (approximately 30 FTEs at this time) as well as the additional employment supported in the surrounding area.

Labor Income: Labor income includes employee compensation and proprietary income. Employee compensation is the total wages and salaries of workers who are paid by employers, as well as the value of benefits such as health care, life insurance, retirement payments, and non-cash compensation. Proprietary income consists of payments received by self-employed individuals as income.

Other Property Type Income: This type of income is payments in the form of rents, royalties, dividends, and includes corporate profits.

Indirect Business Taxes: Indirect business taxes include excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses.

(1). Refuge Operations

The comparison between the indirect and induced economic impacts attributable to Refuge Operations for Refuge Management Alternative E and the "No Action" alternative is summarized in Table 4-38.

Table 4-38. Indirect and Induced Economic Impacts of Operations at Refuge Complex – RM Alternative E

	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	45	45	45
Refuge Management Alternative E	31	27	22
Labor Income			
No Action Alternative	$1,066,457	$1,066,457	$1,066,457
Refuge Management Alternative E	$641,785	$553,290	$464,795
Other Property Type Income			
No Action Alternative	$222,664	$222,664	$222,664
Refuge Management Alternative E	$25,065	$25,065	$25,065
Indirect Business Taxes			
No Action Alternative	$493,149	$493,149	$493,149
Refuge Management Alternative E	$439,499	$377,526	$315,553

(2). Refuge Agricultural Program

The comparison between the indirect and induced economic impacts attributable to agricultural activities, cattle grazing and rice farming, on the Refuge Complex for Refuge Management Alternative E and the "No Action" alternative is summarized in Table 4-39.

Table 4-39
Indirect and Induced Economic Impacts of Agricultural Activities at Refuge Complex – RM Alternative E

	Year 1 - 5	Year 6- 10	Year 11 - 15
Employment (FTEs)			
No Action Alternative	20	20	20
Refuge Management Alternative E	0	0	0
Labor Income			
No Action Alternative	$587,382	$587,382	$587,382
Refuge Management Alternative E	$0	$0	$0
Other Property Type Income			
No Action Alternative	$272,759	$272,759	$272,759
Refuge Management Alternative E	$0	$0	$0
Indirect Business Taxes			
No Action Alternative	$87,668	$87,668	$87,668
Refuge Management Alternative E	$0	$0	$0

This Table reflects the elimination of both the Grazing Program and the Cooperative Farming Program under Refuge Management Alternative E.

(3). Refuge Recreational Programs

The comparison between the indirect and induced economic impacts attributable to expenditures by recreational visitors at the Refuge Complex for Refuge Management Alternative E and the "No Action" alternative is summarized in Table 4-40.

Table 4-40
Indirect and Induced Economic Impacts of Recreational Activities at Refuge Complex – RM Alternative E

	Annual Average		
Employment (FTEs)	Year 1 - 5	Year 6- 10	Year 11 - 15
No Action Alternative	25	26	26
Refuge Management Alternative E	22	18	14
Labor Income			
No Action Alternative	$609,908	$621,374	$629,040
Refuge Management Alternative E	$612,891	$423,679	$347,310
Other Property Type Income			
No Action Alternative	$224,963	$229,144	$231,939
Refuge Management Alternative E	$193,175	$156,187	$127,938
Indirect Business Taxes			
No Action Alternative	$136,816	$139,559	$141,394
Refuge Management Alternative E	$117,599	$95,644	$78,894

2. Population Impacts

Management actions associated with the Refuge Complex are not expected to have notable impacts on population trends within the study area. Population trends in Jefferson and Chambers counties have shown increases in recent years though these increases are likely not influenced by activities at the Refuge Complex. Any population change that could be associated with implementation of alternatives under consideration in the EIS would likely be linked to employment changes. Under Refuge Management Alternative E, employment associated with the Refuge Complex is expected to fall by nearly half relative to the No Action Alternative. While the decline in employment resulting from this alternative is not expected to have significant impacts to population in the two county study area, there may be noticeable changes to overall employment in some local, largely rural areas which are closest to the Refuge Complex (e.g. Anahuac).

3. Fiscal Impacts on Local Governments

Refuge management has the potential to impact the fiscal conditions of local government entities. This fiscal effect could be on revenues and/or expenditures. The "Economics Impacts" section above has already evaluated impacts from the various current refuge management activities on indirect business taxes. In addition to the increased indirect business taxes, the USFWS makes substantial payments to local governmental entities under the Refuge Revenue Sharing Act.

Changes in demand for government services could vary with changes in population tied to the Refuge Complex and could cause undue strain on infrastructure (e.g. roads, utilities, schools, etc). As discussed above, since notable population changes are not expected, identifiable changes in demand for government services due to changes in population are not expected. Changes in recreation activities could also cause some impacts to local government services through changes in demand though they are not expected to be notable under current management or any of the proposed alternatives.

Management actions can also affect local government services directly. For instance, the USFWS currently purchases water from the Chambers Liberty Counties Navigation District (District) to support its management activities. This provides positive impacts to this local District that has experienced a decrease in water purchases due to a decline in rice production in the area. These water purchases would likely cease under Refuge Management Alternative E with the discontinuation of the cooperative rice farming program.

4. Social Impacts

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, natural resource management actions such as those made by the USFWS on the Refuge Complex. Additionally, Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them)
- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions)
- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability)

- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others)

The interactions between USFWS activities and people are already evident in the area. Current direct and indirect interactions between the USFWS and the local and regional population base include visitation to the refuges (e.g., recreation opportunities), participation in USFWS volunteer programs, an awareness of refuge activities (but not direct participation in these activities), or simply driving by the Refuge Complex land holdings. These interactions would basically remain the same for the vast majority of the nearby population under any of the Refuge Management Alternatives being considered in this EIS, and there would be a relatively small magnitude and frequency of "new" impacts since the USFWS has been managing lands within the Refuge Complex for many years.

Additionally, implementation of any of the Refuge Management Alternatives would not lead to substantial new population or changes in the demographic or other characteristics of the existing population. One of the most important causes of potentially significant social effects is a new population that is 1) relatively large in relation to the existing population, and/or 2) demographically or socially different than the existing population. Since there would be little change in population or demographics directly or indirectly from any of the alternatives, this cause/effect relationship is not of concern in this EIS analysis.

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Issues would arise when management activities are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships between the USFWS and Stakeholder Groups

General categories of stakeholder groups describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A summary of potential future relationships between the USFWS and stakeholder groups follows. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole. The following is a list of local stakeholder groups who could be affected by USFWS management activities on the Refuge Complex:

- Residents and/or Employees
- Landowners
- Recreationalists
- Governmental or Quasi-Governmental Agencies
- Businesspersons and/or Business Owners
- Conservation or Environmental Protection Advocates

Overall, USFWS management activities and objectives under all the Refuge Management Alternatives may in some cases conflict with some of the goals, beliefs, and objectives of many of the local stakeholders. This situation will lead to the continued need for the USFWS to interact with the public (see next section) and to find a proper balance to its activities. However, socioeconomic issues would continue to exist among the various stakeholder groups with regard to their opinion of the USFWS role, responsibilities, and actions; many of these issues would remain unresolved in the future as discussed later in this section.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. Under Refuge Management Alternative E, current USFWS public outreach efforts would continue but likely at reduced levels.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

The following is a summary of socioeconomic issues associated with USFWS activities at the Refuge Complex. The proposed USFWS management actions under the Refuge Management Alternatives would have no major effect on the existence or resolution of these current issues. Under any of the Refuge Management Alternatives:

- There would be points that continue to be in dispute or unsettled between different parties regarding the existence and/or management of the Refuge Complex.
- Different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions.
- Some people would continue to think positively about the role of the USFWS in the area; others would continue to think negatively about this role; and others would continue to have no opinion or be neutral about the USFWS role and activities within the area.
- As with existing conditions, issues would be unresolved and one party could not be determined to be “right” and the other party “wrong” with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future.

Under Refuge Management Alternatives B through E, management philosophies and priorities would change from current conditions. The USFWS management of the Refuge Complex would continue to be primarily oriented to support wildlife habitat management and enhance fish and wildlife values; however, the philosophy of the primary management approach would differ for each Refuge Management Alternative. These different management approaches and philosophies have a relationship with social structures and lifestyle, but the differences among alternatives from a specific social structure/lifestyle perspective would not be substantial except on a localized or case-specific basis. Under all Refuge Management Alternatives, the USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however the “appropriateness” of any chosen alternative would depend on individual and group values, beliefs, and goals.

While the Refuge Management Alternatives support different philosophies and priorities, and the differences among Alternatives may be identifiable on a localized basis, the social structure and lifestyle conditions and trends within the Refuge Complex would generally remain the same as current conditions.

d. Environmental Justice

The need to conduct an environmental justice analysis for the Texas Chenier Plain Refuge Complex EIS/CCP/LPP is based on Executive Order (EO) 12898. Several areas have been identified as having potential minority or low-income populations within the primary or secondary study areas. EO 12898 requires an assessment as to whether these populations might be disproportionately affected by the management alternatives.

Based on the results of the socioeconomic and environmental impact analysis conducted for this project, it can be concluded that those persons who reside in and around the Refuge Complex would bear both adverse and beneficial effects by the continued operation and/or expansion of the Refuge Complex. However, any identified socioeconomic or environmental impacts from continued operation of the Refuge Complex by the USFWS would not be localized nor be placed primarily on the identified minority and/or low-income population components. Overall, the identified minority and/or low-income populations would not be disproportionately affected compared to other segments of the general population in the area.

Additionally, persons of all races and income levels were invited to participate in the public participation process for the EIS, and comments or input into the process from any minority or low-income persons were considered equally with all other persons. Therefore, implementation of any of the Refuge Management Alternatives would be in compliance with EO 12898.

VI. IMPACTS TO CULTURAL RESOURCES FROM REFUGE MANAGEMENT ALTERNATIVES

Impacts on Cultural Resources

Impacts on cultural resources can include inundation, destruction, damage, and/or disruption. Impacts can directly result from ground-disturbing activities or indirectly from human use or land use and management. Potential ground-disturbing activities include facilities construction, road construction, ditch digging, oil and gas activities, and water control projects (such as levee construction, repair, or removal). Human use activities include increased public access and watercraft wakes. Intense wildfires and cattle tromping may indirectly impact cultural sites as well. Natural phenomenon may also impact cultural sites through inundation, wind/water/wave erosion, subsidence, tree bioturbation, and animal burrowing.

Impact Analysis for Refuge Management Alternatives

There is a potential for direct and indirect impacts to cultural sites under all of the Refuge Management alternatives; however, avoidable impacts would not be considered adverse, but rather minor in nature. Unavoidable adverse impacts are anticipated to continue to occur at potentially eligible sites from natural phenomenon.

Natural impacts, including inundation, wind/water/wave erosion, subsidence, tree bioturbation, and animal burrowing, poses the greatest threat to shell middens. Due to the marshy, undeveloped nature of the Refuge Complex and location of the shell middens along shorelines, full protection of the shell middens is not feasible without completely altering the site or removing the material from its context. Inundation of many of the sites has already occurred and the unavoidable adverse impacts are highly likely to continue. The eligible McFaddin beach site is already inundated by the naturally altered coastline and is subject to water erosion and loss of material. Cultural resource management actions are not proposed for the shell midden sites under the Refuge Management alternatives. Existing and proposed shoreline protection projects and water control structures under Refuge Management Alternatives A, B, C, and D would reduce wave fetch and intensity of wave action and shoreline protection projects may indirectly benefit shoreline sites by reducing wave intensity under these Refuge Management alternatives. Discontinuing water management and erosion abatement under Refuge Management Alternative E would reduce the protection of the middens indirectly afforded by these management actions.

Ground disturbing activities, including facilities construction, road construction, ditch digging, oil and gas activities, and water control projects (such as levee construction, repair, or removal), would be subject to a ground survey and consultation requirements with the State Historic Preservation Officer (SHPO) under the NHPA Section 106 regulations. Privately initiated oil and gas activities create ground disturbance in the Refuge Complex with road, pipeline, and well pad construction. Any dredge or fill projects in the Refuge Complex proposed and conducted by the U.S. Army Corps of Engineers under all Refuge Management alternatives, including shoreline and marsh restoration projects, would be subject the Section 106 process and potential impacts to the NHRP eligible sites. All ground-disturbing activities, whether initiated by the USFWS or other entities, would be subject to restrictions imposed on Refuge Complex lands and consultation with the SHPO under Section 106 regulations. The potential for any ground-disturbing activities to impact known sites or undiscovered sites would be identified and resolved appropriately through the Section 106 process.

Maintenance of existing shoreline protection projects and water control infrastructure as well as additional water management projects under Refuge Management Alternatives A, B, C, and D may result in the identification of addition cultural resources sites and better protection of the sites from wake action. Because water control and facilities construction and improvements occur more frequently under Refuge Management Alternatives C and D, cultural resources may indirectly benefit. Discontinuing water control management under Refuge Management Alternative E may lead to increased erosion of shell middens along shorelines indirectly over time.

The burn intensity of fires may affect archaeological and historical resources. Low-intensity burns are usually associated with lightly burned grasslands during prescribed burns. Low-intensity burns are not anticipated to affect cultural resources, but may cover the resources in soot. High-intensity burns are typically associated with wildfires in dry areas that have abundant litter accumulation due to unnatural fire suppression. High-intensity fires may char or consume cultural resources leading to a potential impact. There is very little likelihood of a high-intensity fire occurring since the Refuge Complex is primarily wet, has high soil moisture content, and was subject to burning by Native Americans, present-day natural resource managers, and lightning-ignited fires. According to the Fire Management Plan (2001), wildland fires on the Refuge Complex are rarely controlled with suppression tactics, firebreaks, or chemical retardants, which are only used sparingly if necessary to protect life and/or property. Natural wildfires are suppressed only when they threaten Refuge Complex facilities, adjacent private property, and/or public health and safety. Rotational prescribed burning considered in Refuge Management Alternatives A, B, C, and D would reduce the potential for damage to cultural resources from intense wildfires. Reliance on natural lightning starts only under Refuge Management Alternative E may lead to more fuel accumulation and higher intensity fires; however, due to the high soil moisture, severe damage is not anticipated and minor charring, at worst, may occur on the surface of cultural sites in the long-term.

Cattle grazing may damage cultural resources by inadvertent tromping. Some of the shell midden sites recorded have already experienced damage by cattle tromp. Cattle on the Refuge Complex typically feed as they disperse in the wet areas and congregate on higher, dry grounds, which typically include manmade dikes or berms. Shell middens are typically associated with undisturbed, wet areas and may be subject to occasional tromping from the dispersed cattle; however, damage by cattle tromp is not likely to be exceeded by damage through natural erosion. The potential for inadvertent cattle tromping is likely to occur under Refuge Management Alternatives A, B, C, and D. Inadvertent tromping is not anticipated under Refuge Management Alternative E in which grazing is discontinued.

Refuge visitors and their activities may inadvertently damage cultural sites; however, recreational access to the Refuge Complex is limited by the under-developed character of the area. Recreational activities are limited to Anahuac, McFaddin, and Texas Point NWRs. Bird and wildlife observation, fishing, and hunting would continue under all management alternatives and typically occur in previously disturbed areas. Minor improvements to recreational access, such as trails and boat launches is limited to existing developed areas under Refuge Management Alternatives B, C, and D and would be subject to ground truthing for cultural items before disturbance. Bird and wildlife observation is typically limited to easily accessible areas that comprise a small portion of Refuge Complex lands, where existing shell midden sites are typically not found. Fishing and hunting recreationalists may reach more remote areas by boat. Most of the recreational boat traffic occurs on the interconnected manmade bayous, ditches, and water delivery systems that have already be modified from their original landforms through straightening and dredging. Impacts to shell middens from wake action created by smaller fishing boats in the Refuge Complex is likely to be minor since airboats are not allowed and motor sizes are regulated. Continuing public interpretation and education programs under Refuge Management Alternatives A, B, C, D, and E may indirectly lead to improved public appreciation and awareness of the Refuge Complex lands and resources contained therein. Public appreciation and awareness would be promoted most under Refuge Management Alternative D and least under Refuge Management Alternative E.

VII. IMPACTS COMPARISON TABLE FOR THE REFUGE MANAGEMENT ALTERNATIVES

The impacts discussed in detail in the preceding section, *Part A: Impact Analysis for the Five Refuge Management Alternatives*, are summarized and condensed in the following table. The impacts under the "No Action" Alternative A are the base of comparison for the other four "Action" Refuge Management Alternatives. The table is organized by resource area, the same way the detailed impact analysis in Part A is organized. The table allows for a quick comparison of the impacts in a specific resource area between Alternatives.

NO ACTION ALTERNATIVE	ACTION ALTERNATIVES			
RM Alternative A	**RM Alternative B**	**RM Alternative C**	**RM Alternative D**	**RM Alternative E**
Impacts to Air Quality				
Potential smoke impacts to air quality from USFWS prescribed burns on 12-15,000 acres annually	Potential smoke impacts to air quality increased by expanding prescribed burns to 35,000 acres annually. Decreased potential for smoke impacts from wildfires	Potential smoke impacts to air quality decreased by reducing prescribed burns to 5-6000 acres annually. More potential smoke impacts from wildfires	Same as RM Alternative A.	Prescribed burning discontinued; more potential for smoke impacts to air quality from wildfires
Impacts to Geology and Soils				
Shoreline protection & marsh restoration help reduce coastal land loss. Water management and prescribed burning may contribute to organic soil formation.	Same as RM Alternative A. Additional prescribed burning and structural marsh management may contribute to enhanced organic soil formation	Substantial increase in shoreline protection & restoration using dredge material through expanded interagency coordination.	Same as RM Alternative A. Substantial increase in shoreline protection and marsh restoration using dredge material through expanded interagency coordination. Expanded monitoring and research on factors affecting coastal land loss.	Discontinued shoreline protection & restoration projects resulting in increased coastal land loss and saltwater intrusion.
Impacts to Hydrology and Water Quality				
Extensive water management helps maintain historic continuum of coastal marsh habitats by reducing saltwater intrusion, managing water levels, and providing freshwater inflows. Protects nationally-declining wetland types.	Same as RM Alternative A. Water management enhanced by two new marsh semi-impoundments of 6500 acres.	Expand interagency coordination on watershed-scale hydrologic restoration projects to reduce saltwater intrusion and increase freshwater inflows. Acquire additional water rights.	Same as RM Alternative A. Expand interagency coordination on watershed hydrologic restoration projects, enhance water management, and acquire additional water rights. Expand water quality monitoring.	Active water management & restoration discontinued resulting in saltwater intrusion, loss of freshwater & altered hydroperiods.

RM Alternative A	RM Alternative B	RM Alternative C	RM Alternative D	RM Alternative E
Impacts to Vegetation/Habitats				
Impacts from Habitat Management and Restoration Activities				
Structural marsh management helps maintain/restore historic continuum of coastal marshes and plant & animal communities that are dependent on these habitats. Moist soil units and cooperative rice farming provide high quality freshwater wetland habitat for migratory birds. Native prairie restored and coastal woodlots protected. Integrated burning, grazing & water management creates and maintains diverse plant communities. Integrated Pest Management (IPM) program helps control exotic and invasive plant & animal species. Shoreline protection & restoration beneficially protects wetland habitats.	Added marsh semi-impoundments, expanded moist soil and cooperative rice farming increase provide additional wetland habitats for migratory birds. Reduced scope of prairie restoration. Expanded burning and grazing programs enhance wetland and upland habitats for waterfowl and other migratory birds. IPM program, shoreline protection same as RM Alternative A.	Hydrologic restoration to restore freshwater inflows. Cooperative rice farming phased-out with expanded restoration to native prairie and wetlands. Native prairie plant associations increased by restoring 4535 acres to native prairie (a Globally Imperiled habitat) & 29 acres to woodlands. Reduced burning and grazing. IPM program expanded to additional areas. Expand interagency coordination efforts to increase shoreline and marsh protection & restoration.	Enhanced structural marsh management same as Alt. A. Expanded moist soil units and same levels of cooperative rice farming. Native prairie plant associations increased by restoring 2223 acres to native prairie & 29 acres to woodlands. Refined burning and grazing to increase benefits to migratory birds and other wildlife. IPM program expanded to additional areas. Expand interagency coordination efforts to increase shoreline protection and marsh restoration. Additional monitoring and research to assess threats to habitats.	Active marsh management ends resulting in saltwater intrusion, loss of freshwater inflows, and altered hydro-periods. Moist soil units and coop rice farming terminate. No active habitat restoration. End of prescribed burning and grazing results in higher successional plant communities. End of IPM program results in increased populations of exotic/invasive plant and animal species. Shoreline protection & restoration discontinued increasing rate of shoreline retreat and coastal land loss, including conversion of vegetated marshes to open water.
Impacts from Public Use Programs				
Some impacts to wetland vegetation, primarily from motorized boating (associated with hunting/fishing) and local impacts to habitats in heavily used areas. Regulations help ensure that Impacts are localized and not substantial	Same as RM Alternative A.	Same as RM Alternative A, except for reduced impacts in wetland habitats due to decrease in hunting use.	Same as RM Alternative A except with potential to increase with overall increase in visitation.	Same as RM Alternative A except less extensive with overall decrease in visitation.

RM Alternative A	RM Alternative B	RM Alternative C	RM Alternative D	RM Alternative E
Impacts to Vegetation/Habitats				
Impacts from Biological Program, Management of Oil & Gas Exploration/Development, and Community Outreach and Partnerships				
Surveys & monitoring support an adaptive habitat management approach. Oil & gas management minimized impacts to habitats. Outreach and partnerships result in additional habitat restoration/enhancement.	Same as RM Alternative A.	Same as RM Alternative A with more focus on restoration and enhancement of native prairie & coastal woodlot habitats.	Same as RM Alternative A with expanded monitoring and research to guide habitat management and restoration and improve exotic and invasive species management. Expanded outreach and partnerships increase habitat restoration and protection.	Surveys and monitoring only document impacts of passive management. Oil & gas management same as RM Alternative A. Reduced outreach & partnerships results in little habitat restoration or enhancement.
Impacts to Fish and Wildlife Resources				
Impacts from Habitat Management and Restoration Activities				
Management/restoration activities have greatest beneficial impact on wintering, resident and migrating waterfowl. Management activities which result in a mosaic of diverse habitats positively impact other avian species. Activities which maintain/restore productive wetland habitats benefit fisheries in long-term. Management aimed at ensuring biological diversity & ecological integrity benefit T&E and declining species. Most other wildlife species benefit from management activities.	Focus on enhancing waterfowl habitats provide additional benefits for wintering, resident and migrating waterfowl and other wetland-dependent birds. Impacts on fisheries, T&E species and other wildlife species generally same as RM Alternative A.	Emphasis on restoration with less water management reduces benefits to waterfowl and other wetland-dependent migratory birds. Prairie restoration and woodlot protection benefit many declining species. Impacts on fisheries, T&E species and other wildlife generally same as RM Alternative A.	Expanded and enhanced management results in a diverse habitat mosaic which increases benefits to wintering waterfowl, Mottled Ducks, shorebirds, wading birds and other wetland-dependent migratory birds. Prairie restoration and woodlot protection benefit many declining landbird species. Overall, this Alternative provides greatest diversity of habitats benefiting several Avian Species of Conservation Concern. Increased beneficial impacts to fisheries by incorporating fish passage into water management protocols. Impacts to T&E species and other wildlife species same as RM Alternative A.	Discontinued management would decrease habitat values and use by waterfowl and other migratory birds. Habitat values and use by other avian species would also decrease. Curtailed wetland management has short-term benefit for fisheries but habitat loss/degradation of coastal wetlands would have long-term negative impact. Passive management has negative impacts on T&E and other wildlife species.

RM Alternative A	RM Alternative B	RM Alternative C	RM Alternative D	RM Alternative E
Impacts to Fish and Wildlife Resources				
Impacts from Public Use Programs				
Waterfowl harvest managed through regulations has no impacts on overall populations & long-term viability of these populations. Sanctuary areas mitigate disturbance impacts from hunting. Minimal disturbance impacts to other wildlife species from other wildlife-dependent recreational activities. No impacts to T&E species or fisheries.	Same as RM Alternative A.	Same as RM Alternative A.	Increase in all types of visitation expected to result in minimal, localized increase in impacts to migratory birds and other wildlife. No change in impacts to T&E species or fisheries.	Expected overall decrease in visitation over time would decrease impacts. No impacts to fisheries or T&E species.
Impacts from Biological Program, Management of Oil & Gas Exploration/Development, and Community Outreach and Partnerships				
Surveys and monitoring track & document impacts of management strategies on fish & wildlife supporting adaptive management approach. Oil & gas management reduces impacts on fish & wildlife. Outreach & partnerships result in benefits to fish & wildlife as habitats are restored or enhanced.	Same as RM Alternative A except with more benefits from expanded outreach & partnerships.	Same as RM Alternative A except with more benefits from expanded outreach & partnerships especially in restored prairie woodland habitats.	Expansion of all programs would enhance benefits to fish and wildlife resources. Additional monitoring and research focuses on priority avian and other wildlife species.	Surveys and monitoring would only document impacts from passive management approach. Continued oil & gas management reduces impacts on fish & wildlife. Reduced outreach and partnerships reduce habitat restoration/enhancement and benefits to fish & wildlife.

RM Alternative A	RM Alternative B	RM Alternative C	RM Alternative D	RM Alternative E
Economic Impacts				
Refuge operations contribute $2.7m* direct to local economy & refuge agriculture programs add $2.1m* (grazing) and $.25m* (rice farming). Direct expenditures by recreational visitors contribute another $1.1m*. Indirect & induced economic impacts from these direct impacts contribute an estimated $3.3m* more to local economies. *m = million $	Increased direct contributions from refuge operations by 10%, from grazing by $.5m*, rice farming by $.16m*, and recreational visitors by $.1m*. Corresponding increases in indirect & induced economic impacts from increases in direct impacts.	Increased direct contributions from refuge operations by 25%, but substantial decrease from grazing by $1.1m* and rice farming by $.25m*. Very small increase in direct expenditures by recreational visitors. Corresponding increases or decreases in indirect & induced economic impacts dependent on direction of change in direct impacts.	Substantial increase in direct contributions from refuge operations by $1.0m*. Smaller increases in grazing, $.3m* & recreational visitors, $.2m* but rice farming same as Alt. A. Corresponding increases in indirect & induced economic impacts with increases in direct impacts.	Major decreases in direct contributions from refuge operations (by more than half by end of planning period) along with complete elimination of all refuge agricultural programs. Small decrease in direct expenditures by recreational visitors. Corresponding major decreases in indirect & induced economic impacts with decreases in direct impacts.
Impacts on Population, Fiscal Impacts on Local Governments, and Social Impacts				
No environmental justice or population impacts. Payments to local gov't entities under Refuge Revenue Sharing Act. Social conditions remain generally unchanged with unresolved issues.	Same as Refuge Management Alternative A.	Same as Refuge Management Alternative A.	Same as Refuge Management Alternative A.	Same as Refuge management Alternative A except for small localized reduction in employment in a rural area.

PART B: IMPACT ANALYSIS FOR FOUR REFUGE BOUNDARY EXPANSION ALTERNATIVES

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Summary of Refuge Boundary Expansion Alternatives

The four Refuge Boundary Expansion Alternatives are graphically depicted on the maps beginning on page 86 of Chapter 2, Part B. The following is a summary describing each of the Refuge Boundary Expansion Alternatives and the focus for each one:

Refuge Boundary Expansion Alternative A ***(NEPA No Action Alternative)*** *- No Expansion, Current Status*

This Alternative assumes no change from the existing refuge boundaries within the Refuge Complex. This is the "No Action" alternative as required under NEPA and is considered the base from which to compare the other Refuge Boundary Expansion Alternatives. There would be no expansion of any of the four refuge boundaries within the Refuge Complex.

Refuge Boundary Expansion Alternative B - 33,590 Acre Expansion

This Alternative continues the four refuges' historic focus on land acquisition primarily in the coastal marsh and the adjacent agricultural uplands. Acquisition would continue to focus on habitats of particular value to the waterfowl resource and other wetland-dependent migratory birds. This Refuge Boundary Expansion Alternative concentrates on high-value wintering waterfowl habitats near the coast that are contiguous to existing refuges. In addition to these high biological value wetland habitats, this Alternative also includes areas adjacent to existing refuges identified as necessary for refuge management. Expansion is proposed for each of the four refuges in the Refuge Complex.

Refuge Boundary Expansion Alternative C ***(Preferred Alternative) -*** *64,260 Acre Expansion*

Please note that this alternative includes all of the lands in the preceding Refuge Boundary Expansion Alternative B. Similar to Refuge Boundary Expansion Alternative B, this Alternative continues the four refuge's historic focus on land acquisition primarily in the coastal marsh and adjacent agricultural uplands. Much of the acquisition would still focus on habitats of particular value to the waterfowl resource and other wetland-dependent migratory birds. The wetland portions of this Refuge Boundary Expansion Alternative concentrate on high-value wintering waterfowl habitats near the coast that are contiguous to existing refuges. In addition to these primarily wetland areas, this Alternative includes two areas of important native coastal prairie with high habitat value for resident Mottled Ducks, many species of grassland-dependent migratory birds, and a wide variety of other native wildlife species. In addition to these two kinds of high biological value habitats, this alternative also includes areas adjacent to existing refuges identified as necessary for refuge management. Expansion is proposed for each of the four refuges in the Refuge Complex.

Refuge Boundary Expansion Alternative D - 104,120 Acre Expansion

Please note that this alternative includes all of the lands in the preceding Refuge Boundary Expansion Alternative C. Similar to Refuge Boundary Expansion Alternative C, this alternative continues the four refuge's historic focus on land acquisition primarily in the coastal marsh and adjacent agricultural uplands. Much of the acquisition would still focus on habitats of particular value to the waterfowl resource and other wetland-dependent migratory birds. The wetlands portions of this Refuge Boundary Expansion Alternative concentrate on high-value wintering waterfowl habitats near the coast which are contiguous to existing refuges. In addition to these primarily wetland areas, this Alternative includes two areas of important native coastal prairie with high habitat value for resident Mottled Ducks,

many species of grassland-dependent migratory birds, and a wide variety of other native wildlife species. This Alternative also includes an important near-coast bottomland hardwood area, which is an acquisition target new to this Refuge Complex. The primary habitat type in this area is forested wetlands which provide high quality wintering, migrational, and nesting habitats for waterfowl and other wetland-dependent migratory bird species, and important migration stop-over habitats for many neotropical migratory birds making trans- and circum-Gulf migrations. Finally, in addition to these various kinds of high biological value habitats, this Alternative also includes areas adjacent to existing refuges identified as necessary for refuge management.

The estimated acreage for each proposed expansion (Alternative A – D) is summarized for each of the four refuges in the Refuge Complex in Table 4-41.

Table 4-41
Total Estimated Acreage within the Refuge Boundary Expansion Alternatives

Refuge	Estimated Acreage			
	Alternative A "No Action"	Alternative B	Alternative C	Alternative D
Moody	0	5,050	7,920	7,920
Anahuac	0	20,500	47,750	64,910
McFaddin	0	7,190	7,190	29,890
Texas Point	0	850	1,400	1,400
Total	**0**	**33,590**	**64,260**	**104,120**

Assumptions

- **The impacts for the Refuge Boundary Expansion Alternatives are analyzed assuming that all of the lands within an expansion area would be acquired in fee simple within the first year following approval of that proposed boundary expansion. This assumption assures that the maximum possible impacts are addressed even though the proposed "willing seller" acquisition program would obviously not produce this result.**

- **The impacts for the Refuge Boundary Expansion Alternatives are analyzed assuming that the lands within the existing Refuge Complex and those lands acquired in the future would be managed according to the strategies contained in Refuge Management Alternative D, the Preferred Alternative.**

Impacts to Cultural Resources

The impacts to cultural resources on the Complex from the actions proposed in the Refuge Boundary Expansion Alternatives are discussed in a separate section at the end of this part. The impacts for all of the alternatives are grouped together in one discussion because the impacts are very similar and only differ in quantity of acreage proposed for acquisition.

Organization of Impact Analysis

As in Part A of this Chapter, all of the impacts for Refuge Boundary Expansion Alternative A (No Action) will be presented in its own separate section. The impacts occurring under this Alternative become the base for comparison of the impacts from the other "action" alternatives.

Impacts for the other three Refuge Boundary Expansion Alternatives will be presented together in one section. This is done because the impacts from each of the three "action" alternatives are the same and differ only in quantity depending on the size of the expansion proposal. The only exception is the impact to the development potential in Taylors Bayou within Refuge Boundary Expansion Alternative D and this impact is described separately.

I. IMPACT ANALYSIS FOR REFUGE BOUNDARY EXPANSION ALTERNATIVE A (NO ACTION) NO EXPANSION, CURRENT STATUS

Overview

Under Refuge Boundary Expansion Alternative A, the refuge boundaries would not be expanded. Lands within the proposed boundary expansion areas in Refuge Boundary Expansion Alternatives B, C and D would not be acquired by the USFWS, and would likely remain in private ownership. Current land uses within the areas in identified in Refuge Boundary Expansion Alternatives B, C, and D are primarily agricultural, and include livestock grazing and rice farming. Many privately-owned agricultural properties in the project area are leased by individuals or commercial guides and outfitters for waterfowl hunting and dove hunting. These uses would likely continue as long as they are economically beneficial to the landowner.

Rice farming, which can provide valuable wildlife habitat when managed for those purposes, is declining in the project area. Much of the acreage in the USDA farm program in Chambers and Jefferson counties is now either fallow or has been converted to improved pasture. Fallowed rice fields and improved pasture are now being managed primarily for cattle grazing. Areas not grazed are quickly invaded by exotic plant species, particularly Chinese tallow and deep-rooted sedge. Once infested, these areas provide few benefits for wildlife and require restoration at significant costs to resume rice production or provide suitable pasture for cattle.

Changes in land ownership patterns in the project area may be impacting the extent to which management on private lands specifically includes providing enhanced habitats for fish and wildlife. Many large land holdings formerly owned and managed under single ownership have been divided into multiple ownerships. In many of these cases, land management for wildlife which formerly occurred over large areas is now less likely to occur.

Some land owners in the project area are intensively and very successfully managing properties to enhance wetland habitats for wintering waterfowl, and agricultural practices such as rice farming and cattle grazing can provide substantial benefits to waterfowl and other migratory birds. Overall within the project area, however, economic considerations other than fish and wildlife benefits dictate land uses and land management practices on private lands. This will likely continue to be the case under Refuge Boundary Expansion Alternative A.

Under Refuge Boundary Expansion Alternative A, future land uses would be subject to the discretion of the landowners. Land could remain undeveloped with continued agricultural uses, or be converted to other uses such as residential, recreational or industrial development.

The authorized acquisition boundary for each of the refuges would remain as it is today. The USFWS would continue to manage the lands already acquired and could only acquire the remaining lands, if any, within their existing boundaries.

Summary of Current Land Acquisition Status:

Refuge	Approved Boundary	Acquired Lands	Percent Acquired
Moody NWR	3,516 acres	3,516 acres	100%
Anahuac NWR	34,339 acres	34,339 acres	100%
McFaddin NWR	70,710 acres	58,861 acres	83%
Texas Point NWR	8,952 acres	8,952 acres	100%

A. Natural Resources Section

1. Impacts to Air Quality

The predominant impact to the region's air quality from current land uses is from agricultural burning in support of grazing and rice production. Burning on private lands is conducted mainly to improve forage for livestock and to control brush. Some landowners also burn marshes to enhance habitat for wintering waterfowl. Under Refuge Boundary Expansion Alternative A, private landowners would continue to conduct burning on their lands. Marsh burning generally occurs in September or October. In upland areas, private landowners tend to burn in the late spring for brush control and to create more palatable forage for cattle. Marshes and pastures are typically burned annually. In heavily grazed areas, reduced fuel loads allow only portions of pastures to burn.

The primary source of negative air impacts from burning is from smoke. Regional air quality is affected only when many acres are burned concurrently on the same day. Temporary, localized decreases in air quality occur more frequently, but may be severe at times due to the large quantities of smoke that can be produced in a given area during a short period of time (USFS 1989). Smoke is made up primarily of carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons and other organics, nitrogen oxides, and trace minerals. The composition of smoke varies with fuel type. Nitrogen oxides are usually produced at temperatures only reached in piled slash or very intense wildfires; only inconsequential amounts are produced in prescribed fires (USFS 1989). Particulate matter is the major pollutant of concern from wildfire and prescribed fire smoke. Particulate matter is a general term for a mixture of solid particles and liquid droplets found in the air. Particulate matter from smoke tends to be very small (less than one micron in diameter) and, as a result, is more of a health concern than the coarser particles that typically make up road dust. Because of their size range, particulates scatter light effectively and, therefore, reduce visibility easily.

The atmospheric conditions that affect the movement and dispersal of smoke include the following: wind direction, wind speed, mixing height (the elevation in the atmosphere that the smoke mixes and disperses), transport wind speed and direction (the direction and speed of upper level winds responsible for moving the smoke from the immediate area), and Category day/dispersion (a combination of mixing height and transport wind speed to give an over all indicator of smoke dispersion potential). The Category day 1, 2, 3, 4 or 5 equates to poor, fair, good, very good and excellent smoke dispersal (USFWS 2003).

Burning may temporarily expose local residents to low concentrations of drift smoke, which is more of a temporary inconvenience than a health problem. However, high smoke concentrations typically produced from large burns can present health concerns, particularly near homes of people with respiratory illnesses or near health-care facilities (USFS 1989). The human health effects from smoke vary from irritation of the eyes and respiratory tract to more serious disorders including asthma, bronchitis, reduced lung function, and premature death. Particulate matter is the main source of health effects, but carbon dioxide and toxic air pollutants from wildfires can also cause health concerns (Therriault 2001). Additionally, the burning of noxious plants such as poison ivy can affect human respiratory systems, as well as cause severe skin rashes (USFS 1989). Wildlife can also be negatively impacted by smoke, particularly where large areas are ignited in a short period of time.

Burning on private lands in the project area often occurs under conditions of low humidity associated with frontal passages and north winds which typically transport smoke away from communities and other smoke sensitive areas. However, burning activities on private lands also regularly do not adhere to State regulations governing outdoor burning. These include regulations under the Texas Commission on Environmental Quality's Outdoor Burning Rule: 1) sensitive receptors must not be within 300 feet downwind of burning activities; 2) burning must occur no earlier that one hour after sunrise and no later than one hour before sunset; 3) burning must not be permitted when surface winds are less than six mph or more than 23 mph; and 4) burning must not be permitted during periods of persistent (actual or predicted) low level atmospheric temperature inversions (Therriault 2001, USFWS 2003). As such, burning on private lands under conditions which cause smoke impacts to communities in the area is not

uncommon. Burning in areas with heavy fuel accumulations which extends over several days produces the most severe smoke impacts.

2. Impacts to Geology and Soils

Soil erosion is a physical process whereby soils are degraded by the action of water and wind. Other forms of soil degradation including soil compaction, low organic matter, loss of soil structure, poor internal drainage, salinization, and soil acidity problems usually contribute to accelerated soil erosion. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil.

Current agricultural uses on private lands within the project area are impacting soil characteristics. Fertilization, fresh water irrigation that desalinizes soils, and aeration that increases oxidation positively affect soil chemistry and stabilize soils thereby preventing accelerated erosion. Conversely, heavy grazing or intense agricultural uses can destabilize soils and lead to increased soil erosion through excessive removal of vital soil nutrients, soil compaction, removal of vegetation and extensive use of broad spectrum herbicides and pesticides.

The combination of rising sea levels and land subsidence (relative sea level rise) and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water. In addition to ongoing impacts, relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps suggests that current projections of relative sea level rise related to global climate change may be underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

Although shoreline retreat and along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has accelerated rates of shoreline retreat along the Gulf shoreline. On the upper Texas Coast, this reduced sand supply has led to loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges.

The historic barrier beach/dune system has been almost entirely loss on both the Texas Point and McFaddin NWRs and adjacent private lands in Jefferson County. Shoreline erosion and retreat along the Gulf is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and significant portions of the McFaddin NWR shoreline is eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of beach and dune habitat, this loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is

occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of plant productivity may decrease of the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water. (On McFaddin NWR, coastal erosion and damage from storm tidal surges have destroyed a portion of Texas State Highway 87, a coastal highway that has been closed since 1989.)

Shoreline erosion and retreat is resulting in loss of coastal habitats on public and private lands throughout the project area. The shore of East Galveston Bay on the Anahuac NWR is eroding at 1.2 meters annually (Carrol 1974). Paine and Morton (1986) determined the East Bay shoreline of Anahuac NWR consistently eroded at a rate of 3 feet/year between 1850 and 1982. Erosion along the GIWW in the project area is occurring at rates between 5 to 10 feet annually. This is resulting in current or pending loss of intermediate and brackish marsh habitats, and further threatening these habitats with saltwater intrusion.

Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels have caused erosional loss of organic marsh soils, also leading to conversion of vegetated marshes to open water. Conversion of vegetated marshes to open water has also occurred throughout the region in areas where rapid land subsidence has resulted in submergence of wetlands. It is likely that these impacts have been the most severe in areas subject to both saltwater intrusion and rapid subsidence.

Under Refuge Boundary Expansion Alternative A, it is expected that coastal land loss (as shorelines erode and retreat and emergent marshes convert to open water) would continue at existing or accelerated rates in areas now under private ownership. To date, most shoreline protection projects on private lands in the area have focused on protecting residential and recreational infrastructure. In general, sufficient economic incentives are not in place for private landowners to participate in the types of major conservation-oriented hydrologic restoration and shoreline protection projects which will be required to counter the future effects of relative sea level rise and altered hydrological regimes.

Other land management practices occurring on private lands such as burning are impacting soils and soil formation. Insufficient data exists to adequately address the effects of fire on marsh accretion. Evidence exists suggesting root mass is a significant contributor to vertical accretion via peat formation (DeLaune *et al.* 1983, Nyman *et al.* 1993). In a study on the McFaddin NWR, both root volume and sediment elevation recovered faster in a burned area relative to an unburned area after salt water flooding (M. Ford and D. Cahoon, unpubl. data). Gabrey and Afton (2001) found that unburned and cover-burned Chenier plain marshes showed no differences in belowground biomass. Fire has been shown to increase primary productivity in some Gulf coast marshes (Hackney and Cruz 1981, Gabrey and Afton 2001). While these studies examined the effects of cover burns (burns conducted when sufficient water is present in the marsh to restrict biomass consumption to aerial plant material), root and peat burns can have a profound impact on marsh accretion. Root fires consume the litter layer and shallow root systems, while peat fires burn deeper into the soil consuming available organic matter (Lynch 1941). Nyman and Chabreck (1995) concluded that fire should be used with caution until its effects on marsh accretion is better understood. Burning frequency and timing will likely determine the net effect on vertical accretion. Marsh burning on private lands occurs primarily in support of grazing and hunting operations, and typically marshes are burned annually.

Some landowners in the project area are managing water levels and salinities in coastal marshes, primarily to enhance habitats for wintering waterfowl and to reduce saltwater intrusion which can negatively impact grazing and rice farming operations. Structural marsh management techniques, such as weirs and impoundments, may affect marsh vertical accretion (Nyman *et al*. 1993). In a survey in Louisiana regarding the effects of weir management on marsh loss, Nyman *et al*. (1993) concluded that weirs did not affect marsh loss or accretion, but that weirs may have different effects under different hydrological conditions, and that the effects of herbivore activity (muskrats) were important. Bryant and Chabreck (1998) found three structurally managed marshes in the Chenier Plain of Louisiana had

significantly lower accretion than adjacent unmanaged marshes, while the fourth managed marsh had higher accretion than the adjacent unmanaged marsh. The managed marsh with higher accretion rates remained permanently flooded, while the three managed marshes with lower accretion underwent frequent drainage. It was hypothesized that structurally managed marshes are hydrologically isolated from tidal sediment subsidies and that frequent forced drying oxidized organic material in the soil. Gabrey and Afton (2001) found that belowground biomass was higher in unimpounded than impounded marshes. Perez and Cahoon (2005) did not find any difference in marsh accretion between structurally managed marshes on McFaddin NWR and adjacent unmanaged marsh.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Marsh accretion in the Chenier Plain region's fresher marshes is very dependent on the accumulation of organic matter, as opposed to mineral sediment deposition which is very important in the deltaic marshes of southeastern Louisiana. Water management activities on private lands in fresh to brackish coastal marshes which reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying would benefit soil formation and vertical accretion by increasing plant productivity and preventing oxidation of marsh soils. Conversely, management which results in increased saltwater intrusion or excessive inundation or "drowning" of emergent marshes may result in lowered plant productivity and reduced soil formation.

In general, it is likely that economic considerations rather than the potential impacts of burning and water management on marsh accretion will continue to dictate the scope, extent and timing of these activities on private lands under Refuge Boundary Expansion Alternative A.

3. Impacts to Hydrology and Water Quality

a. Hydrology

The Chenier Plain region's coastal marshes were historically influenced by high annual precipitation and substantial freshwater riverine inflows, creating a continuum of coastal estuarine marsh types associated with a natural salinity gradient, from fresh to saline. Fresh and intermediate marshes formed a substantial component of this continuum. The natural hydrologic regimes of the coastal marshes throughout the project area have been greatly modified by the construction of the GIWW and numerous smaller canals and ditches, upstream dams and reservoirs, roads, levees and impoundments, and by the deepening and channeling of most natural waterways and other inland drainage improvements. The hydrological consequences of these activities include saltwater intrusion, reduced or restricted freshwater and nutrient/sediment inflows, and altered hydroperiods (wetting and drying cycles). Hydrological changes in turn have impacted natural biological diversity and in some cases contributed to a net loss of estuarine wetlands in the region (Moulton *et al*. 1997).

Conversion of vegetated marshes to open water has occurred throughout the Chenier Plain region in areas where increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels has caused erosional loss of organic marsh soils.

Saltwater intrusion and soil waterlogging has been associated with peat collapse and subsequent conversion of coastal marsh to open water (DeLaune *et al*. 1994). Naidoo *et al.* (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Work conducted by Nyman *et al*. (1995b) indicate that marshhay cordgrass has higher root production at lower salinity levels. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al.* 1983, Nyman *et al.* 1993).

Excessive flooding, salt water intrusion, and sulfide stress can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Loss of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et al*. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). It is likely that conversion of vegetated marshes to open water have been greatest in areas subject to both saltwater intrusion and rapid subsidence.

In addition to ongoing impacts, relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps suggests that current projections of relative sea level rise related to global climate change are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al.* 1993).

Some landowners in the project area are managing water levels and salinities in coastal marshes, primarily to enhance habitats for wintering waterfowl and to reduce saltwater intrusion which can negatively impact grazing and rice farming operations. Management infrastructure comprised of water control structures, levees, and water delivery systems (including pumps, ditches and canals) is used to manage and manipulate water and soil salinities and water levels within structurally-managed marshes. Water management activities on private lands in fresh to brackish coastal marshes which reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying helps maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes. In turn, these habitats support a natural diversity of native plant, fish and animal communities. Such management also helps prevent the conversion of vegetated marsh to open water, promotes plant productivity and contributes to marsh surface elevation gain (accretion). Conversely, management on private lands which results in increased saltwater intrusion, excessive inundation or "drowning" and/or too rapid drainage and excessive drying of emergent marshes is likely resulting in loss and degradation of coastal wetlands.

Changes in land ownership patterns in the project area may be impacting the extent and scope of water management and other land management practices which formerly benefited wildlife and habitat on private lands. Many large land holdings formerly owned and managed under single ownership have been divided into multiple ownerships, making it less likely that management activities such as large-scale hydrologic management or restoration in marshes will take place. In general, it is likely that economic considerations rather than habitat and fish and wildlife conservation objectives will dictate the types and scope of management activities affecting hydrology on private lands under Refuge Boundary Expansion Alternative A.

b. Water Quality

Potential sources of contaminants affecting water quality in the project area include accidental releases from oil and gas exploration and production activities, including spills and leaks from wells, production facilities, and pipelines. Oil and gas exploration and development activities have increased in the project area in recent years. A high volume of petrochemicals is transported through the project area on a daily basis via the GIWW. Municipal development and agricultural practices may also impact water quality in the project area. Non-point pollution sources such as storm drain run-off from local cities and towns are

major sources of pollutants entering the Galveston Bay estuarine ecosystem (Galveston Bay National Estuary Program 1995). Point source pollution from upstream facilities such as landfills is also of concern.

Rice cultivation contributes important freshwater inflows to the Galveston Bay and Sabine Lake estuarine ecosystems, but agricultural practices as a whole may also contribute excess nutrients and toxins to surface waters within these coastal watersheds. Herbicide application is used on rice, soybeans, sorghum, and hay throughout the region. Concentrations of herbicides are greatest during May, June and July, with the lowest concentrations occurring in the fall and winter. Nitrates from nutrient loading are common in agricultural areas where fertilizer application enters into streams, creeks, and bayous during storm events.

In general, it is likely that economic considerations will dictate the types and scope of activities which affect water quality on privately-owned lands under Refuge Boundary Expansion Alternative A.

4. Impacts to Vegetation/Habitats

Land management practices affecting vegetation and habitats on private lands within the project area are undertaken in support of agricultural uses, primarily livestock grazing and rice cultivation. Practices include pasture management (including haying, conversion to “improved” pasture, and control of Chinese tallow), burning, and the soil and water manipulations associated with rice farming. Some landowners implement structural water management in coastal marshes, primarily to enhance habitats for wintering waterfowl and to reduce saltwater intrusion which can negatively impact grazing and rice farming operations. Concurrent with agricultural uses, some private lands are also being managed to provide wildlife benefits, primarily in support of waterfowl hunting. Some rice farming operations are managed so as to provide quality habitat for wintering and migrating waterfowl. A small number of land owners are implementing moist soil management practices to create shallow freshwater wetland habitat, also to enhance habitat values for waterfowl. Most private lands capable of supporting waterfowl and/or dove hunting are leased to individuals or commercial hunting guides and outfitters.

Some land owners in the project area are intensively and very successfully managing properties to enhance habitats for wintering waterfowl, and rice farming and cattle grazing can provide substantial benefits to waterfowl and other migratory birds. Overall in the project area, however, economic considerations other than fish and wildlife benefits dictate land uses and land management practices on private lands. This will continue under Refuge Boundary Expansion Alternative A.

a. Impacts to Vegetation and Habitats from Habitat Management and Restoration Activities

(1). Wetland Specific Management and Restoration

Water management activities (e.g., establishing freshwater inflows, water level management, and restricting saltwater intrusion) impact geology, soils and hydrologic regimes throughout the project area. Such activities also influence vegetation found in wetland habitats.

(a). Water Management in Coastal Marshes

Some landowners in the project area are managing water levels and salinities in coastal marshes to both support agricultural uses and enhance habitats for wintering waterfowl. Controlling saltwater intrusion in support of grazing and rice farming also increases habitat quality for wintering waterfowl. Managed marshes on private lands within project area are under varying degrees of structural control. Some are entirely or almost entirely behind man-made levees and water control structures, and are intensively managed through manipulation of the water control structures. Most are managed less intensively, relying to some degree on natural topography and drainage to control hydrologic regimes. Ditch construction in marshes for drainage and/or access purposes has occurred extensively throughout the region.

Management infrastructure comprised of water control structures, levees, and water delivery systems (including pumps, ditches and canals) is used to manage and manipulate water and soil salinities and water levels within these structurally-managed marshes. On lands being managed for waterfowl, water levels and salinities favorable for producing abundant crops of submerged aquatic vegetation in open water habitats are maintained. Water levels during fall and winter months are maintained to promote utilization by puddle ducks and geese.

Water management activities on private lands in fresh to brackish coastal marshes which reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying are helping to maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes. In turn, these habitats will continue to support a natural diversity of native plant, fish and animal communities. Such management would also help prevent the conversion of vegetated marsh to open water, promote plant productivity and contribute to marsh surface elevation gain (accretion). Conversely, structural marsh management which results in increased saltwater intrusion or excessive inundation or "drowning" of emergent marshes would result in loss and degradation of coastal wetlands.

On many properties being managed for livestock grazing as the primary economic use, marshes are drained immediately following the hunting season and kept dry as long as possible to increase availability of forage for livestock and increase the amount of dry ground available for calving. Marshes are typically "drawn down" as quickly as possible beginning in late January.

(b). Moist Soil Management

A few private landowners in the project area use moist soil management to enhance wintering waterfowl habitat. Water management and mechanical soil manipulations are timed to promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia. Water management (drawdowns and flooding) in moist soil units is accomplished with water control structures, levees, and water delivery systems including pumps and canal systems. Conventional farm machinery with discs and roller choppers are used to manipulate soils and vegetation.

Moist soil management contributes to increasing and maintaining the biological diversity of an area. Moist soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). Over 80 percent more species have been found to occur in moist-soil impoundments than in adjacent row crops and include invertebrates, herpetofauna (amphibians and reptiles), prairie and marsh passerines, shorebirds, wading birds, waterfowl, gallinaceous birds, raptors, and mammals (Fredrickson and Taylor 1982).

(c). Rice Farming

Rice and livestock production are the predominant agricultural activities in the project area, and rice fields and pastureland are the predominant upland agricultural habitats. Conversion of native habitats to agricultural uses has occurred throughout the project area on most lands that would support these uses.

Rice production requires seasonal flooding, which creates shallow freshwater wetland habitat utilized by many avian and other wildlife species throughout the spring and summer. During fall and winter, flooded rice stubble and rice fallow, plowed fields, water leveled fields, weedy fields, ryegrass fields, and pastureland in the project area provide habitats that historically have supported large concentrations of wintering and migrating waterfowl, shorebirds, and wading birds. Flooding after harvest makes waste grain available to waterfowl. Reservoirs associated with rice production provide permanent, deepwater wetland habitats.

Rice production in the project area has declined significantly in recent years, and only a relatively small amount of base acreage currently in the USDA farm program is being actively farmed. On lands identified under Refuge Boundary Expansion Alternative B, 3,013 acres are currently being subsidized for

rice under the USDA farm program, on which an average of 99 acres per year have been in rice production in recent years. On lands identified under Refuge Boundary Expansion Alternative C, 3,506 acres are currently being subsidized for rice under the USDA program, of which an average of 211 acres per year has been in rice production in recent years. On lands identified under Refuge Boundary Expansion Alternative D, 13,290 acres are currently being subsidized for rice under the USDA program, of which an average of 1,229 acres per year has been in rice production in recent years.

Former rice fields are either left fallow or are being converted to improved pasture. Much of this acreage is supporting livestock operations. Permanently fallowed rice fields which are not grazed are rapidly being invaded by Chinese tallow and deep-rooted sedge. These exotic plant species are so invasive that they quickly replace native plants and provide few benefits for wildlife. The decline in rice production in the project area has significantly reduced the amount of farmed wetland acreage available to waterfowl and other migratory birds. It has undoubtedly contributed to reduced numbers of waterfowl wintering in the area.

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Most of the historic native coastal tallgrass prairie in the project area has been converted to agricultural uses, primarily for rice production and pasture for grazing. Some private lands, primarily in Chambers County, contain some of the only remaining large tracts of native prairie on the upper Texas Coast. Land holdings with remnant native prairie stands are utilized and managed primarily to support grazing by cattle.

Increasingly, fallowed rice fields and other privately-owned uplands in the project area are being converted to “improved pasture” in support of cattle grazing operations. This generally involves planting of tame grasses including Jiggs Bermuda, Coastal Bermuda, and Bahia grasses. Improved pastures are typically used as warm season pastures. Winter wheat and rye grass are planted to produce cattle feed for use during the cool season. Improved pastures do not to support the plant and animal diversity found in native prairie or rice fields.

(b). Woodlot Restoration and Protection

Coastal woodlots found on private lands in the project area are typically part of the overall land area used for livestock grazing. Woodlots are typically found on higher elevation sites, and cattle will typically congregate on these sites for shade. Grazing typically reduces or eliminates understory shrubs in woodlots, and may preclude natural reproduction of woody plant species.

(3). General Habitat Management Activities

(a). Fire Management - Prescribed Burning

Private landowners in the project area routinely use burning in marsh and upland areas, mainly to improve forage and control brush in support of grazing operations. Some landowners with hunting leases and/or commercial hunting operations also burn marshes to enhance habitat for wintering waterfowl.

Under Refuge Boundary Expansion Alternative A, private landowners would continue to conduct agricultural burning on their lands. Marsh burning generally occurs in September or October. In upland areas, private landowners tend to burn in the late spring for brush control and to create more palatable forage for cattle. Marshes and upland pastures are typically burned annually. In heavily grazed areas, reduced fuel loads often allow only portions of pastures to burn. In areas where fire cannot be applied, private landowners are more dependent on herbicides to control brush.

Although primarily done in support of grazing operations, burning on private lands has the potential to provide the following benefits:

- Hazardous fuels are reduced within immediate proximity to facilities and structures, which ensures protection of life and property. Prescribed burning lessens the potential of uncontrollable wildfires by reducing the accumulation of rank vegetation and litter.
- Habitat for waterfowl and other migratory birds is restored, maintained, or improved by maintaining early successional plant communities in marsh habitats, by increasing production and nutritional quality of these foods, and enhancing the availability of these foods by creating openings in otherwise dense strands of vegetation. For example, prescribed burning (integrated with grazing and water management) encourages seed producing annual grasses such as sprangletops and millets, and tuber producing plants such as Olney bulrush preferred by waterfowl. Snow geese heavily use recent marsh burns because they can readily access roots, tubers, and young green shoots of the regrowth. Both geese and ducks use burned areas as roosts or loafing areas.
- Encroachment of undesirable woody shrubs, including Chinese tallow, bigleaf sumpweed, and Eastern baccharis, is suppressed. Without fire disturbance, both marsh and prairie habitats are subject to invasion by such woody plant species, which in turn reduces habitat quality for many grassland-dependent avian species. Burning makes vegetation more desirable to herbivores and will increase grazing pressure. Post-fire herbivory, whether by geese or cattle, prolongs early successional marshes and creates habitat for other wildlife. Post-fire herbivory will slow the recovery of climax vegetation and prolong early serial stages and open marsh conditions favorable to waterfowl (USFWS 1994). Livestock turn the soil through hoof action and further set back succession (Chabreck 1968, Stutzenbaker and Weller 1989).

Interstitial vegetation, often seed producing annuals such as sprangletops (*Leptochloa* spp.) and millets (*Echinochloa* spp.), increases after a fire, particularly when followed by grazing and suitable hydrology. Burning opens up dense vegetation and allows waterfowl access to seeds and other plant parts (Lynch 1941). Fire can remove plant cover and create open water conditions conducive to Mottled Duck brood-rearing habitat (Stutzenbaker 1988). Generally speaking, burning creates open marsh conditions and sets back succession if timed properly, particularly when followed by herbivory. Burning is an effective tool to manipulate vegetation composition and create a habitat mosaic (Fredrickson and Laubhan 1996).

The impacts of burning in wetland habitats conducted specifically to enhance habitats for waterfowl (in combination with controlled grazing and water level and salinity management) include: 1) increasing plant species diversity, 2) maintaining and enhancing desirable emergent marsh plant communities such as Olney bulrush and leafy three-square bulrush, 3) creating openings in otherwise dense stands of emergent marsh vegetation; and 4) helping to control exotic and/or invasive plants. Burning (integrated with control livestock grazing and water management) in wetland habitats promotes the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al.* 1979). In intermediate and brackish marsh habitats, these include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. The impacts of burning in upland grassland habitats include: 1) maintaining and enhancing native prairie plant communities, including several native grasses and forbs, by enhancing conditions which encourage reproduction and growth of these species; and 2) helping to control exotic and/or invasive plants, most notably Chinese tallow and Eastern baccharis, which often outcompete and replace native grasses in areas where fire has been excluded or its frequency decreased.

While burning can have many positive effects on native habitats, it can also have detrimental impacts ranging from an undesirable change in plant species composition to actual conversion of emergent marshes to open water. Proper timing of burns under appropriate conditions of soil moisture, fuel loads and fuel moisture is essential to minimize negative impacts. For example, burning under excessively dry conditions could result in destruction of desirable vegetation, consume organic matter and decrease marsh soil elevation, which in turn could result in permanent conversion to open water. Hot fires may result in root burns, which can cause mortality of desirable marsh plant species. Fire increases the soil erosion potential until regrowth occurs. Recently burned areas are especially susceptible to erosion during storm surges from tropical storms and hurricanes. Hot fires occurring without adequate soil

moisture can also cause a temporary reduction in microflora and microfauna in wetland soils. Burning cannot restore lost marsh or counter the effects of excessive flooding or salinity (Chabreck 1994). Burning is not as beneficial in more saline marshes, because the resulting subclimax plant community is not as diverse (Spicer *et al*. 1986). Annual burning over a long period time likely reduces plant species diversity in both wetland and upland habitats.

(b). Livestock Grazing

Livestock grazing is the primary agricultural use on private lands within the project area. Controlled grazing can be an effective and inexpensive tool in wetland and grassland management providing habitat components that benefit waterfowl and other wildlife species. The relation of cattle grazing to wildlife varies considerably, depending on stocking rate, seasonality, plant community, and wildlife concerned (Chabreck 1968). Research indicates that dual use of grasslands by wildlife and livestock is often compatible when livestock grazing is carefully managed and wildlife needs are considered (Holechek *et al*).

Grazing (especially when integrated with fire and water management) in wetland habitats promotes the germination, growth and reproduction of several "early successional" plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et a*l. 1979). In intermediate and brackish marsh habitats, these include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Moderate grazing following burns in marshes also results in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al*. 1979). Grazing also helps provide optimal physical structure of vegetation for waterfowl utilization in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining plant communities such as seashore paspalum which grow low to the ground. When shallowly flooded, stands of low-growing seashore paspalum and seashore saltgrass interspersed with ponds provide ideal habitat conditions for many waterfowl, shorebird and wading bird species. These conditions also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds. Private grazing operations involving high stocking rates in marsh habitats often result in improved habitat conditions for waterfowl and increased waterfowl utilization of grazed areas (assuming proper water levels and salinities).

Specifically, the beneficial effects of grazing in wetland habitats include:

- Reduces rank vegetation which enables migratory birds access to roots and tubers of mature plants and shoots of new plants.
- Reduces competing growth of marshhay cordgrass and other dominant climax plant communities, allowing for the growth of subdominant plant species, many of which are preferred foods of ducks and geese.
- Creates open water which provide loafing spots for birds and allow them to access aquatic invertebrates.
- Compliments marsh burning by prolonging the time that browse is available for goose use.
- Improves plant vigor, increases plant productivity, speeds nutrient recycling, and prevents excessive build-up of residual plant material.
- Reduces the amount of hazardous fuel loading, reducing the amount and intensity of wildfires.
- Breaks up capped soils through hoof action, which assists in seedling establishment.

- Maintains regrowth of vegetation in recently burned areas in more palatable stages for wintering waterfowl.

- Provides a reliable disturbance tool that is not as dependent on favorable weather and fuel conditions as prescribed fire.

Although grazing operations on private lands in the project area often provide enhanced wetland habitats for waterfowl and other migratory birds, they are not always compatible with maintaining the overall diversity of the region's native plant and animal communities. Typically, marsh pastures used during the cool season on private lands are grazed year after year. Upland pastures are often used year-round. Overall plant species diversity in both wetland and upland habitats will decrease over time in areas which are heavily grazed year after year. On areas used for summer pasture that include fallowed rice, wet prairies or fresh marsh, heavy grazing limits the production of seeds of annual grasses such as the millets and sprangletop. Inhibiting seed production decreases the amount of vital food sources available in these habitats for waterfowl the following fall and winter. Native plant species diversity, productivity and reproduction in remnant native prairie habitats are also reduced by perennial heavy grazing. In areas which are repeatedly overgrazed, potential detrimental impacts include excessive trampling of vegetation, compaction of soils, reduction of percolation rates, increased soil erosion, and reduced water quality from fecal coliform bacteria and excessive nutrients.

(c). Exotic/Invasive Species Management

Many private landowners in the project area actively control exotic/invasive plant species, particularly Chinese tallow, primarily to improve range conditions for livestock. A broad array of pesticides is used in support of rice farming operations to control various agricultural pests including noxious weeds, insects and fungal diseases.

Typically, broad spectrum herbicides and mechanical removal are used for Chinese tallow control on private lands. Aerial application is used for most pesticide applications on rice and for control operations on larger stands of Chinese tallow. While control of Chinese tallow enhances grassland habitats, wide-scale use of broad spectrum herbicides in the project area has contributed to loss of native plant species diversity.

Feral pigs occur in substantial numbers throughout the project area. Rooting and wallowing by feral hogs cause significant habitat and infrastructure damage. These soil disturbances in marsh and upland sites allow invasive plants to establish and reduce the value of the habitats to wildlife. Feral pigs are particularly damaging to water management infrastructure. They wallow and root extensively on levees and within rice fields and moist soil units effecting the management of thousands of acres of habitat. Feral hogs are prolific and are able to exploit wetland and upland habitats. Hunting and trapping of feral hogs would continue to occur on private lands in the project area. Effectiveness in controlling populations and reducing impacts to native vegetation and habitats would depend on the intensity of removal operations.

(d). Shoreline Protection and Restoration

As previously discussed, erosion along the Gulf of Mexico and Galveston Bay shorelines is a major issue in the project area. It is likely that most private landowners in the project area will not engage in significant efforts to restore or protect shorelines due to lack of economic incentives.

(e). Mowing and Haying

Many privately-owned pastures (improved and natural) in the project area are hayed. Haying results in invigorating growth of grasses, while reducing vigor of undesirable herbaceous weeds and woody plants including Chinese tallow and Eastern baccharis.

5. Impacts to Fish and Wildlife Resources

Under Refuge Boundary Expansion Alternative A, land management practices on private lands described in *Impacts on Vegetation and Habitats* would continue to impact the following important fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians
- Invertebrates

Some landowners in the project area are intensively and very successfully managing properties to enhance habitats for wintering waterfowl, and many agricultural practices provide substantial benefits to waterfowl and other migratory birds. In general, however, economic considerations other than fish and wildlife benefits dictate land uses and land management practices on private lands in the project area. This would continue under Refuge Boundary Expansion Alternative A.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Coastal habitats in Texas are part of the southern terminus in the U.S. for most of the ducks and geese in the Central Flyway. The 2004 mid-winter waterfowl survey indicated that 7,901,489 waterfowl used the Central Flyway. Of those birds, 5,110,022 waterfowl (65%) wintered in Texas. Available wintering waterfowl habitat in Texas is shrinking due to changes in agricultural uses, industrial and urban development, increased pollutants (Cain 1988), land subsidence, rising sea levels, and man-made hydrological changes such as canals resulting in saltwater intrusion (Michot 1996). Loss or degradation of habitat on landscape scale increases the importance of public and private lands managed specifically for supporting wintering and migrating waterfowl.

Since the mid-1950s to the early 1990s, approximately 211,000 acres of wetlands were lost on the Texas Gulf coast, to both natural and man-made causes (Moulton *et al*.1997), with most of the palustrine wetland lost to agriculture (in recent years agricultural lands have decreased by urban development). Palustrine emergent marshes showed the largest decline, primarily by conversion to upland agriculture and other uses; and most estuarine wetlands loss was due to land subsidence. Tacha *et al*. (1992) concluded that between 1976 and 1991 the total ducks in the Chenier Plain of Texas declined by 89%, and these decreases were highly correlated with losses and degradation of wetland habitat.[18] Wintering and migrating waterfowl along the Texas Coast tend to prefer freshwater coastal marshes and freshwater prairie wetlands. Rice agriculture provided an especially valuable habitat for wintering waterfowl.

Under Refuge Boundary Expansion A, the following land uses and management practices on private lands would have the greatest impacts on waterfowl populations.

18 During the 1969 through 1994 period, the Louisiana coastline experienced major wetland losses, similar to the Texas coast. However, there appears to have been no declines in duck populations of coastal Louisiana marshes between 1969 and 1994 (Michot, 1996).

(a). Wetlands Management and Restoration

Under Refuge Boundary Expansion Alternative A, some privately-owned marshes would continue to be structurally managed to improve habitat for wintering and migrating waterfowl, utilizing water control structures, levees, and water delivery systems. Marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl. For example, structural management of brackish and intermediate marshes may directly increase the abundance of preferred plant species, such as Olney bulrush and widgeongrass, which provide food resources for wintering and migrating waterfowl (Chabreck 1976, Broome *et al.* 1995). Management of water levels would also provide optimal conditions for foraging and resting waterfowl.

A small number of landowners would continue to use moist soil management to provide habitat for wintering and migrating waterfowl. Moist soil management provides optimal conditions for germination and growth of preferred waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia.

Under Refuge Boundary Expansion A, rice farming operations in the project area which are concurrently managed for waterfowl would continue to provide important freshwater wetland habitat and high quality food resources for wintering and migrating waterfowl. Fall and winter flooding of fallow rice fields would also provide weeds and seed that are heavily utilized by waterfowl.

Rice production in the project area has declined significantly in recent years, and only a relatively small amount of base acreage currently in the USDA farm program is being actively farmed. Former rice fields are either left fallow or are being converted to improved pasture. Much of this acreage is supporting livestock operations. Permanently fallowed rice fields which are not being managed for grazing are rapidly being invaded by Chinese tallow and deep-rooted sedge. These exotic plant species are so invasive that they quickly replace native plants and provide few benefits for wildlife. The decline in rice production in the project area has significantly reduced the amount of farmed wetland acreage available to waterfowl and other migratory birds. It has undoubtedly contributed to reduced numbers of waterfowl wintering in the area. Any future declines in rice production would further exacerbate these impacts.

On properties in the project area being managed for livestock grazing as a primary economic use, marshes and flooded rice fields and moist soil impoundments are usually drained immediately following the hunting season. This is done to increase availability of forage for livestock and increase the amount of dry ground available for calving. These wetland habitats are typically “drawn down” as quickly as possible beginning in late January. This practice reduces wetland habitat available during late winter and spring for migrating waterfowl and other migratory birds.

Utilization of broad spectrum herbicides and pesticides in rice farming and pasture management in the project area may reduce abundance and diversity of invertebrates important as a food sources for waterfowl and other migratory birds.

(b). General Habitat Management and Restoration Activities

The integrated combination of burning, livestock grazing and water management in wetland habitats on private lands being managed specifically for waterfowl in the project area would continue to provide optimum habitat conditions for wintering waterfowl and many additional migratory bird species. Burning and grazing promote the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al.* 1979). Burning and moderate grazing also results in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al*. 1979). Target plant communities in intermediate and brackish marsh habitats on the Refuge Complex include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Burning and grazing also help provide optimal physical structure of vegetation for waterfowl utilization of emergent marshes and other vegetated

wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds. Control of Chinese tallow and deep-rooted sedge in and adjacent to freshwater marshes, moist soil units and rice fields also enhances waterfowl habitat.

On a year to year basis, overall habitat quality for waterfowl in the project area will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers can also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Mottled Ducks are year-round residents of the Chenier Plain region. This species prefers fresh to slightly brackish marshes (Gosselink *et al*.1979); although a variety of marsh habitats, prairie, and agricultural wetlands (rice fields) are also utilized. Mottled Ducks in the project area are part of the western Gulf Coast population of Mottled Ducks. Banding studies have indicated that WGC Mottled Ducks do move between Mexico, Texas, Louisiana and Mississippi and Alabama, but no interchange occurs between this population and the Florida population of Mottled Ducks.

Mottled Duck numbers on national wildlife refuges on the Texas Coast have declined precipitously during the last 20 years, as indexed by annual breeding pair surveys and monthly aerial counts conducted September through March (USFWS, Division of Migratory Birds, unpublished reports). Stutzenbaker (1988) reported that the most serious threat facing Mottled Ducks is degradation and loss of habitat. In Texas, factors contributing to loss of habitat include conversion of native habitats for agricultural and urbanization, drainage, marsh subsidence, saltwater intrusion, spread of introduced species (Stutzenbaker 1988, Morton and Paine 1990), as well as increased pollutants (Cain 1988). Saltwater intrusion into wetlands that range from fresh to moderately brackish probably affects growth and survival of ducklings (Moorman *et al.* 1991). Encroachment of Chinese tallow into nesting habitat probably leads to abandonment of nesting areas (Stutzenbaker 1988). Other potential factors influencing Mottled Duck populations include extended periods of drought, mortality from predation due to increasing populations of alligators and possible increases in mammalian predators, a continued high incidence of lead pellet ingestion, and harvest (USFWS Division of Migratory Birds, unpublished reports).

Under Refuge Boundary Expansion Alternative A, the following would continue to be the primary land management activities on private lands impacting Mottled Ducks in the project area. The landscape level issues described above are likely to control population dynamics of the Western Gulf Coast Mottled Duck population.

(a). Wetlands Management and Restoration

Wetland management activities on private lands in the project area being managed for waterfowl would enhance habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Managing water levels and salinities in managed coastal marsh units would maintain fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. Marsh management also would enhance diversity and productivity of submerged aquatic vegetation which provides important year-round food sources for this species. Rice farming and moist soil management would continue to provide critical shallow freshwater habitat and nutritious food resources for use by Mottled Ducks year-round.

On properties in the project area being managed for livestock grazing as a primary economic use, marshes and flooded rice fields and moist soil impoundments are usually drained immediately following the hunting season. This is done to increase availability of forage for livestock and increase the amount

of dry ground available for calving. These wetland habitats are typically "drawn down" as quickly as possible beginning in late January. This practice reduces wetland habitat available for Mottled Duck nesting and brood-rearing during late winter, spring and summer.

(b). Uplands Management and Restoration

The historical prairie-wetland continuum of the upper Texas coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and mima mounds that are characteristic of coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as "sennabean ponds," as valuable brood rearing habitat. Conversion of most native coastal prairie habitats to agricultural uses in the project area has removed these habitat features.

Some agricultural practices on privately-owned uplands within the project area undertaken to improve forage conditions for cattle may also benefit Mottled Ducks. Controlling brush encroachment in grasslands using burning, livestock grazing, herbicide application and mowing/haying in salty and non-saline prairies (and on levees and along fence lines) would be expected to improve nesting success of Mottled Ducks.

Conversion of fallowed rice fields and other grassland habitats to "improved pasture" and invasion of Chinese tallow and other exotic plants in unmanaged fallowed rice fields would likely have negative impacts on Mottled Ducks by reducing suitable nesting habitat.

(c). General Habitat Management Activities

The integrated combination of burning, livestock grazing and water management in wetland habitats on private lands being managed specifically for waterfowl in the project area which provide optimum habitat conditions for wintering waterfowl also benefit Mottled Ducks during all phases of their life cycle. Burning and grazing promote the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al*. 1979). Burning and grazing also help provide optimal physical structure of vegetation for waterfowl utilization of emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for Mottled Ducks and other migratory birds. Control of Chinese tallow on private lands in and adjacent to freshwater marshes, moist soil units and rice fields also enhances habitat values for Mottled Ducks.

Agricultural management practices also have the potential to negatively impact Mottled Ducks in the project area. For example, burning may result in the excessive removal of vegetation reducing suitability as Mottled Duck nesting habitat, and burning at the wrong time of year could destroy nests (Baker 1983). Salt prairies occur as a broad zone between coastal prairies and marshes, and commonly as a ridge between marshes and bays or the Gulf of Mexico. Higher, well drained, salt prairie ridges juxtaposed with lower wetland areas have been identified as important Mottled Duck nesting areas in the Chenier Plain region of Louisiana (Baker 1983) and Texas (Stutzenbaker 1988). These cordgrass ridges are dominated by gulf cordgrass with marshhay cordgrass, knotroot bristlegrass (*Setaria parviflora*) and some brush species typically subdominant. Baker (1983) found that salt prairie invaded with Sesbania (*Sesbania* spp.) and Baccharis (*Baccharis halimifolia*) were avoided by nesting Mottled Ducks. Burned areas appeared to be undesirable for nesting to three years post-fire. Vegetation heights were comparable to unburned areas by the second year post-fire, but residual senesced vegetation remained low. Fire is necessary in the management of Mottled Duck nesting habitat. Fire must be frequent enough to keep brush at low densities, but infrequent enough to maximize years with dense nesting cover for Mottled Ducks. Annual burning of salt prairies would reduce nesting habitat. Overgrazing by cattle may

reduce desirable nesting habitat in marshes and salty prairies, especially after spring burns (Baker 1983, Stutzenbaker 1988).

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because the category of shorebirds, wading birds, and other marsh and waterbirds consists of a wide variety of species, individual species use microhabitats (e.g., vegetative cover and water depth) differently than other species in the same category (Gosselink *et al*. 1979, Skagen *et al.* 1999). For example, bare to sparse vegetative cover for foraging is preferred by species such as Piping Plover and the Least Tern. Denser vegetation is preferred by other species, for example Little Blue Heron, Black-crowned Night Heron, Yellow-crowned Night Heron, Least Bittern, American Bittern, King Rail, and Clapper Rail. Other species have broad vegetation density requirements, and can utilize areas ranging from relatively bare of vegetation to dense vegetation, for example Reddish Egret and Wood Stork.

This category of avian species also varies greatly in the amount of soil moisture and water depths they prefer, usually for feeding activities. These requirements range from relatively dry or shallow water (a few centimeters deep), such as the Piping Plover, to slightly deeper (but still relatively shallow) water, such as the Western Sandpiper and Least Sandpiper, to waters about 8-12 cm deep, such as the Black-bellied Plover and Willet. Other species prefer deeper waters, often within wading depth for long legged birds, such as the White-faced Ibis (State-listed Threatened) and the Least Tern. Some species can utilize deep waters as well as shallower waters (Wilson's Phalarope, Red-necked Phalarope, Olivaceous Cormorant, Double-breasted Cormorant, Laughing Gull, and Forster's Tern). Some species are year-round residents, such as Brown Pelican (Federally listed Endangered), Double-breasted Cormorant, Great Blue Heron, Little Blue heron, Great Egret, and Black Skimmer. Other species are mostly migrant, including Wood Stork, White Ibis, and Forster's Tern.

(a). Wetlands Management and Restoration

Marsh habitats actively managed for waterfowl on some private lands in the project area (utilizing water control structures, levees, impoundments, etc.) include a wide variety of habitat types used by shorebirds, wading birds and marsh and waterbirds. In general, shorebirds and wading birds would also continue to benefit from rice farming and moist soil management on private lands. Both provide shallow freshwater wetland habitat, which provide invertebrates and plants that are a preferred food source (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002). The timing and depth of flooding on managed agricultural fields would influence the type of and intensity of use by such birds (Huner *et al*. 2002).

On properties in the project area being managed for livestock grazing as a primary economic use, marshes and flooded rice fields and moist soil impoundments are usually drained immediately following the hunting season. This is done to increase availability of forage for livestock and increase the amount of dry ground available for calving. These wetland habitats are typically "drawn down" as quickly as possible beginning in late January. This practice reduces wetland habitat available for migrating shorebirds and other wetland-dependent avian species during spring and summer.

(b) Uplands Management

Some agricultural practices on privately-owned uplands within the project area undertaken to improve forage conditions for cattle may also benefit some shorebirds. For example, heavily grazed wetter prairies are used by Golden Plovers and Black-necked Stilts. Conversion of fallowed rice fields and other grassland habitats to "improved pasture" and invasion by Chinese tallow and other exotic plants in unmanaged fallowed rice fields would likely have negative impacts on shorebirds by reducing suitable nesting, migration and wintering habitat.

(c). General Land Management Activities

The integrated combination of burning, livestock grazing and water management in wetland habitats on private lands being managed specifically for waterfowl in the project area also benefit shorebirds, wading birds and other marsh and waterbirds. Water management activities in coastal marshes which maximize the annual production of submerged aquatic plant species provide improved habitat for invertebrates and small vertebrates, which are the primary prey items for many shorebird, wading bird and marsh bird species. Prescribed burning and controlled livestock grazing help create optimal physical structure of vegetation for shorebirds and wading birds in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions also provide excellent habitat for many invertebrate species, another important food source for shorebirds. Exotic and invasive plant and animal control activities would also enhance wetland and upland habitats for these species

Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (*Coturnicops noveboracensis*, Mizell 1998), sparrows (*Emberizidae*) and wrens (*Troglodytidae*) (Gabrey *et al*. 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et al*. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al*. 2000). Not surprisingly, these secretive marshland bird species decline in the first year post-fire. Other bird species such as Icterids (Gabrey *et al*. 2001) and Wilson's Snipe (*Gallinago delicate*), (USFWS unpublished data) increase immediately post-burn.

The susceptibility of wildlife to mortality during fire events seems to be dependent on weather, fuel characteristics (moisture, loading and continuity), fire characteristics (as influenced by ignition strategies), and the capability and behavior of the species in question. Black rail mortality has been observed where large areas are burned with little unburned escape cover available, while mortality was not observed in a burn containing a mosaic of unburned escape cover (Legare *et al*. 1998). No fire induced mortality was observed for three species of rails during fire operations on the Texas Mid-Coast, though data were insufficient to draw strong conclusions (Grace *et al*. 2005). Burns conducted under fuel and weather conditions that allow for patches of unburned habitat within the unit may minimize wildlife mortality. Burns ignited in a way that maximizes escape options, primarily through the use of backing and widely spaced strip flanking fires, probably minimizes wildlife mortality while maintaining fire-dependent habitat. Ignition methods and patterns for agricultural burning in the project area likely are not influenced by issues such as potential wildlife mortality.

Other land uses and land management activities in the project area could negatively impact some species of shorebirds, wading birds, marsh and water birds, dependent on intensity and timing. Grazing could negatively impact some ground-nesting species such as Black-necked Stilts by trampling nests and grazing on emergent pond vegetation used by those birds, and may also disturb nesting pairs (Whyte and Cain 1979).

Utilization of broad spectrum herbicides and pesticides in pasture management and rice farming in the project area may reduce abundance and diversity of invertebrates, an important food source for shorebirds and wading birds.

(4). Impacts to Landbirds

Landbird species found in the project area require a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf coast (Mueller 1981, Barrow *et al*. 2000). Some raptor species prefer intermingled field and forested areas (e.g., red-tailed hawks and owls). Other land bird species prefer grassland habitats including marshes and prairies (Peterson *et al*. 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other wildlife species.

(a). Wetlands Management and Restoration

Water management activities on private lands in the project area aimed at enhancing habitats for wintering waterfowl in coastal marshes would continue to indirectly benefit several landbird species which utilize these habitats.

(b). Uplands Management and Restoration

Some agricultural practices on privately-owned uplands within the project area undertaken to improve forage conditions for cattle may also benefit some landbird species. Controlling brush encroachment to enhance grasslands using burning, livestock grazing, herbicide application and mowing/haying in salty and non-saline prairies (and on levees and along fence lines) would benefit certain species of grassland songbirds.

Conversion of fallowed rice fields and other grassland habitats to "improved pasture" and invasion by Chinese tallow and other exotic plants in unmanaged fallowed rice fields would likely have negative impacts on grassland songbirds by reducing suitable nesting, migration and wintering habitat.

Coastal woodlots and near-coastal bottomland forests support a diverse avian community, which includes several species of neotropical migratory birds. Coastal woodlots and bottomland forests found on private lands in the project area are typically part of the overall land area used for livestock grazing. Coastal woodlots are typically found on higher elevation sites, and cattle will typically congregate on these sites for shade. Grazing typically reduces or eliminates understory shrubs and may preclude natural reproduction of woody plant species. Where this occurs, habitat quality for migrating and resident landbirds is negatively impacted.

(c). General Habitat Management Activities

The integrated combination of burning, grazing and water management occurring on some private lands in the project area to provide optimal habitat conditions for waterfowl also enhances wetland and upland habitats used by many land bird species. Chinese tallow control would also enhance wetland and upland habitats for these species, especially in grassland and coastal woodlot habitats.

Seaside sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al*. (2001) reported that breeding seaside sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested.

Gabrey *et al*. (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (1995) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife.

Heavy grazing could adversely affect some ground-nesting birds by reducing suitable nesting habitat, trampling and by disturbing nesting pairs (Whyte and Cain 1979). Utilization of broad spectrum herbicides and pesticides in pasture management and rice farming in the project area may reduce abundance and diversity of invertebrates, an important food source for many land bird species.

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al.* 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al*. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al.* 1990, Kneib 1991, Rozas 1995).

Some private landowners in the project area utilize structural marsh management to reduce saltwater intrusion which negatively impacts livestock and rice farming operations and to enhance habitat quality for waterfowl. Burning, grazing, and Chinese tallow control on private lands also enhance estuarine wetlands, and help create wetland habitat diversity and productivity important to a variety of fish and shellfish species.

Managing water levels and salinities (e.g., using water control structures, levees, impoundments, etc.) in managed marsh units may restrict access of some finfish and invertebrate fisheries species to managed areas. Actively managing water levels may impede access for some aquatic organisms, such as fish and crustaceans (Rogers *et al.* 1992, Kuhn *et al.* 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a natural stable or deteriorating deltaic marsh (Peterson *et al*.1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown.

(6). Impacts to Threatened and Endangered Species

Three Federally-listed Threatened or Endangered avian species occur in the project area: Bald Eagle, Piping Plover, and Brown Pelican. Water management activities on private lands in the project area aimed at enhancing habitats for wintering waterfowl in coastal marshes would continue to indirectly benefit these avian T&E species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found in the project area include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species on the Refuge Complex. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic animals.

In general, land uses and management practices on private lands which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of mammal species.

Land uses on private lands which create or maintain freshwater wetland habitats (structural management of marshes, rice farming, and moist soil management) are particularly beneficial to amphibians and reptiles. Reliable freshwater habitat is critical for most amphibian and reptiles, including frogs,

salamanders, aquatic snakes (e.g., western cottonmouth), turtles, and alligators. Habitat conditions which increase the abundance of insects, crustaceans, and other small prey benefit most species of amphibians and reptiles during at least a portion of their lifecycle. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas.

Many landowners in the project area control coyote populations as a means of reducing losses of domestic livestock. Control of exotic and/or invasive woody species in wetland and upland habitats may decrease habitat quality for certain mammals such as raccoon and striped skunk. Overgrazing by livestock can destroy swamp rabbit and cottontail rabbit habitat (Gosselink *et al*. 1979). Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, reptiles, and invertebrates.

Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et al*. 1989) summarizes by saying "Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil litter stabilize." Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data).

B. Socioeconomics Resource Section

The socioeconomic impacts for Refuge Boundary Expansion Alternative A (No Action) are the same as the socioeconomic impacts analyzed for Refuge Management Alternative D, the Preferred Alternative, in Part A. of this Chapter. This is because they both address the present set of conditions at the Refuge Complex and in the project area. The Refuge Complex would remain the same size as present, as no refuge boundary expansion would occur under this Alternative, and the management strategies from Refuge Management Alternative D (Preferred Alternative) would be implemented on the existing refuges. **For socioeconomic impact analysis information, please refer to Refuge Management Alternative D (Preferred Alternative) in the set of Refuge Management Alternatives in Part A of this Chapter. For comparative purposes, socioeconomic impacts under Refuge Boundary Expansion Alternative A (No Action) are compared to those under Refuge Boundary Expansion Alternatives B, C and D in Section II of Part B of this chapter, beginning on the following page.**

II. IMPACT ANALYSIS FOR REFUGE BOUNDARY EXPANSION ALTERNATIVES B, C, AND D

Overview

Refuge Boundary Expansion Alternatives B, C, and D would establish new boundaries for the Moody, Anahuac, McFaddin, and Texas Point NWRs. The USFWS would then be authorized to purchase lands, or interests in lands such as conservation easements, from private landowners within the newly established refuge boundaries. Lands would be acquired from private landowners only on a willing-seller basis and at fair market value, subject to availability of funds. Lands so acquired would become part of the National Wildlife Refuge System, and refuge management programs to be implemented on the existing refuges (as described under Refuge Management Alternative D) would also be implemented on newly acquired lands.

Management of newly acquired lands would be focused specifically on meeting the establishment purpose(s) of the refuges and the mission of the National Wildlife Refuge System. All lands becoming part of the National Wildlife Refuge System would remain undeveloped in perpetuity. Management programs on newly acquired lands would include habitat management and restoration activities in coastal wetlands, prairies and woodlands which emphasize conservation and management of migratory birds, consistent with restoring and maintaining biological integrity and biological diversity. Habitat management activities in wetland habitats would include managing water levels and salinities in coastal marshes and moist soil management to restore shallow freshwater wetlands. Management of uplands would focus on restoration of native coastal prairie and increasing native plant species diversity in coastal woodlots. Economic uses which serve as important management tools in meeting conservation objectives, such as rice farming and livestock grazing, would also be used. A cooperative rice farming program would use fall and winter flooding of second crop rice and first- year fallow fields to provide high quality habitat for migrating and wintering waterfowl, shorebirds and other migratory birds. Grazing would employ techniques such as grazing unit rotations, prescribed stocking levels, and timing and duration of use.

The USFWS would also focus on addressing threats to coastal habitats and fish and wildlife resources on newly acquired lands posed by relative sea level rise, altered hydrological regimes, exotic/invasive plants and animals, and environmental contaminants. Increased coordination with local, State and Federal agencies would be aimed at implementing major coastal habitat restoration projects. An integrated pest management program would be used to manage exotic/invasive plants and animals, with an overall goal of reducing use of chemical herbicides and pesticides over time. Management of oil and gas exploration and development activities would focus on minimizing impacts to habitats and fish and wildlife, including implementing strict pollution controls. Expanded field surveys and scientific monitoring and research would support an adaptive approach for conservation of native habitats and fish and wildlife resources.

Recreational and educational public uses of newly acquired lands would include the National Wildlife Refuge System's six priority wildlife-dependent uses: hunting, fishing, wildlife observation and photography, environmental education and interpretation. Development of visitor facilities similar to those found on the Refuge Complex would occur and could include trails, boardwalks and observation decks, fishing piers, boat ramps and photography blinds. The USFWS would also continue and expand outreach efforts and development of community-based partnerships.

Refuge Boundary Expansion Alternative B includes approximately 22,479 acres of coastal wetlands (primarily estuarine marshes) and 9,233 acres of upland habitats. Refuge Boundary Expansion Alternative C includes 29,308 acres of coastal wetlands (primarily estuarine and palustrine marshes) and 32,197 acres of upland habitats, including significant acreage of native coastal prairie. Refuge Boundary Expansion Alternative D includes 40,600 acres of coastal wetlands, including palustrine forested wetlands (bottomland hardwoods), and 55,617 acres of upland habitats.

A. Natural Resources Section

1. Impacts to Air Quality

The USFWS fire management program has the greatest potential of all refuge management activities to impact the region's air quality. Fire management activities on any newly acquired lands under Refuge Boundary Expansion Alternatives B, C and D would include both the suppression of unplanned wildland fires and prescribed burning.

Suppression of wildland fires on newly acquired lands would continue as prescribed in the USFWS Texas Chenier Plain Refuge Complex Fire Management Plan (USFWS 2001). Suppression involves utilization of "Appropriate Management Response" to each wildland fire, ranging from direct attack to monitoring. Decisions regarding suppression options and tactics consider firefighter and public safety, protection of private or publicly-owned structures and other infrastructure, and protection of natural and cultural resources. Reducing smoke impacts to surrounding communities is also an important consideration in planning and implementing suppression actions on all wildland fires occurring on Refuge lands.

The USFWS would use prescribed burning on newly acquired lands primarily to maintain and improve habitat for wintering and migrating waterfowl and other migratory birds and to reduce accumulations of hazardous fuels. Most burning would be conducted in emergent marsh habitats from September to late November, in order to maximize the benefits of integrated burning/grazing/water management programs and strictly adhere to management prescriptions. Limited prescribed burning during summer would be conducted if needed to control invasive woody vegetation. Prescribed burning in upland prairie habitats would occur primarily during late winter and early spring, with summer burns conducted as needed to control woody vegetation. Annual burning may occur in newly acquired areas initially if needed to control brush, however, burning frequency on prairies would be reduced over the long-term as grasslands are restored.

Although prescribed burning conducted by the USFWS would continue to be beneficial to habitats and wildlife (as discussed under *Section II.A.4.* and *II.A.5* below); this management action could also negatively impact local air quality, primarily through the production of smoke. Smoke from unplanned wildland fires and from planned prescribed burning could be transported by prevailing winds and affect air quality and transportation safety over a large area which includes the cities of Houston, Beaumont and Port Arthur and numerous smaller local communities. However, because prescribed burning is conducted by the USFWS under strict prescriptions which include implementing smoke management measures, impacts to local and regional air quality will be minimal. Prescription parameters which must be met prior to ignition and for the predicted duration of a prescribed burn include surface and transport wind direction and speed, mixing height, ambient air temperature and humidity, and fuel moisture. Both current and predicted climatic conditions are considered when deciding whether to proceed with a prescribed burn, and these conditions are regularly monitored for the duration of the burn as a further safeguard.

Prescribed burning by the USFWS under these controlled conditions would also reduce the potential for smoke impacts to air quality from unplanned wildland fires by effectively managing vegetative fuels. Most lightning-cause wildland fires on the Refuge Complex occur during the months of June through October, when prevailing winds typically include a southerly component which transports smoke towards communities and other smoke-sensitive areas. Wildland fires are less likely to start in areas with reduced fuel loads because of prescribed burning, and fires that do start burn with less intensity, produce less smoke, and are easier to suppress than in unburned areas with excessive accumulations of hazardous fuels.

2. Impacts to Geology and Soils

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the

western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water. In addition to ongoing impacts, relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps suggests that current projections of relative sea level rise related to global climate change are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

Although shoreline erosion and retreat and along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has accelerated rates of shoreline retreat along the Gulf shoreline. This reduced sand supply has led to loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges.

Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels have caused erosional loss of organic marsh soils, also leading to conversion of vegetated marshes to open water. Conversion of vegetated marshes to open water has also occurred throughout the region in areas where rapid land subsidence has resulted in submergence of wetlands. Conversion of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et al*. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). It is likely that conversion of vegetated marshes to open water have been greatest in areas subject to both saltwater intrusion and rapid subsidence.

Under Refuge Expansion Alternatives B, C and D, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss on newly acquired lands. On McFaddin NWR and Texas Point NWRs, these partnerships would continue to focus on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Coordination with other agencies and conservation organizations would be expanded, with a goal of implementing a major project to restore the entire barrier beach/dune system on McFaddin NWR. Major structural erosion abatement projects would also been implemented, including breakwater construction along the GIWW and East Galveston Bay shorelines.

Restoration of the barrier beach/dune system on McFaddin NWR and increased use of dredged material on Texas Point NWR would contribute to increasing coarse sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994). If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and additional beneficial use of dredge material projects

on Texas Point NWR could substantially reduce current rates of land loss. These projects would also restore historic elevations along the shoreline and protect inland marshes, and plant productivity therein, by reducing saltwater intrusion. Offshore rock breakwaters and shoreline armoring would also reduce the erosion of shoreline. Restoring emergent marsh by planting smooth cordgrass along shorelines will reduce land loss and increase sedimentation and vertical accretion within vegetation stands.

Other USFWS management activities on newly acquired lands Refuge Boundary Expansion Alternatives B, C and D would also impact soils and soil formation. Structural marsh management techniques, such as weirs and impoundments, may affect marsh vertical accretion (Nyman *et al.* 1993). In a survey in Louisiana regarding the effects of weir management on marsh loss, Nyman *et al.* (1993) concluded that weirs did not affect marsh loss or accretion, but that weirs may have different effects under different hydrological conditions, and that the effects of herbivore activity (muskrats) were important. Bryant and Chabreck (1998) found three structurally managed marshes in the Chenier Plain of Louisiana had significantly lower accretion than adjacent unmanaged marshes, while the fourth managed marsh had higher accretion than the adjacent unmanaged marsh. The managed marsh with higher accretion rates remained permanently flooded, while the three managed marshes with lower accretion underwent frequent drainage. It was hypothesized that structurally managed marshes are hydrologically isolated from tidal sediment subsidies and that frequent forced drying oxidized organic material in the soil. Gabrey and Afton (2001) found that belowground biomass was higher in unimpounded than impounded marshes. Perez and Cahoon (2005) did not find any difference in marsh accretion between structurally managed marshes on McFaddin NWR and adjacent unmanaged marsh.

Conversion of coastal marshes to open water is often associated with plant stresses such as salt water intrusion and soil waterlogging (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al*. 1983, Nyman *et al*. 1993, DeLaune and Pezeshki 2003). Excessive flooding and salt water intrusion can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Marsh accretion in the Chenier Plain region's fresher marshes is very dependent on the accumulation of organic matter, as opposed to mineral sediment deposition which is very important in the deltaic marshes of southeastern Louisiana. USFWS water management activities in fresh to brackish coastal marshes on newly acquired lands would reduce saltwater intrusion and prevent excessive and artificially-prolonged inundation or excessive drainage and drying. These management activities therefore would benefit soil formation and vertical accretion by increasing plant productivity and preventing oxidation of marsh soils.

Prescribed burning on newly acquired lands could also affect soils and vertical accretion in marshes. Insufficient data exists to adequately address the effects of fire on marsh accretion. Evidence exists suggesting root mass is a significant contributor to vertical accretion via peat formation (DeLaune *et al.* 1983, Nyman *et al.* 1993). In a study on the McFaddin NWR, both root volume and sediment elevation recovered faster in a burned area relative to an unburned area after salt water flooding (M. Ford and D. Cahoon, unpubl. data). Gabrey and Afton (2001) found that unburned and cover-burned Chenier plain marshes showed no differences in belowground biomass. Fire has been shown to increase primary productivity in some Gulf coast marshes (Hackney and Cruz 1981, Gabrey and Afton 2001). While these studies examined the effects of cover burns (burns conducted when sufficient water is present in the marsh to restrict biomass consumption to aerial plant material), root and peat burns can have a profound impact on marsh accretion. Root fires consume the litter layer and shallow root systems, while peat fires burn deeper into the soil consuming available organic matter (Lynch 1941). In most situations, root and peat fires are avoided by carefully monitoring water levels and soil moisture. Nyman and Chabreck (1995) concluded that fire should be used with caution until its effects on marsh accretion is better understood.

The USFWS would also coordinate and support expanded monitoring and scientific research to determine impacts of shoreline and marsh restoration efforts and the effects of habitat management activities such as structural marsh management and prescribed burning on marsh soils and vertical accretion. This would lead to a greater understanding of how to reduce the impacts of ongoing and future

relative sea level rise and altered hydrological regimes. For example, monitoring and research would help ensure that structural marsh management and prescribed burning programs are being conducted in a way to maximize marsh accretion while meeting short-term habitat objectives.

3. Impacts to Hydrology and Water Quality

a. Hydrology

The Chenier Plain region's coastal marshes were historically influenced by high annual precipitation and substantial freshwater riverine inflows, creating a continuum of coastal estuarine marsh types associated with a natural salinity gradient, from fresh to saline. Fresh and intermediate marshes formed a substantial component of this continuum. The natural hydrologic regimes of the coastal marshes in the region, and on the Refuge Complex, have been greatly modified by the construction of the GIWW and numerous smaller canals and ditches, upstream dams and reservoirs, roads, levees and impoundments, and by the deepening and channeling of most natural waterways and other inland drainage improvements. The hydrological consequences of these activities include saltwater intrusion, reduced or restricted freshwater and nutrient/sediment inflows, and altered hydroperiods (wetting and drying cycles). Hydrological changes in turn have impacted natural biological diversity and in some cases contributed to a net loss of estuarine wetlands (Moulton *et al*. 1997).

Conversion of vegetated marshes to open water has occurred throughout the Chenier Plain region in areas where increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation channels has caused erosional loss of organic marsh soils.

As discussed in *Section 4.B.2* above, salt water intrusion and soil waterlogging has been associated with peat collapse and subsequent conversion of coastal marsh to open water (DeLaune *et al*. 1994). Naidoo *et al*. (1992) found marshhay cordgrass, a common intermediate and brackish marsh species, suffered from low root production and leaf elongation rates under waterlogged soils. Work conducted by Nyman *et al*. (1995b) indicate that marshhay cordgrass has higher root production at lower salinity levels. Root production may partially contribute to vertical accretion via peat accumulation (DeLaune *et al.* 1983, Nyman *et al.* 1993). Excessive flooding, salt water intrusion, and sulfide stress can lead to poor plant vigor and root production which in turn can reduce vertical accretion and exasperate flooding, further reducing plant vigor. Loss of emergent marsh to open water has been blamed on the synergistic effects of rapid land subsidence as well as salt water intrusion and soil waterlogging (Nyman *et al*. 1993). In some areas, rapid land subsidence caused by underground fluid withdrawals has resulted in submergence of wetlands, also leading to conversion of vegetated marshes to open water (White and Tremblay 1995). Land subsidence occurs naturally as geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995, Morton *et al*. 2001). It is likely that conversion of vegetated marshes to open water have been greatest in areas subject to both saltwater intrusion and rapid subsidence.

In addition to ongoing impacts, relative sea level rise and altered hydrological regimes pose a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is a rise of 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps suggests that current projections of relative sea level rise related to global climate change are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise. Increased saltwater intrusion and loss of freshwater and sediment/nutrient inflows may limit the ability of the marshes in the Chenier Plain region to accrete vertically by reducing plant productivity. Below-ground plant productivity is perhaps the primary soil building mechanism in the region's fresh and intermediate marshes (Nyman *et al*. 1993).

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would conduct wetland management and restoration activities on newly acquired lands aimed at minimizing or mitigating impacts of altered hydrological regimes on plant, fish and wildlife resources. These would include structural marsh management, moist soil management, a cooperative rice farming program, and restoration of coastal wetlands. Water management activities in marsh habitats would include water level and salinity management and establishment of freshwater inflows using management infrastructure comprised of water control structures, levees, and water delivery systems (including pumps, ditches and canals). Water levels which mimic natural marsh hydroperiods (wetting and drying cycles) as closely as possible would be maintained. Specifically, management of water levels would be aimed at preventing too rapid drainage and excessive drying or artificially high water levels and/or prolonged periods of inundation. Similar water management infrastructure would be used to intensively manage moist soil units and rice fields. Marsh hydrology would also be restored by removing abandoned roads, levees, and well pads remaining from past oil and gas development.

The wetland management and hydrologic restoration activities implemented by the USFWS on newly acquired lands would help maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes. In turn, these habitats would support a natural diversity of native plant, fish and animal communities. Restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater and nutrient/sediment inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) in coastal marshes would also help to prevent the conversion of vegetated marsh to open water, promote plant productivity and contribute to marsh surface elevation gain.

b. Water Quality

Potential sources of contaminants affecting water quality in the project area include accidental releases from oil and gas exploration and production activities, including spills and leaks from wells, production facilities, and pipelines. Oil and gas exploration and development activities have increased in the project area in recent years. A high volume of petrochemicals is transported through the project area on a daily basis via the GIWW. Municipal development and agricultural practices may also impact water quality in the Refuge Complex. Non-point pollution sources, such as storm drain run-off from local cities and towns, are a major source of pollution entering the Galveston Bay estuarine ecosystem (Galveston Bay Estuary Program 1995). Point source pollution from upstream facilities such as landfills is also of concern.

Rice cultivation contributes important freshwater inflows to the Galveston Bay and Sabine Lake estuarine ecosystems, but agricultural practices as a whole may also contribute excess nutrients and toxins to surface waters within these coastal watersheds. Herbicide application is used on rice, soybeans, sorghum, and hay throughout the region. Concentrations of herbicides are greatest during May, June and July, with the lowest concentrations occurring in the fall and winter. Nitrates from nutrient loading are common in agricultural areas where fertilizer application enters into streams, creeks, and bayous during storm events. Some studies have indicated that rice tail waters entering the Galveston Bay system are relatively free of pollutants.

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would periodically monitor water quality on newly acquired lands through its Environmental Contaminants program, and would work with local, state and federal agencies to address water quality issues. Oil and gas exploration and production activities would be managed, including enforcing conditions of Special Use Permits aimed at preventing pollution from accidental releases. The USFWS would continue to coordinate with State and Federal spill response agencies to maintain a high level of preparedness and to effectively respond to accidental spills affecting water quality (and fish, wildlife and habitats). Overall, these activities would reduce the impacts of point and non-point source pollution sources and accidental spills to water quality and fish, wildlife and plant resources.

4. Impacts to Vegetation/Habitats

USFWS management activities affecting vegetation and habitats on newly acquired lands under Refuge Boundary Expansion Alternatives B, C and D would include the following habitat management and restoration activities in wetland and upland habitats: 1) structural water management in coastal marshes, 2) wetland restoration, 3) prairie grassland management and restoration, and 4) coastal woodlot and near-coastal bottomland forest restoration and protection. Other habitat management and restoration activities with impacts to vegetation and habitats would include prescribed burning, controlled grazing, exotic/invasive plant and animal control, shoreline restoration and protection, and mowing/haying.

The USFWS would administer public uses on newly acquired lands, including the six priority wildlife-dependent uses of the National Wildlife Refuge System: hunting, fishing, wildlife observation and photography, environmental education and interpretation. These uses would have direct and indirect impacts to vegetation and habitats.

Systematic monitoring of vegetation and habitats under the USFWS Refuge Biological Program would be conducted, allowing for ongoing assessment and refinement of management activities.

The USFWS would manage oil and gas activities on newly acquired lands through issuance of Special Use Permits. Stipulations in the SUPs would serve to minimize and mitigate for impacts of these activities on habitats and fish and wildlife resources.

a. Impacts to Vegetation and Habitats from Habitat Management/Restoration Activities

(1). Wetland Specific Management and Restoration

Wetlands management and restoration activities on the Refuge Complex impact hydrologic regimes. Such activities also strongly influence the vegetative communities found in Refuge Complex coastal marshes and prairie wetlands habitats.

(a). Water Management in Coastal Marshes

Coastal marshes provide important food resources and cover to a diversity of wetland-dependent resident and migratory fish and wildlife species. These marshes also provide buffering of tidal storm surge, reduce flooding, and filter excessive nutrients and other contaminants.

Threats to the Chenier Plain region's coastal marshes include altered hydrology resulting in increased saltwater intrusion and loss of freshwater and sediment inflows, and rising sea levels and land subsidence. These processes are resulting in coastal land loss as shorelines are eroded and recede and as inland vegetated wetlands convert to open water, which in turn is decreasing habitat quantity and quality for native fish and wildlife.

The USFWS would use structural water management on newly acquired lands under Refuge Boundary Expansion Alternatives B, C and D to control salinities and water levels within marsh habitats. Managed marsh units within the project area are under varying degrees of structural control, and may best be described as marsh semi-impoundments. Some units are entirely or almost entirely behind man-made levees and water control structures, and are intensively managed through manipulation of the water control structures and water delivery systems including ditches and canals. Most are managed less intensively, relying to some degree on natural topography and drainage to control hydrologic regimes. Most existing water control structures on private lands in the project area are designed to actively control the amount of saltwater or freshwater entering or leaving the managed unit.

The typical water management regime for managed marshes on newly acquired lands would involve maintaining salinities within the range of the particular marsh type being targeted by controlling the volume and timing of inputs of freshwater and saltwater. In general, salinity management promotes the establishment of the aquatic plant communities associated with brackish, intermediate and fresh

marshes. Saltwater inputs would sometimes be increased to higher than target levels if required to control certain aquatic invasive species such as cattail. Water levels would be maintained at target elevations to maintain plant productivity and diversity and to provide optimal wildlife habitat. The general water level management regime across most managed marsh habitats would involve maintaining pre-determined water levels which provide favorable conditions for dabbling ducks and geese during fall and winter. Following the wintering migratory bird season, managed marsh units would be drawn down gradually to create soil conditions favorable for the germination of a variety of seed producing annual plants in emergent marshes and water levels conducive to the germination and establishment of submerged and floating aquatic plants in ponds and other open water habitats. Summer water levels and salinities would be maintained to promote the growth of these plant species and subsequent seed and tuber production. Overall, water levels which mimic natural marsh hydroperiods (wetting and drying cycles) as closely as possible would be maintained. Specifically, management of water levels would be aimed at preventing too rapid drainage and excessive drying or artificially high water levels and/or prolonged periods of inundation.

The above notwithstanding, periodic climatic events such as flooding during periods of high rainfall or due to tidal storm surge and prolonged drought would continue to influence and sometimes be the dominant factor controlling hydrologic regimes and the response of vegetative communities in these coastal marshes.

This management activity would help maintain or restore the historic continuum of fresh, intermediate, brackish and saline marshes and the native plant, fish and animal communities that depend on these habitats. This would include the establishment of diverse and productive submerged and floating aquatic plant communities in open water habitats. Restoring historic hydrological conditions by reducing saltwater intrusion, reducing tidal energies in formerly non-tidal or micro-tidal marshes, establishing freshwater and sediment inflows and managing water levels to mimic historic hydroperiods (wetting and drying cycles) in coastal marshes on newly acquired lands would also help to prevent the conversion of vegetated marsh to open water. By promoting plant productivity, this management activity may also contribute to marsh soil formation and surface elevation gain (marsh accretion).

(b). Marsh Restoration

Under Refuge Boundary Expansion Alternatives B, C, and D the USFWS would expand the level and scope of wetland restoration activities on newly acquired lands. Coordination with the U.S. Army Corps of Engineers and other state and federal agencies would be expanded to develop additional projects which beneficially use dredge material to restore coastal marshes.

Impacts of marsh restoration efforts would be to increase the amount of vegetated marsh in areas which have converted to open water, in turn providing more productive habitats for native fish and wildlife.

(c). Moist Soil Management

Freshwater prairie wetlands on the Gulf Coast have been reduced mainly through development and agriculture (Moulton *et al*. 1997). Like coastal marshes, shallow freshwater prairie wetlands provide important food resources and cover to a diversity of wetland-dependent resident and migratory birds and wildlife. Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would implement moist soil management on newly acquired lands to provide and enhance shallow freshwater wetland habitat for migratory birds and other wetland-dependent wildlife.

Water management and mechanical soil manipulations on new moist soil units would be timed to promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia. Some units would be flooded throughout the summer to provide brood rearing habitat for Mottled Ducks and whistling ducks. This management regime favors the establishment of perennial wetland plants, including several species of floating and submerged aquatic plants, including arrow head, white water lily, and lotus.

Moist soil management increases wetland productivity and waterfowl use on migrating and wintering grounds (Fredrickson and Taylor 1982). Moist soil management is the process of exposing soils by lowering water levels or mechanically manipulating vegetation or soils to create a seedbed for native wetland plants to germinate, grow and reproduce. Flooding provides foraging habitat and cover for diverse communities of migrating and wintering waterfowl and other waterbirds (Fredrickson and Taylor 1982). The seeds, tubers, rhizomes and vegetative portions of moist soil plants provide important foods for waterfowl and other migratory birds.

Moist soil management contributes to increasing and maintaining the biological diversity of an area. Moist-soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). Over 80 percent more species have been found to occur in moist-soil impoundments than in adjacent row crops and include invertebrates, herpetofauna (amphibians and reptiles), prairie and marsh passerines (small- to medium-sized perching birds), shorebirds, wading birds, waterfowl, gallinaceous birds (e.g., pheasants, wild turkeys), raptors, and mammals (Fredrickson and Taylor 1982).

(d). Cooperative Rice Farming Program

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would implement a cooperative rice farming program on newly acquired lands where feasible. Primary objectives of the program would be to provide shallow freshwater wetland habitat with high value food resources for wintering and migrating waterfowl, shorebirds, wading birds and other migratory birds. The program would use Cooperative agreements with local farmers. Preference would be given to those farmers proposing to grow rice organically in order to reduce overall use of chemical herbicides and pesticides on Refuge lands.

Cooperative rice farming on newly acquired lands would provide shallow freshwater wetland habitat and serve several outcomes for migratory bird management: 1) providing habitat and nutritious forage for migrating and wintering waterfowl, 2) creating habitat for migrating shorebirds, and 3) providing fresh water habitat for during spring and summer for breeding and brood rearing Mottled Ducks and fulvous and black-bellied whistling ducks. Flooding after harvest makes existing waste grain available to waterfowl and often produces a second crop of rice, which is also available to wildlife. Fall and winter flooding allows migratory waterfowl to exploit waste rice and other weeds found in the fields. During migration and wintering periods, waterfowl and waterbirds extensively use post-harvest ricefields that were cultivated and at least partially flooded (Czech and Parsons 2002). Managed rice fields would provide wintering and migrational habitat for Blue-winged Teal, Nrthern Pintail, Green-winged Teal and Snow Geese, several shorebirds species including Long-billed Dowitchers and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted sandpipers, and for several wading bird species. Mottled Ducks also heavily use habitats adjacent to rice fields for nesting (Stutzenbaker 1988). Rice farming would also help to offset waterfowl consumption of crops on adjacent privately-owned croplands.

(e). General Habitat Management Activities

The USFWS would also utilize fire management, controlled livestock grazing, and exotic/invasive species control as integrated management tools in wetland habitats. The impacts of these activities on vegetation and habitats are discussed below under *General Habitat Management Activities.*

(2). Upland Specific Management and Restoration Activities

(a). Native Prairie Restoration and Management

Over 9 million acres of native tallgrass prairie once occurred along the western Gulf Coast in Texas and Louisiana (Smeins *et al*. 1991). Based on remnant stands of native grasslands, prairies on the upper Texas coast were characterized by little bluestem, brownseed paspalum, and Indiangrass or eastern

gammagrass and switchgrass associations, depending on hydrology (Diamond and Smeins 1984). It is now estimated that 99.8% and 99.6% of little bluestem and eastern gamma grass/switchgrass prairies, respectfully, have been lost in Texas (McFarland 1995). The little bluestem-brownseed paspalum community has been identified as a threatened natural community and the eastern gammagrass-switchgrass community has been identified as an endangered natural community by the Texas Organization for Endangered Species (Diamond *et al*. 1992). Both communities are assigned a Global conservation status rank of "Critically Imperiled" (G1) by The Nature Conservancy (2002).

Coastal prairie habitats are important for prairie-dependent avian and wildlife. Currently, nine of the 13 avian species listed as Rare and Declining within the Coastal Prairies Region in Texas are present in coastal prairie grasslands on the Refuge Complex. The USFWS has listed seven avian species occurring in prairie habitats on the Refuge Complex as Avian Species of Conservation Concern in the Gulf Prairies Bird Conservation Region (USFWS 2005).

Refuge Boundary Expansion Alternatives C and D include the largest contiguous native coastal prairie remnants on the upper Texas Coast. Under Refuge Boundary Expansion Alternatives B, C and D, the following prairie habitat restoration and management activities would be used on newly acquired lands: 1) protect and manage existing native prairies and restore prairie on suitable upland sites; 2) restore shallow depressional "prairie wetlands"; 3) conduct a rotational prescribed burning program on existing and restored prairies; 4) conduct a rotational livestock grazing program; 5) utilize an integrated pest management program, consisting of herbicide application, mechanical removal, prescribed burning and controlled livestock grazing to manage exotic/invasive plant species such as Chinese tallow and deep-rooted sedge which are negatively impacting prairie habitats; and 6) mow or hay to control weed and woody species infestations.

Overall, prairie restoration and management activities on newly acquired lands would increase the abundance of native prairie grasses and forbs, including the increasingly rare little bluestem/brownseed paspalum and eastern gamma grass/switchgrass prairie plant communities. The USFWS would use integrated application of prescribed burning, controlled livestock grazing, herbicide application, and mowing/haying to restore the historic mosaic of prairie plant communities and the different structural characteristics of these habitats. Brush encroachment by exotic and native plant species would be reduced. Previously-drained shallow depressional "prairie wetlands" within extant stands of native prairie would be restored. Additional native prairie and freshwater wetlands would be restored on adjacent fallowed agricultural fields. Management and restoration of native prairie habitats on newly acquired lands would help conserve an important and increasingly rare component of the western Gulf Coast ecosystem. The long-term protection and management of the remaining largest contiguous tracts of native prairie on the Upper Texas Coast will provide functional habitats to support many declining native plant and wildlife species, including plant associations classified as Globally Imperiled and many Avian Species of Conservation Concern.

Seed viability in prairie plants is believed to be reduced in highly fragmented prairie landscapes due to loss of genetic variability as remnant stands become smaller and more isolated. Prairie plants on the upper Texas Coast evolved under relatively unique climatic conditions of high annual rainfall and hydric soils. Conservation of existing coastal prairie remnants in the project area under Refuge Boundary Expansion Alternatives B, C and D would protect important reservoirs of genetic material and extremely valuable sources of viable local seed and plant materials. Future restoration of native coastal prairie in the region would greatly benefit by the protection of these existing viable local seed and plant material sources.

(b). Woodlot Restoration and Protection

Although comprising a small percentage of the upland habitats in the project area, coastal woodlots help support a diverse avian community which includes several sensitive songbird species. Six of the seven avian species listed as Rare and Declining within the coastal prairies region in Texas are present in woodland habitats in the project area. Migratory birds depend on coastal woodlots for cover and food. At least 63 species of migratory birds regularly use the wooded habitats of the Chenier Plain prior to or

immediately after crossing the Gulf of Mexico (Barrow *et al.* 2000). Trans-Gulf or circum-Gulf migratory songbirds use Texas Coastal woodlots as stopover habitat (Mueller 1981), which is critical at a time when the birds are depleted of water and energy reserves (Leberg *et al.* 1996).

A primary threat to coastal woodlots is encroachment by the Chinese tallow tree, which provides poor habitat for migratory songbirds. Although the Chinese tallow trees attract birds as frequently as other trees, they provide poorer forage because of sparse insect populations. Specifically, they harbor fewer insects and spiders, especially *Lepidopteron* larvae. Chinese tallow woodlots may thus be an "ecological trap" that provide cover but little food for migrants when they are energy-depleted after migration (Barrow and Renne 2001).

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would protect and manage coastal woodlots and near-coastal forests on newly acquired lands by: 1) native tree and shrub plantings; 2) exotic/invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts. Under Refuge Boundary Expansion Alternative D, an important near-coastal bottomland hardwood forest (Taylors Bayou bottomlands) would be protected.

Overall, implementation of the USFWS management actions discussed above on newly acquired lands would improve coastal woodlot and bottomland forest habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodland habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging.

(3). General Habitat Management Activities

Under Refuge Boundary Expansion Alternatives B, C, and D, the USFWS would use fire management, controlled livestock grazing, exotic/invasive species management, and mowing/haying on newly acquired lands to enhance habitats for migratory birds and other native fish and wildlife. Shoreline restoration and protection activities would be implemented to counter ongoing coastal land loss caused by relative sea level rise, altered hydrological regimes and loss of coarse sediment supply. These management and restoration activities would be used to conserve, enhance and restore both wetland and upland habitats on newly acquired lands.

(a). Fire Management - Prescribed Burning/Wildland Fire Suppression

Natural fire and herbivory by native species likely occur less frequently or at reduced levels than historically in the Chenier Plain region, primarily due to human influences on this coastal ecosystem. This has reduced diversity and productivity of native wetland and upland habitats. For example, in brackish and intermediate marsh habitats, reduced disturbance generally allows marshhay cordgrass, considered a climax plant community, to become the dominant emergent plant. Dense, homogeneous stands of marshhay cordgrass are less biologically diverse and productive than marsh habitats in which burning and herbivory create a mosaic of plant communities with greater plant species composition and greater structural diversity (attributes such as stem densities, height, and erect vs. decumbent growth habits). In upland coastal prairie habitats, encroachment by native and exotic woody species, such as Eastern baccharis and Chinese tallow, occurs in areas where fire is excluded, also resulting in loss of native habitat diversity and productivity.

Fire has long had a role in the ecology of the Texas Chenier Plain marshes. Pre-European settlement, fire frequency for these marshes is estimated to be 1-3 years (Frost 1995). Lightning caused wildfires were common in coastal marshes (Hoffpauer 1968, Frost 1995). Additionally, Native Americans used fire to facilitate hunting and travel (O'Neil 1949, Givens 1962). In the past, fires in the Gulf coast prairies and marshes probably varied greatly in spatial extent. Natural firebreaks existed in many forms. Bayous, tidal creeks, fault lines, animal trails, and areas previously disturbed by fire or animal herbivory all may limit the spread of wildfires. Weather, fuel conditions, and water levels influence the effectiveness of the natural firebreaks and ultimately the size of the fire. Anecdotal data suggest that prior to human caused changes

in historic isohaline lines and hydroperiods, much of the vegetation that dominated these fresher marshes (i.e. Sawgrass (*Cladium mariscus* subsp. *jamaicence*), maidencain (*Panicum hemitomon*), giant cutgrass (*Zizaniopsis miliacea*), and bullwhip (*Schoenoplectus californicus*)) were less pyrogenic than common vegetation found today, such as marshhay cordgrass. This may have reduced the frequency and size of historical fires in the region's marshes compared to current vegetative conditions. Conversely, natural fire starts in the region have undoubtedly been significantly reduced because of the landscape-level conversion of upland prairie habitats to agricultural uses. Navigation canals, ditches, levees and roads constructed throughout upland and wetland habitats effectively serve as firebreaks and have greatly affected fire spread and the ultimate size of present-day natural fires.

Generally, three types of fires in coastal marshes are recognized: cover, root, and peat burns (Lynch 1941). Soil moisture and organic content, as well as surface water at the time of the fire, determine the type of burn that occurs. Water levels and soil conditions must be considered carefully to meet management objectives of prescribed burns (Bacchus 1995, Hungerford *et al*. 1995). The USFWS would carefully consider these parameters in implementing its fire management program on newly acquired lands.

The most common and widely used fire in coastal marshes is the cover burn (Hoffpauer 1968). This type of fire, taking place when water levels are at or near the marsh surface, removes the aerial portions of the vegetation. Recommended water levels for a cover burn range from marsh surface to five inches (Lynch 1941, O'Neil 1949, Hoffpauer 1968). Cover burns temporarily remove dense emergent vegetation and attract wildlife and cattle to the new growth (Lynch 1941, Hoffpauer 1968). Marshes recover quickly after winter cover burns. Soil moisture or surface water protects the subterranean plant parts from damage. Gabrey and Afton (2001) found in the Chenier Plain of Louisiana that the total above ground biomass was reduced for two years while dead above ground biomass was reduced for three years post fire compared to unburned control plots. In addition, they found that plant species composition in burned plots was the same as unburned plots, with a slight increase in richness during the first growing season post-fire.

Root burns occur in marshes under dryer conditions. The roots of plants may move into the litter layer in marshes that have not burned in several years (Lynch 1941). If the litter layer is dry enough to support combustion, a root burn may occur. Root fires burn away the litter layer and destroy shallow root systems. This type of burn can create significant changes in the plant community. Climax species such as maidencane and marshhay cordgrass are often set back, allowing subclimax species to increase. Because the fire is in the litter layer and soil is not consumed, this type of burn would also be classified as a surface fire by most fire researchers, though the results of the fire would be very different.

The last type of marsh fire is the peat burn. This takes place under the driest soil conditions. In a peat burn, the fire removes the organic subsurface fuels and in some instances will burn down to the underlying clay pan. This type of fire typically removes existing vegetation and creates open water conditions that may last for decades (Lay and O'Neil 1942, O'Neil 1949, Hoffpauer 1968). Peat burns can create quality waterfowl habitat by burning holes into the marsh that later become open water (Lynch 1941, Uhler 1944, Baldassare and Bolen 1994). Despite this, peat burns are not a management goal in most instances. The prolonged smoldering involved in peat burns would likely cause smoke management problems in surrounding communities. With the alarming loss of coastal wetlands to sea-level rise and subsidence, these types of burns cannot be justified in most situations (Nyman and Chabreck 1995). The general fire management community would classify peat burns as a ground fire.

Once a burn has been completed, many factors can affect post-fire conditions. If excessive rainfall causes water to cover the vegetation stubble for prolonged periods of time, the vegetation can die off (Hoffpauer 1968). Soils are particularly susceptible to erosion until the vegetation recovers. Excessive high tides, particularly storm driven tides, can push salt water over the burn area and cause plant mortality.

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would use its fire management program on newly acquired lands to manage prescribed burning and to suppress wildfires in a manner beneficial to native plant and animal communities and ecological functions, while providing for public and

employee safety and minimizing negative impacts to the surrounding communities (USFWS 2001). In wetland habitats, prescribed burning would be implemented in combination with controlled livestock grazing and water level and salinity management with of primary goal of providing diverse high-quality wintering habitats for waterfowl, shorebirds and other marsh and water birds. In upland habitats, prescribed burning and controlled grazing would be used to control encroachment by woody species and to enhance germination and growth of native prairie grasses and forbs, benefiting many grassland avian species.

Prescribed burning would generally occur on a three-year rotation; however, the actual condition of vegetation and fuel loading would dictate the need for a burn (USWS 2001). The majority of the prescribed burning in marsh habitat would be conducted from September to late November. Prescribed burning of upland grassland habitat would occur primarily in late winter and early spring to stimulate native warm season grasses. Summer burning would occur in wetland and upland habitats when necessary to control invasive woody vegetation.

The USFWS fire management program would be conducted on newly acquired lands to achieve the following benefits:

- Hazardous fuels reduction within immediate proximity to USFWS and private facilities and structures (to protect life and property). Prescribed burning lessens the potential of uncontrollable wildfires by reducing the accumulation of rank vegetation and litter.

- Habitat for waterfowl and other migratory birds is restored, maintained, or improved by maintaining early successional plant communities in marsh habitats, by increasing production and nutritional quality of these foods, and enhancing the availability of these foods by creating openings in otherwise dense stands of vegetation. For example, prescribed burning encourages tuber producing plants such as Olney and leafy three-square bulrush preferred by waterfowl. Snow geese heavily use recent marsh burns because they can readily access roots, tubers, and young green shoots of these plant species. Both geese and ducks use burned areas as roosts or loafing areas.

- Encroachment of undesirable woody shrubs, including Chinese tallow, bigleaf sumpweed, and Eastern baccharis, is suppressed. Without fire disturbance, both marsh and prairie habitats in the project area are subject to invasion by such woody shrubs, which in turn reduces habitat quality for many grassland-dependent avian species and other wildlife. Management of exotic and invasive species such as Chinese tallow, deep-rooted sedge and Eastern baccharis using an integrated pest management approach enhances germination, growth and reproduction of native prairie grasses and forbs. The mechanical removal of undesirable woody and weed plant species reduces competition with native plant species, and enhances germination, growth and reproduction of native prairie grasses and forbs.

Burning makes vegetation more desirable to herbivores and will increase grazing pressure. Post-fire herbivory, whether by geese or cattle, prolongs early successional marshes and creates habitat for other wildlife. Post-fire herbivory will slow the recovery of climax vegetation and prolong early serial stages and open marsh conditions favorable to waterfowl (USFWS 1994). Livestock turn the soil through hoof action and further set back succession (Chabreck 1968, Stutzenbaker and Weller 1989).

Interstitial vegetation, often seed producing annual grasses such as sprangletops (*Leptochloa* spp.) and millets (*Echinochloa* spp.), increases after a fire, particularly when followed by grazing and suitable hydrology. Burning opens up dense vegetation and allows waterfowl access to seeds and other plant parts (Lynch 1941). Fire can remove plant cover and create open water conditions conducive to Mottled Duck brood-rearing habitat (Stutzenbaker 1988). Generally speaking, burning creates open marsh conditions and sets back succession if timed properly, particularly when followed by herbivory. Burning is an effective tool to manipulate vegetation composition and create a habitat mosaic (Fredrickson and Laubhan 1996).

USFWS fire management practices in non-saline coastal prairies on newly acquired lands would include prescribed burning in late winter prior to green-up of the warm season grasses. This is the most common type of prescribed burn currently conducted on remnant native prairies and restored coastal prairie sites on the Refuge Complex, and it is used to promote the growth of these native grasses. Burning would be conducted on upland non-saline grasslands when target warm-season grass species have less than 10cm of green foliage, prior to the grasses' growth points becoming elevated. This strategy of prescribed burning is considered a restoration phase in the management of non-saline uplands on the Refuge Complex.

One of the primary objectives of burning non-saline upland grasslands on newly acquired lands would be the control of Chinese tallow. Tallow is generally non-flammable and in heavily infested situations suppresses herbaceous plants and fine fuel loading, limiting the potential for fire (Grace *et al.* 2001). Thus, the invasion of Chinese tallow converts a fire-adapted grassland site to a non-flammable, near monotypic woodland. Work has been conducted on Brazoria NWR in the Texas Mid-Coast region on the relationship between fire and Chinese tallow. Preliminary results indicate that while total control was not realized with one treatment, some mortality was achieved (Grace 1998). Further, sites with fuel characteristics more typical of coastal prairies (high fuel loading, species composition, and continuity of fuels) achieved better control of Chinese tallow using fire than did abandoned agricultural fields.

The impacts of prescribed burning in wetland habitats (in combination with controlled grazing and water level and salinity management) would include: 1) increasing plant species diversity; 2) maintaining and enhancing desirable emergent marsh plant communities such as Olney bulrush and leafy three-square bulrush; 3) creating openings in otherwise dense stands of emergent marsh vegetation; and 4) helping to control exotic and/or invasive plants. Prescribed burning (integrated with control livestock grazing and water management) in wetland habitats would promote the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al.* 1979). Target plant communities in intermediate and brackish marsh habitats would include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato.

The impacts of prescribed burning in upland grassland habitats would include: 1) maintaining and enhancing native prairie plant communities, including several native grasses and forbs, by enhancing conditions which encourage reproduction and growth of these species; and 2) helping to control exotic and/or invasive plants, most notably Chinese tallow and Eastern baccharis, which often outcompete and replace native grasses in areas where fire has been excluded or its frequency decreased.

While this valuable habitat management tool has many positive effects, prescribed burning can have detrimental impacts ranging from an undesirable change in vegetative species composition to actual conversion of emergent marshes to open water when fires occur at the wrong time. Proper timing of burns under appropriate conditions of soil moisture, fuel loads and fuel moisture is essential to minimize negative impacts. For example, burning under excessively dry conditions could result in destruction of desirable vegetation, consume organic matter and decrease marsh soil elevation, which in turn could result in permanent conversion to open water. Hot fires may result in root burns, which can cause mortality of desirable marsh plant species. Fire increases the soil erosion potential until regrowth occurs. Recently burned areas are especially susceptible to erosion during storm surges from tropical storms and hurricanes. Hot fires occurring without adequate soil moisture can also cause a temporary reduction in microflora and microfauna in wetland soils. Burning cannot restore lost marsh or counter the effects of excessive flooding or salinity (Chabreck 1994). Burning is not as beneficial in more saline marshes, because the resulting subclimax plant community is not as diverse (Spicer *et al*. 1986). Under Refuge Expansion Alternatives B, C and D, the USFWS prescribed burning program on newly acquired land would consider factors including soil and vegetative fuel moisture, seasonality and timing, ignition patterns, habitat type and previous burn history to ensure maintenance of diverse and productive at wetland and upland habitats. In addition, the USFWS would use short and long-term ecological fire effects monitoring on newly acquired lands to guide an adaptive approach to implementing its fire management program. Additional research studies to determine fire effects on marsh soils and vertical

accretion, vegetation, and wildlife would be conducted through new and expanded partnerships with the U.S. Geological Survey and academic institutions.

(b). Controlled Livestock Grazing

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would use controlled grazing on newly acquired lands (integrated with fire management and water management) to maintain and increase diversity (plant species composition and structural attributes) and productivity in wetland and upland habitats.

Grazing strategies would include variations in stocking rates, timing (cool vs. warm season) and duration. Smaller grazing units would be grazed on a rotational basis, providing "rest" as needed to maintain plant diversity and productivity. Stocking rates and rotations would be determined annually according to management objectives for the various grazing units and the quantity and condition of forage and availability of fresh water in those units. Cool season and summer cattle grazing on various marsh and upland units would be used. The USFWS would expand the use of high intensity, short duration grazing on upland prairie habitats to mimic historic patterns of herbivory.

Controlled grazing can be an effective and inexpensive tool in wetland and grassland management providing habitat components that benefit waterfowl and other wildlife species. Research indicates that dual use of grasslands by wildlife and livestock is often compatible when livestock grazing is carefully managed and wildlife needs are considered (Holechek 1982).

Grazing (integrated with fire and water management) in wetland habitats on newly acquired lands would be managed to promote the germination, growth and reproduction of several "early successional" target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al.* 1979). Target plant communities in intermediate and brackish marsh habitats would include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Moderate grazing following burns in marshes would result in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al*. 1979). Grazing would also help provide optimal physical structure of vegetation for waterfowl utilization in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining plant communities such as seashore paspalum which grow low to the ground. When shallowly flooded, stands of low-growing seashore paspalum and seashore saltgrass interspersed with ponds provide ideal habitat conditions for many waterfowl, shorebird and wading bird species. These conditions would also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Specifically, the beneficial effects of the USFWS controlled grazing program in wetland habitats would include:

- Reduction of rank vegetation which enables migratory birds access to roots and tubers of mature plants and shoots of new plants.
- Reduction of competing growth of marshhay cordgrass and other dominant climax plant communities, allowing for the growth of subdominant plant species, many of which are preferred foods of ducks and geese.
- Creation of open water which provides loafing spots for birds and allows them to access aquatic invertebrates.
- Complimenting marsh burning by prolonging the time that browse is available for goose use.

- Increased plant vigor, increased plant productivity, enhanced nutrient recycling, and prevention of excessive build-up of residual plant material.

- Reduction of hazardous fuel loading, reducing the amount and intensity of wildfires.

- Breaking up of capped soils through hoof action, which assists in seedling establishment.

- Maintenance of regrowth of vegetation in recently burned areas in more palatable stages for wintering waterfowl.

- Provides a reliable disturbance tool that is not as dependent on favorable weather and fuel conditions as prescribed fire.

Carefully managed grazing (and prescribed burning) in coastal prairie habitats increases vigor of many native prairie grasses, and increases overall plant species and structural diversity.

Potential detrimental affects of grazing includes the risk of overgrazing, excessive trampling of vegetation, compaction of soils reducing percolation rates, and increased soil erosion. The deposition of excess nutrients in the form of feces in areas where livestock concentrate (USFWS 1994) may negatively impact surface water quality. Fecal coliform from geese and livestock are the main pollutants contaminating the shellfish waters of East Galveston Bay (Galveston Bay Estuary Program 1995). Overgrazing in prairie habitats reduces native prairie plant diversity, as native grasses and some native forbs are more palatable and are preferentially selected by livestock. Soil disturbance by excessive hoof action can provide conditions favorable for establishment of exotic and invasive plant species such as Chinese tallow, and cattle can spread seed of undesirable plant species by physically carrying them or ingesting them. The USFWS would continue to monitor grazing programs and adjust grazing strategies so as to avoid detrimental impacts.

(c). Exotic/Invasive Species Management

Under Refuge Boundary Expansion Alternatives B, C, and D, the USFWS would expand the scope of exotic and invasive species management activities on newly acquired lands. An Integrated Pest Management (IPM) program would be implemented to control the following exotic and invasive plant species:

- Chinese tallow, Eastern baccharis, willow, deep-rooted sedge and King Ranch bluestem in freshwater marshes, prairies, woodlots and on levees and roadsides.

- Water hyacinth, alligatorweed, Salvinia, common reed, and cattail in waterways and managed wetland units.

- Red rice, coffeebean, barnyard grass, and other grasses in rice fields.

- Invasive broadleaf weeds and King Ranch bluestem in restored prairies.

Integrated pest management would be implemented using a combination of treatments including herbicide application, mechanical control, approved and permitted biological controls, prescribed burning, controlled grazing and water level and salinity management. The overall goal of the USFWS IPM program would be to achieve results while decreasing dependence on and use of chemical herbicides to control and manage invasive plant species. Spot treatments using target-specific herbicides would be used in wetland and upland habitats when target stands are small enough to treat by hand. In wetland habitats, this would include treatment of invasive plant species including cattail, common reed, and California bulrush where these plants have formed dense, homogeneous stands which result in pond closure and loss of open water. Control of exotic floating aquatic plants such as water hyacinth, alligatorweed and Salvinia also restores open water habitats. Aerial herbicide application would be

required to initiate control on large mature stands of Chinese tallow. Mowing/haying and burning would be used on upland grassland habitats, and burning, controlled grazing and salinity management would be primary tools used in marsh habitats. Discing or roller chopping would be used in rice fields and moist soil units.

The USFWS would also expand monitoring programs for exotic/invasive species on newly acquired lands using GIS and GPS technologies to document and track infestations and evaluate the effectiveness of treatments. Additional research would also be supported through new and expanded partnerships with the U.S. Geological Survey and academic institutions.

Control of invasive emergent and floating plants in ponds would promote the growth of native floating and submerged aquatic plant species important to native fish and wildlife.

The control of Chinese tallow and deep-rooted sedge in prairie and woodlots would result in increased diversity of native plants. In woodlots, reduction of Chinese tallow and increasing native tree and shrub abundance would likely increase abundance of forage insects for migrating birds (especially Lepidopteran larvae) (Barrow and Renne 2001).

The USFWS would also continue to control exotic animal species to conserve biological diversity and to maintain habitat quality for migratory birds and other native wildlife. Feral pigs are the primary species currently impacting habitats in the project area. Rooting and wallowing by feral pigs causes significant habitat and infrastructure damage. These soil disturbances in marsh and upland sites allow invasive plants to establish and reduce the value of the habitats to wildlife. Feral pigs are particularly damaging to water management infrastructure. They wallow and root extensively on levees and within rice fields and moist soil units affecting the management of thousands of acres habitat. Feral hogs are prolific and are able to exploit wetland and upland habitats. Control of feral hogs would decrease damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging, and reduce the creation of disturbed areas that enable establishment of Chinese tallow and other undesirable plants.

Although nutria have not reached population levels capable of damaging habitats in recent years in the project area, this exotic animal has been highly destructive in coastal wetlands in neighboring Louisiana and other coastal states. Control activities for nutria which could be implemented as necessary on newly acquired lands.

(d). Shoreline Protection and Restoration

As discussed under Part B in *Section II.A.2. Impacts to Geology and Soils*, altered hydrological regimes and relative sea level rise resulting in erosion and land loss along the Gulf and Bay shorelines are major threats to wetland and upland habitats on the Refuge Complex. Barrier beach and dunes along the Gulf of Mexico provide habitat for a variety of plant and animal species, protect and stabilize the coastline and help protect landward wetland habitats. Shoreline erosion threatens Gulf of Mexico beach and dune habitats throughout the Chenier Plain region. Although shoreline erosion during storms is a natural process, a severe sediment deficit in the Gulf's littoral system resulting from construction of navigation channels, jetties and upstream dams on rivers has greatly accelerated rates of shoreline retreat. Rising sea levels and land subsidence are also causative factors in the accelerated loss of coastal habitats.

Under Refuge Expansion Alternatives B, C and D, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss on newly acquired lands. On McFaddin NWR and Texas Point NWRs, these partnerships would continue to focus on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Coordination with other agencies and conservation organizations would be expanded, with a goal of implementing a major project to restore the entire barrier beach/dune system on McFaddin NWR. Structural erosion abatement projects would also be implemented, including breakwater construction along the GIWW and East Galveston Bay shorelines.

Restoration of the barrier beach/dune system on McFaddin NWR and increased use of dredged material on Texas Point NWR would contribute to increasing coarse sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994). If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR could substantially reduce current rates of land loss. These projects would also restore historic elevations along the shoreline and protect inland marshes, and plant productivity therein, by reducing saltwater intrusion. Offshore rock breakwaters and shoreline armoring would also reduce the erosion of shoreline. Restoring emergent marsh by planting smooth cordgrass along shorelines will reduce land loss and increase sedimentation and vertical accretion within vegetation stands.

Shoreline protection and restoration activities on newly acquired lands would continue to positively impact vegetation resources and habitats by restoring upland and protecting existing wetland habitats. Restoration of barrier dunes along the Gulf of Mexico would protect interior intermediate marshes and their plant communities from excessive inundation with saltwater during high tidal events, as well as restoring an upland native habitat type which has been almost completely lost in the project area. Use of dredged material along existing shorelines would protect existing marshes by reducing shoreline retreat and direct loss of these habitats, provide a substrate for reestablishment of marsh vegetation and restoration, and increase net sediment supply to marshes which provides nutrients and increases plant productivity (Chabreck 1976, 1994). Breakwaters would enhance marine habitat by functioning as an artificial reef, providing opportunities for oyster spat, barnacles, algae, baitfish, and predator fish utilization. Restoring emergent marsh by planting smooth cordgrass between the breakwaters and existing shorelines would restore vegetated wetlands that have converted to open water. The stands of smooth cordgrass would also provide habitat for snails, shrimp, crabs, insects, and numerous benthic organisms.

(e). Mowing and Haying

Under Refuge Boundary Alternatives B, C and D, the USFWS would continue to utilize mowing and haying in upland grassland habitats on newly acquired lands. Mowing and haying would invigorate growth of many native grasses, while reducing vigor of undesirable herbaceous weeds and woody plants. Reduction of herbaceous and woody cover often results in the “release” of native prairie plants. Mowing and haying would be used where the vegetation to be controlled is undesirable to livestock, or where the terrain or soil conditions are difficult to graze without excessive environmental damage. Mowing and haying facilitates more control over the amount and locations of vegetation management, however, costs per acre are much higher than for controlled grazing or prescribed burning. Mowing and haying would also reduce use of chemical herbicides.

b. Impacts from Public Use Programs

The greatest potential for impacts to vegetation resources and habitats on newly acquired lands under Refuge Boundary Expansion Alternatives B, C and D would likely be from motorized boating activities. Motor boats, vehicles and walking would be the primary means of access to areas opened to the public for wildlife-dependent recreational uses including hunting, fishing, wildlife observation and photography and environmental education and interpretation. Wetland vegetation, especially submerged aquatic vegetation, can be impacted by motorboat activity. For example, propeller scarring has been shown to detrimentally impact seagrass beds in the Laguna Madre in South Texas (Pulich *et al*.1997, Dunton *et al*. 1998) and in Florida (Madley *et al.* 2004). Propeller scarring leaving permanent channels in shallow pond and waterway bottoms on the Refuge Complex has also raised concerns about the potential for increased saltwater intrusion, with concurrent negative impacts on emergent and submergent aquatic vegetation.

Foot traffic in areas open to hunting, fishing, wildlife observation and photography, environmental education and interpretation could lead to vegetation trampling, and in heavy use areas, cause plant mortality. The more extreme impacts would occur in areas heavily used for shoreline fishing. Some vegetation trampling and trailing from hunter foot traffic occurs in marsh habitats in Refuge Complex hunt areas, although these impacts tend to be short-term.

These impacts would be expected to be localized and minimal. Regulations, including horsepower restrictions and area closures to motorized boating would be used to protect wetland habitats and public safety. Access for other recreational and educational uses would be restricted to established roads. The USFWS would also construct trails, boardwalks, and observation platforms and fishing piers on newly acquired lands to support recreational uses while reducing trailing impacts.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

No direct impacts to vegetation and habitats would occur as a result of implementation of the USFWS Biological Program on newly acquired lands. Habitat and vegetation monitoring activities and research studies would support an adaptive management approach by providing information which helps refine and improve exiting management practices.

d. Impacts from Management of Oil and Gas Exploration and Development

Lands acquired under Refuge Boundary Expansion Alternatives B, C and D would be acquired subject to exploration and development of reserved and outstanding mineral interests. The USFWS would manage oil and gas exploration and development activities on newly acquired lands through the issuance of Special Use Permits. Stipulations in the Special Use Permit would include those aimed at minimizing impacts to vegetation and habitats, including required use of specialized equipment, location and size of facilities, and required pollution controls. As per federal regulations (50 CFR 29.21), the USFWS would ensure that impacted sites are restored as closely as possible to pre-project conditions upon cessation of activities. Conditions of the Special Use Permit would also require mitigation for all impacted habitats. Required mitigation activities include restoration and/or enhancement of habitats on the Refuge Complex which are similar to those impacted by oil and gas activities.

The net effect of USFWS management of oil and gas exploration and development on newly acquired lands would be to reduce impacts on vegetation and habitats from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would continue to develop partnerships with private land owners to restore and enhance wetland and upland habitats on private lands by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife Program and other private lands initiatives such as the Texas Prairie Wetlands Project. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands. It is anticipated that continuation of outreach and partnership efforts would result in additional habitat restoration and enhancement.

5. Impacts to Fish and Wildlife Resources

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS habitat management and restoration and biological program activities on newly acquired lands would be focused on conservation of the following fish and wildlife resources:

- Waterfowl - Wintering and Migrating
- Waterfowl – Resident (Mottled Ducks)
- Shorebirds, Wading Birds, and Other Marsh and Waterbirds
- Landbirds (passerines, raptors, and non-passerines)
- Fisheries
- Threatened and Endangered Species
- Mammals
- Reptiles and Amphibians

- Invertebrates

The USFWS would manage the six priority wildlife-dependent uses on newly acquired lands. These uses would have impacts to fish and wildlife. Impacts would be mitigated by on-refuge habitat management activities, refuge-specific regulations governing public uses, and law enforcement for protection of natural resources and public safety.

USFWS management of oil and gas exploration and development and community outreach and partnership programs would also impact these resources.

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

Coastal habitats in Texas are part of the southern terminus in the U.S. for most of the ducks and geese in the Central Flyway. The 2004 mid-winter waterfowl survey indicated that 7,901,489 waterfowl used the Central Flyway. Of those birds, 5,110,022 waterfowl (65%) wintered in Texas. Available wintering waterfowl habitat in Texas is shrinking due to changes in agricultural uses, industrial and urban development, increased pollutants (Cain 1988), land subsidence, rising sea levels, and man-made hydrological changes such as canals resulting in saltwater intrusion (Michot 1996). Loss or degradation of habitat on landscape scale increases the importance of public and private lands managed specifically for supporting wintering and migrating waterfowl.

Since the mid-1950s to the early 1990s, approximately 211,000 acres of wetlands were lost on the Texas Gulf Coast, to both natural and man-made causes (Moulton *et al.* 1997), with most of the palustrine wetland lost to agriculture (in recent years agricultural lands have decreased due to urban development). Palustrine emergent marshes showed the largest decline, primarily by conversion to upland agriculture and other uses; and most estuarine wetlands loss was due to land subsidence. Tacha *et al*. (1992) concluded that between 1976 and 1991 the total ducks in the Chenier Plain of Texas declined by 89%, and these decreases were highly correlated with losses and degradation of wetland habitat.[19] Wintering and migrating waterfowl along the Texas Coast tend to prefer freshwater coastal marshes and freshwater prairie wetlands. Rice agriculture provided an especially valuable habitat for wintering waterfowl.

Under Refuge Boundary Expansion Alternatives B, C and D, the following USFWS management activities would have the greatest impacts on wintering and migrating waterfowl populations in the project area.

(a). Wetlands Management and Restoration

Under Refuge Boundary Expansion Alternatives B, C and D, marsh habitats on newly acquired lands would be structurally managed to enhance habitat for wintering waterfowl and other migratory birds. This management activity would utilize existing water control structures, levees, and water delivery systems. Marsh management would help maintain the full continuum of marsh types, from fresh to saline, and native emergent, submergent and floating plant communities which provide food for wintering waterfowl. For example, structural management of brackish and intermediate marshes may directly increase the abundance of preferred plant species, such as Olney bulrush and widgeongrass, which provide food resources for wintering and migrating waterfowl (Chabreck 1976, Broome *et al*. 1995). Management of water levels would also provide optimal conditions for foraging and resting waterfowl.

The USFWS would use moist soil management on newly acquired lands to provide shallow freshwater wetland habitat for wintering and migrating waterfowl. Existing rice farming infrastructure on permanently fallowed fields would be adapted to provide this capability. Moist soil management provides optimal conditions for germination and growth of preferred waterfowl food plants, including annual grasses such

19 During the 1969 through 1994 period, the Louisiana coastline experienced major wetland losses, similar to the Texas coast. However, there appears to have been no declines in duck populations of coastal Louisiana marshes between 1969 and 1994 (Michot 1996).

as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and purple ammenia.

The USFWS would use a cooperative rice farming program on newly acquired lands, also to provide shallow freshwater wetlands with high quality forage for wintering and migrating waterfowl. Management of first year fallowed rice fields would also provide weeds and seed that are heavily utilized by waterfowl.

The USFWS would implement marsh and wetland restoration activities on newly acquired lands. Restoration would create additional emergent marsh and open water habitats and provide additional habitat for wintering and migrating waterfowl.

Wetland management and restoration implemented by the USFWS on newly acquired lands would likely increase use by wintering and migrating waterfowl. Management and restoration of newly acquired lands would benefit three wintering waterfowl species listed by the USFWS as Game Birds Below Desired Condition: Northern Pintail, Lesser Scaup and Ring-necked Duck. On a year-to-year basis, overall habitat quality for waterfowl on Refuge lands and in the project area as a whole will continue to be influenced by climatic events and trends, most specifically by extreme periods of drought or high rainfall and/or the occurrence of tropical storms and hurricanes and associated tidal surges. Annual fluctuations in waterfowl numbers in the project area would also be expected based on a variety of factors including trends in continental waterfowl populations, habitat conditions affecting wintering distribution along migration routes and in wintering areas (as affected by climatic conditions), regional and local changes in agricultural land uses and practices, and variability in regional and local hunting pressure. Recent decreases in rice production have reduced available habitat and subsequently wintering waterfowl numbers in the project area, and any future declines in rice production would further exacerbate these impacts.

(b). General Habitat Management and Restoration Activities

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would use an integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats to create optimal habitat conditions for wintering waterfowl and other migratory bird species. Prescribed burning and controlled grazing would promote the germination, growth and reproduction of several “early successional” target plant communities which are especially beneficial to migratory birds as food sources (Allen 1950, Gosselink *et al.* 1979). Burning and moderate grazing would also result in the growth of new grass shoots, a valuable food for snow geese (Gosselink *et al.* 1979). Target plant communities in intermediate and brackish marsh habitats would include Olney bulrush, saltmarsh bulrush, seashore paspalum, seashore saltgrass and annual grasses including millets and sprangletops, several sedges, and several annual forbs such as purple ammenia and Delta duck potato. Burning and grazing would also help provide optimal physical structure of vegetation for waterfowl utilization of emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining plant communities with low growth habits such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions would also provide excellent habitat for many invertebrate species, another important food source for waterfowl and other migratory birds.

Waterfowl habitat on newly acquired lands would be enhanced through the control of undesirable invasive vegetation such as common reed, cattail, and California bulrush in areas where these plants have formed dense homogeneous stands and resulted in loss open water habitats. Infestations of exotic and invasive floating plants such as water hyacinth, alligatorweed and Salvinia would also be controlled to restore and maintain open water habitats. Maintaining an interspersion of open water and vegetated emergent wetlands would provide the habitat diversity needed to support wintering waterfowl and other migratory birds. Restoring open water habitats would increase the production of submerged and floating aquatic plants, an important food source. Control of Chinese tallow and deep-rooted sedge in and adjacent to freshwater marshes, moist soil units and rice fields would also enhance waterfowl habitat.

The USFWS would implement shoreline protection and restoration activities on newly acquired lands, which would enhance wintering waterfowl habitat by decreasing saltwater intrusion into inland marshes and reducing threats of additional saltwater intrusion. If successfully implemented, large-scale restoration of the barrier beach/dune system on newly acquired lands within McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR could substantially enhance wetland habitats for wintering waterfowl on these refuges. Offshore rock breakwaters and shoreline armoring on East Galveston Bay and the GIWW would protect habitats of high importance to wintering waterfowl.

(2). Impacts to Resident Waterfowl - Mottled Ducks

Mottled Ducks are year-round residents of the Chenier Plain region. This species prefers fresh to slightly brackish marshes (Gosselink *et a*l. 1979), although a variety of marsh habitats, prairie, and agricultural wetlands (rice fields) are also utilized. Mottled Ducks in the project area are part of the western Gulf Coast (WGC) population of Mottled Ducks. Banding studies have indicated that WGC Mottled Ducks do move between Mexico, Texas, Louisiana and Mississippi and Alabama, but no interchange occurs between this population and the Florida population of Mottled Ducks.

Mottled Duck numbers on the Refuge Complex (and other national wildlife refuges on the Texas Coast) have declined precipitously during the last 20 years, as indexed by annual breeding pair surveys and monthly aerial counts conducted September through March (USFWS, Division of Migratory Birds, unpublished reports). Stutzenbaker (1988) reported that the most serious threat facing Mottled Ducks is degradation and loss of habitat. In Texas, factors contributing to loss of habitat include conversion of native habitats for agricultural and urbanization, drainage, marsh subsidence, saltwater intrusion, spread of introduced species (Stutzenbaker 1988, Morton and Paine 1990), as well as increased pollutants (Cain 1988). Saltwater intrusion into wetlands that range from fresh to moderately brackish probably affects growth and survival of ducklings (Moorman *et al*. 1991). Encroachment of Chinese tallow into nesting habitat probably leads to abandonment of nesting areas (Stutzenbaker 1988). Other potential factors influencing Mottled Duck populations include extended periods of drought, mortality from predation due to increasing populations of alligators and possible increases in mammalian predators, a continued high incidence of lead pellet ingestion, and harvest (USFWS Division of Migratory Birds, unpublished reports).

Under Refuge Expansion Alternatives B, C and D, the following habitat management and restoration activities would continue to be the primary management activities impacting Mottled Ducks on newly acquired lands. All would be expected to have positive impacts on this species, although the landscape level issues described above are likely to control population dynamics of the WGC Mottled Duck population.

(a). Wetlands Management and Restoration

Wetland management and restoration activities on newly acquired lands under Refuge Boundary Expansion Alternatives B, C and D would provide and enhance habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Managing water levels and salinities in managed coastal marsh units would maintain fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. Marsh management also would enhance diversity and productivity of submerged aquatic vegetation which provides important year-round food sources for Mottled Ducks. Moist soil management and the cooperative rice farming program would provide critical shallow freshwater habitat and nutritious food resources for use by Mottled Ducks year-round. The USFWS would manage selected moist soil units each year specifically to provide brood-rearing habitat for Mottled Ducks during summer.

(b). Uplands Management and Restoration

The historical prairie-wetland continuum of the upper Texas Coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and

mima mounds that are characteristic of native coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as "sennabean ponds," as valuable brood rearing habitat.

Under Refuge Boundary Expansion Alternatives B, C and D, native prairie restoration and management activities on newly acquired lands would benefit Mottled Ducks primarily by protecting, restoring and enhancing nesting and brood-rearing habitats.

The native coastal prairie habitats within the proposed refuge boundary expansion areas under Refuge Boundary Expansion Alternatives C and D have great potential to provide high quality nesting and brood-rearing habitat for this species. USFWS management activities in native prairie habitats and adjacent fallowed agricultural lands would be aimed at increasing native plant species diversity and productivity. The USFWS would use integrated application of prescribed burning, controlled livestock grazing, herbicide application, and mowing/haying to restore the historic mosaic of prairie plant communities and the different structural characteristics of these habitats. Brush encroachment by exotic and native plant species would be reduced. Previously-drained shallow depressional "prairie wetlands" within extant stands of native prairie would be restored. Additional native prairie and freshwater wetlands (using moist soil management) would be restored on adjacent fallowed agricultural fields. Restored and enhanced prairie habitats and prairie wetland habitats would likely increase overall reproductive success of Mottled Ducks in the project area.

(c). General Habitat Management Activities

Under Refuge Expansion Alternatives B, C and D, the USFWS would use prescribed burning, grazing, and exotic/invasive species management, and shoreline protection and restoration activities on newly acquired lands. The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats would enhance wetland and upland habitats used by Mottled Ducks during all life history phases: pair formation, breeding, nesting, brood rearing, molting and wintering. Exotic and invasive plant and animal control activities would also enhance wetland and upland habitats for Mottled Ducks, as would shoreline protection and restoration activities. If successfully implemented, large-scale restoration of the barrier beach/dune system on newly acquired lands within McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR would enhance wetland habitats for Mottled Ducks on these refuges. Offshore rock breakwaters and shoreline armoring on East Galveston Bay and the GIWW would protect habitats of high importance to Mottled Ducks.

(3). Impacts to Shorebirds, Wading Birds, and other Marsh and Waterbirds

Because the category of shorebirds, wading birds, and other marsh and waterbirds consists of a wide variety of species, individual species use microhabitats (e.g., vegetative cover and water depth) differently than other species in the same category (Gosselink *et al*. 1979, Skagen *et al.* 1999). For example, bare to sparse vegetative cover for foraging is preferred by species such as Piping Plover (Federally listed Threatened) and the Least Tern (State-listed Endangered). Denser vegetation is preferred by other species, for example Little Blue Heron, Black-crowned Night Heron, Yellow-crowned Night Heron, Least Bittern, American Bittern, King Rail, and Clapper Rail. Other species have broad vegetation density requirements, and can utilize areas ranging from relatively bare of vegetation to dense vegetation, for example Reddish Egret (State-listed Threatened) and Wood Stork (State-listed Threatened).

This category of avian species also varies greatly in the amount of soil moisture and water depths they prefer, usually for feeding activities. These requirements range from relatively dry or shallow water (a few centimeters deep), such as the Piping Plover, to slightly deeper (but still relatively shallow) water, such as the Western Sandpiper and Least Sandpiper, to waters about 8-12 cm deep, such as the Black-bellied Plover and Willet. Other species prefer deeper waters, often within wading depth for long legged birds, such as the White-faced Ibis (State-listed Threatened) and the Least Tern. Some species can utilize deep waters as well as shallower waters (Wilson's Phalarope, Red-necked Phalarope, Olivaceous Cormorant, Double-breasted Cormorant, Laughing Gull, and Forster's Tern). Some species are year-

round residents, such as Brown Pelican (Federally listed Endangered), Double-breasted Cormorant, Great Blue Heron, Little Blue heron, Great Egret, and Black Skimmer. Other species are mostly migrant, including Wood Stork, White Ibis, and Forster's Tern.

Because of the wide diversity of habitat requirements by this category of birds, USFWS habitat management and restoration activities on newly acquired lands which result in a mosaic of diverse habitat types (plant species composition, structural characteristics, water levels and salinities) would positively impact shorebird, wading bird, marsh and waterbird species found in the project area.

(a). Wetlands Management and Restoration

The USFWS would manage water levels and salinities (by utilizing water control structures, levees, impoundments, etc.) in structurally managed marshes on newly acquired lands, which would protect and enhance habitats used by many avian species in this group. In general, shorebirds and wading birds would benefit from moist soil management and rice farming activities on newly acquired lands that would result in increased abundance of invertebrates and plants that are a preferred food source (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002). The timing and depth of flooding on managed agricultural fields would influence the type of and intensity of use by such birds (Huner *et al*. 2002).

The USFWS would manage some moist soil units on newly acquired lands specifically to provide wetland and mudflat habitat for shorebirds during spring and fall migrations. Targeted shorebird species would include several species identified as Avian Species of Conservation Concern and/or as needing conservation action under the U.S. Shorebird Conservation Plan, Gulf Coast Joint Venture All-bird Conservation Initiative and North American Waterbird Conservation Plan: Long-billed Dowitcher, Semi-palmated Plover, Black-bellied Plover, Black-necked Stilt, Whimbrel, American Avocet, Long-billed Curlew, Hudsonian and Marbled Godwits, and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted Sandpipers. Wading and marsh bird species using moist soil habitats would include American Bittern, Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, Tri-colored Heron, Black-crowned and Yellow-crowned Night Herons, White Ibis, White-faced Ibis, and Roseate Spoonbill.

(b). Uplands Management and Restoration

Under Refuge Boundary Expansion Alternatives B, C and D, restoration and enhancement of native prairie habitats on newly acquired lands would benefit some avian species in this category, primarily by providing improved habitat for migrating and wintering birds. Three Avian Species of Conservation Concern (USFWS 2005) (also listed as needing conservation action under the U.S. Shorebird Conservation and North American Waterbird Conservation plans) would benefit from these activities: Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would conduct prescribed burning, controlled grazing, and exotic/invasive species management, and shoreline protection and restoration activities on newly acquired lands. The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats would enhance wetland and upland habitats used by many shorebird, wading bird and marsh bird species. Water management activities in coastal marshes which maximize the annual production of desirable submerged aquatic plant species provide improved habitat for invertebrates and small vertebrates, which are the primary prey items for many shorebird, wading bird and marsh bird species. Prescribed burning and controlled livestock grazing would help create optimal physical structure of vegetation for shorebirds and wading birds in emergent marshes and other vegetated wetlands (flooded moist soil and rice fields) by creating openings in otherwise dense stands of vegetation and maintaining short plant communities such as seashore paspalum which when shallowly flooded provide ideal habitat conditions. These conditions

also provide excellent habitat for many invertebrate species, another important food source for shorebirds. Exotic and invasive plant and animal control activities would also enhance wetland and upland habitats for these species. The removal of invasive vegetation that forms dense, homogeneous stands resulting in pond closure, such as common reed, cattail, and California bulrush, would improve habitat conditions for wading bird and marsh and waterbird species that utilize open water habitats. Shoreline restoration activities including dune restoration and creation of emergent marsh and mudflats in intertidal zones behind breakwaters would benefit many shorebird and wading bird species.

Short-term studies show that the lack of vegetative cover in the months immediately following a burn has a negative effect on King and Clapper Rails (Sikes 1984), Yellow Rails (Mizell 1998), sparrows (*Emberizidae*) and wrens (*Troglodytidae*) (Gabrey *et al*. 1999). In some situations, leaving unburned patches of vegetation for cover for Yellow Rails (Mizell 1998), sparrows, and wrens (Gabrey *et a*l. 1999) can partially mitigate this negative effect. Fires in coastal wetlands are considered stand-replacing fires (Wade *et al*. 2000). Not surprisingly, these secretive marshland bird species decline in the first year post fire. Other bird species such as Icterids (Gabrey *et a*l. 2001) and Wilson's Snipe (USFWS unpublished data) increase immediately post-burn.

The susceptibility of wildlife to mortality during fire events seems to be dependent on weather, fuel characteristics (moisture, loading and continuity), fire characteristics (as influenced by ignition strategies), and the capability and behavior of the species in question. Black rail mortality has been observed where large areas are burned with little unburned escape cover available, while mortality was not observed in a burn containing a mosaic of unburned escape cover (Legare *et al*. 1998). No fire induced mortality was observed for three species of rail during fire operations on the Texas mid-coast, though data were insufficient to draw strong conclusions (Grace *et al*. 2005). Burns conducted under fuel and weather conditions that allow for patches of unburned habitat within the unit may minimize wildlife mortality. Burns ignited in a way that maximizes escape options, primarily through the use of backing and widely spaced strip flanking fires, probably minimizes wildlife mortality while maintaining fire-dependent habitat. The USFWS would use these techniques in prescribed burning operations on newly acquired lands.

Some USFWS management activities on newly acquired lands could negatively impact some species of shorebirds, wading birds, and marsh and waterbirds. For example, some species in this group have a relatively narrow range of optimal water depth for feeding and other activities, ranging from almost dry sediment to relatively deeper water (Skagen *et al*. 1999). Management activities that increase water depth may negatively impact those species that prefer shallow or no water, and those that prefer deeper water are negatively impacted when management activities lower water levels. Similar impacts could occur with management of vegetative cover, as some species prefer areas devoid of vegetation, while others prefer heavy vegetative cover. However, most avian species in this group (especially migrants) have evolved with unpredictable available resources, and are able to find suitable microhabitats in an adequately diversified landscape that contains a mosaic of microhabitats, both spatially and temporally. The USFWS strategy of management to maintain a mosaic of available habitats and resources should provide an adequate range of habitats for this group of avian species.

Other habitat management activities could negatively impact some species of shorebirds, wading birds, marsh and waterbirds, especially if improperly implemented or timed. Grazing could negatively impact some ground-nesting species such as Black-necked Stilts by trampling nests and grazing on emergent pond vegetation used by those birds, and may also disturb nesting pairs (Whyte and Cain 1979).

(d). Management of Oil and Gas Exploration and Development

Lands acquired under Refuge Boundary Expansion Alternatives B, C and D would be acquired subject to exploration and development of reserved and outstanding mineral interests. Under Refuge Boundary Expansion Alternatives B, C, D, the USFWS would continue to manage oil and gas exploration and development activities on newly acquired lands through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to shorebirds, wading birds, marsh and other waterbirds, including timing of activities to avoid major periods of utilization, offsets

to avoid nests and concentrations of birds, required use of specialized equipment, location and size of facilities, and required pollution controls.

The net effect of USFWS management of oil and gas exploration and development would be to reduce impacts on fish and wildlife resources, including avian species in this group, from these activities.

(4). Impacts to Landbirds

Landbird species found in the project area use a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf Coast (Mueller 1981, Barrow *et al*. 2000). Some raptor species prefer intermingled field and forested areas (e.g., red-tailed hawks and owls). Other land bird species prefer grassland habitats including marshes and prairies (Peterson *et al*. 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

All habitat management and restoration activities conducted by the USFWS on newly acquired lands under Refuge Boundary Expansion Alternatives B, C and D would benefit avian species in this group. Although comprising a relatively small portion of the overall habitats within the project area, restoration, management and protection of native prairies, coastal woodlots and near-coastal forested wetlands (bottomland hardwoods) are of particular significance because of the importance of these habitats to many passerine species, including many neotropical migratory birds.

(a). Wetlands Management and Restoration

The USFWS would implement wetland management and restoration activities on newly acquired lands. Managing water levels and salinities in coastal marshes, marsh restoration, moist soil management, and the cooperative rice farming program would benefit resident and migratory landbirds which depend on wetland habitats. Several landbird species listed as Avian Species of Conservation Concern (USFWS 2005), including the Seaside Sparrow, Nelson's Sharptailed Sparrow and Sprague's Pipit, would benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Many animal species typical of northern prairies, such as Henslow's Sparrows, smooth green snakes, and prairie voles, were all found year-round in the Gulf coastal prairies. Dickcissels still nest in these coastal grasslands, and many other avian species utilize Gulf coastal prairies as wintering and/or migratory habitat. Many of the landbirds that would benefit from protection and management of native coastal prairie habitats under Refuge Boundary Expansion Alternatives B, C and D are species that are declining in the Coastal Prairies Region of Texas (Shackelford and Lockwood 2000), and/or are among several species recently listed by the USFWS as "Avian Species of Conservation Concern" in the Gulf Prairies Bird Conservation Region (USFWS 2005). For example, White-tailed Hawk, Northern Bobwhite, Yellow and Black Rail, Buff-breasted Sandpiper, Short-eared Owl, Sedge Wren, and LeConte's Sparrow are all Avian Species of Conservation Concern that would benefit from conservation of prairie habitats on the Refuge Complex.

The native coastal prairie habitats within the proposed refuge boundary expansion areas under Refuge Boundary Expansion Alternatives C and D have great potential to provide high quality wintering and nesting habitat for several grassland songbird species. The USFWS would manage and restore native prairie habitats and adjacent fallowed agricultural lands on newly acquired lands to increase native plant species diversity and productivity. The USFWS would use integrated application of prescribed burning, controlled livestock grazing, herbicide application, and mowing/haying to restore the historic mosaic of prairie plant communities and the different structural characteristics of these habitats. This habitat

diversity would in turn support many species of grassland songbirds. Native prairie and other upland grassland habitats on newly acquired lands would provide enhanced wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow and Nelson's Sharptailed Sparrow, and nesting habitat for species including Dicksissel and Eastern Meadowlark. Landbirds listed as Avian Species of Conservation Concern utilizing prairie habitats and which would benefit from conservation and management of native coastal prairie in the project area include LeConte's Sparrow, Henslow's Sparrow, Sedge Wren, Loggerhead Shrike, and White-tailed Hawk.

Woodlot Restoration and Management

Although comprising a small percentage of the upland habitats in the project area, coastal woodlots help support a diverse avian community, which includes several sensitive songbird species. Six of the seven avian species listed as Rare and Declining within the coastal prairies region in Texas are present in the project area's coastal woodlots. Migratory birds also depend on coastal woodlots for cover and food. At least 63 species of migratory birds regularly use the wooded habitats of the Chenier Plain region prior to or immediately after crossing the Gulf of Mexico (Barrow *et al.* 2000). Trans-gulf or circum-gulf migratory songbirds use Texas coastal woodlots as stopover habitat (Mueller 1981), which is critical at a time when the birds are depleted of water and energy reserves (Leberg *et al.* 1996).

A primary threat to coastal woodlots is encroachment by the Chinese tallow tree, which provides poor habitat for migratory songbirds. Although the Chinese tallow trees attract birds as frequently as other trees, they provide poorer forage because of sparse insect populations. Specifically, they harbor fewer insects and spiders, especially *Lepidopteron* larvae. Chinese tallow woodlots may thus be an "ecological trap" that provide cover but little food for migrants when they are energy-depleted after migration (Barrow and Renne 2001). Rooting by feral hogs can also damage understory vegetation and soils, and may also cause a shift in plant succession. Such activities can also create disturbed areas that enable easier establishment of invasive plant species. Feral hogs may also directly compete with several species of native wildlife for certain foods.

Under Refuge Boundary Expansion Alternatives B, C and D the following USFWS management actions on newly acquired lands would have beneficial impacts on coastal woodlots: 1) native tree and shrub plantings; 2) exotic/invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts.

Under Alternative D, the USFWS would protect bottomland hardwoods along Taylors Bayou in Jefferson County, an important near-coastal forest that is heavily utilized by neotropical migratory birds, especially during spring migration. Radar studies have identified this area as an important annual "fall-out" area, where large numbers of songbirds stop to rest and renew energy reserves following their trans-Gulf migration (Dr. Sidney Gauthreaux, Clemson University, personal communication).

Overall, implementation of the USFWS management activities on newly acquired lands would improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced coastal woodlots would provide quality habitat for neotropical migratory birds and resident songbirds that require native trees or understory for cover and foraging. Protecting a riparian bottomland hardwood forest under Refuge Boundary Expansion Alternative D would ensure conservation of a near-coastal forest which is especially valuable to neotropical migratory birds. Species to benefit would include three neotropical migratory birds considered to be Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler. Since acreage of woodland habitat in the project area is small relative to its importance to migrating neotropical migratory birds and resident landbirds, such positive impacts for each acre protected are proportionately significant.

(c). General Habitat Management Activities

The USFWS would use prescribed burning, controlled grazing, exotic/invasive species management, and shoreline protection and restoration on newly acquired lands. The integrated combination of water level

and salinity management, fire management and controlled livestock grazing would enhance wetland and upland habitats used by many landbird species. Exotic and invasive plant and animal control activities would also enhance wetland and upland habitats for these species, especially in grassland and coastal woodlot habitats. For example, control of Chinese tallow would lead to increased diversity of native woody plants in the coastal woodlots, as well as increased forage insects (especially Lepidopteran larvae) for migrating passerines and other birds. Chinese tallow stands have an ecological trap effect for migrant songbirds that are drawn to the cover of the woodlots, but then find insufficient food resources to replenish depleted energy reserves (Barrow and Renne 2001).

Seaside Sparrow habitat use is influenced by fire. Whitbeck (2002) found densities of singing males 2.8 (2.2-3.2) times higher the second breeding season following fire than the first, third or fourth season. Gabrey *et al*. (2001) reported that breeding Seaside Sparrows in Louisiana declined in the first year post-fire, increased in the second, and dropped to levels similar to the first year post-fire by the third. It is possible that second year post-fire habitat offers the greatest interspersion of nesting and foraging habitat, though this theory has yet to be tested.

Gabrey *et al*. (1999) found that Seaside Sparrows, Nelson's Sharp-tailed Sparrows, Marsh Wrens, and Sedge Wrens declined in the first winter following a burn, but returned in the second winter. In some situations, leaving unburned patches of suitable habitat can partially mitigate this negative effect. Baldwin (2005) studied over-wintering passerines in coastal prairie on the Texas Mid-Coast. This study found that Savannah Sparrows were highly associated with prairies the first year post-burn, LeConte's Sparrow were most common in prairies burned within the past two years, and Sedge Wrens were most likely to be found in prairies three years post fire. These data indicate that a burn regime varied temporally and spatially is the key to providing habitat for native wildlife and that an inactive burn program can be detrimental to grassland dependent wildlife.

The USFWS fire management program on newly acquired lands would incorporate known habitat needs of the diverse avian communities found on the refuges.

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al*. 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al*. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al.* 1990, Kneib 1991, Rozas 1995).

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would continue to structurally manage marshes, restore coastal wetlands, and conduct vegetative management activities including prescribed burning, controlled livestock grazing, exotic plant and animal control, and shoreline restoration and protection. These management activities would protect, restore and enhance estuarine wetlands, and ensure wetland habitat diversity and productivity important to a variety of fish and shellfish species. The continuum of fresh to saline aquatic environments in the project area support highly diverse aquatic vertebrate and invertebrate communities.

Managing water levels and salinities (using water control structures, levees, impoundments, etc.) in managed marsh units may restrict access of some finfish and invertebrate fisheries species to managed areas. Actively managing water levels may impede access for some aquatic organisms, such as fish and crustaceans (Rogers *et al.* 1992, Kuhn *et al.* 1999). A well vegetated marsh that is not regularly inundated and not accessible to fisheries and invertebrates may not be as productive for fisheries as a

natural stable or deteriorating deltaic marsh (Peterson *et al*. 1994). Densities of resident fisheries in structurally managed marshes can be either higher or lower than unmanaged marshes, depending on implementation of spring drawdown (Rozas and Minello 1999). In contrast to resident species, this study found transient species to be lower in structurally managed marshes regardless of drawdown.

Impacts of structural marsh management to fisheries resources would be reduced by the USFWS on newly acquired lands by incorporating design features into existing water control structures such as vertical slots which allow passage of estuarine organisms, managing structures to facilitate ingress and egress by opening gates during key movement periods, and utilizing rock weirs to counter erosion and enlargement of tidal waterways (as opposed to traditional fixed crest weirs). Ingress/egress slots allow more marine organism passage than fixed crest weirs, with larger openings allowing greater fisheries access (Herke *et al*. 1992). These slots provide a means of allowing movement of estuarine organisms in and out of structurally managed marshes, but assist in maintaining the fresher end of the coastal marsh continuum.

Periods of peak ingress and egress movements are associated with water level fluctuations and tidal cycles. Highest peak fisheries resource movements are often related to periods of combined lunar cycles and major tidal movements. Manipulating water control structures during the full moon and new moon of the lunar cycle allows opportunity for the maximum ingress potential of fisheries resources. Holding slight levels of excess water for several days prior to these cycles and releasing during peak ingress periods greatly increases access to the unit from fisheries species dependent on coastal estuaries. Many species will move towards fresher water during incoming tides (Guillory 1996). The USFWS would also use these techniques on newly acquired lands to enhance fisheries utilization of managed marsh units.

Structural marsh management is employed on portions of the Refuge Complex to reduce impacts of saltwater intrusion and subsequent marsh loss as well as to maintain the historic salinity gradient that characterized coastal marshes of the Chenier Plain. Target salinity ranges typical of structurally managed marshes range from fresh to the low end of brackish, being primarily intermediate (0.5-5.0ppt). While these salinity ranges are used by estuarine species, a study of fisheries use along a salinity gradient in Galveston Bay (Zimmerman *et al*. 1990) found estuarine fisheries were not greatly attracted to intermediate (oligohaline) marshes of the Trinity River delta. This study concluded that the oligohaline environment was not favorable for development of preferred foods, primarily epiphytic algae and peracarid crustaceans. Further, while transient species such as juvenile shrimp, crabs, and fishes had ready access to oligohaline marshes in this area, they did not use them extensively. These data indicate that while water control structures may limit ingress/egress of estuarine organisms, the habitat within may not be optimum for these organisms compared to brackish and saline marshes available on the Refuge Complex.

(6). Impacts to Threatened and Endangered Species

Three avian species occurring in the project area are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon, Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Under Refuge Boundary Expansion Alternatives B, C and D, protection, restoration and management of coastal wetland habitats on the Refuge Complex would benefit the three avian T&E species. Bald eagles observed on the Refuge Complex are usually associated with large concentrations of wintering waterfowl. Brown pelicans utilize shorelines and tidal saline ponds for resting and foraging. Shoreline restoration and protection activities would provide improved habitat for Piping Plover and Brown Pelican. Conservation and management of both wetland and upland habitats aimed at ensuring biological integrity

and biological diversity under Refuge Boundary Expansion Alternatives B, C, and D would benefit Threatened and Endangered species and many other sensitive or declining native fish and wildlife species, including several State-listed T&E species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

Mammals typically found in the project area include muskrats, coyotes, raccoons, bobcats and river otters. Vegetation and other habitat requirements vary greatly among the different mammal species. Muskrat habitat includes brackish and intermediate marshes where they can build burrows or lodges from vegetation or underground. Coyotes and bobcats are found in a wide variety of habitats (but prefer early successional stages of vegetation), and are also highly opportunistic omnivores, adapting to a wide variety of food sources. Raccoons utilize canal levees, bayou edges, mud banks and beaches, marshes, and upland habitats, feeding largely on fish and crayfish, but also many plant species. River otters use various wetland habit types, including open waters, feeding mainly on various aquatic and semi-aquatic fish, shellfish and small animals.

In general, USFWS habitat management and restoration activities on newly acquired lands under Refuge Expansion Alternatives B, C and D which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of wildlife species.

USFWS management activities under which maintain and restore freshwater wetland habitats (structural management of marshes, moist soil management, rice farming) are particularly beneficial to amphibians and reptiles. Reliable freshwater habitat is critical for most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators. Habitat conditions which increase the abundance of insects, crustaceans, and other small prey benefit most species of amphibians and reptiles during at least a portion of their lifecycle. Surveys conducted on and around McFaddin NWR found that anurans have a strong preference for structurally managed marshes compared to adjacent unmanaged areas (USFWS 2006). This indicates that lower salinities provided through structural marsh management is preferable over higher salinities found in unmanaged areas.

Control of exotic and/or invasive woody species in wetland and upland habitats on newly acquired lands may decrease habitat quality for certain mammals such as raccoon and striped skunk. Large, intense and fast-moving fires may result in direct mortality of less mobile species such as small mammals, amphibians, and some reptiles, and invertebrates.

Fire has been shown to alter invertebrate communities in marshes and prairies. A study conducted in brackish marshes (*Distichlis spicata* being the dominant plant species) found that many dominant macro- and microinvertebrates were at higher densities in burned areas than unburned controls (de Szalay and Resh 1997). A notable exception was lower densities of copepods in burned areas. A review of literature available on the effects of fire on invertebrates (Higgins *et al.* 1989) summarizes by saying “Fire causes an immediate decrease in insect populations (except ants and other underground species), followed by a gradual increase in numbers as the vegetation recovers. The insects eventually reach a population level higher than adjacent areas, then decline to near preburn levels as vegetation and soil litter stabilize.” Research conducted in coastal prairie in Galveston County, Texas found that arthropod diversity increased with frequent burning (Hartley, unpublished data). It appears that fire management practices that favor desired vegetation conditions seem to be compatible with maximizing arthropod diversity as long as a mosaic of burned an unburned habitats is maintained.

b. Impacts from Public Use Programs

The USFWS would administer priority wildlife-dependent uses, including hunting, fishing, wildlife observation and photography and environmental education and photography on newly acquired lands identified under Refuge Boundary Expansion Alternatives B, C and D. This would make new recreational and educational opportunities available to the general public.

The USFWS would open specific areas within newly acquired lands to the public for these uses. Facilities similar to those currently found on the Refuge Complex including trails, boardwalks, observation decks, boat ramps and fishing piers would be developed over time to support these uses. Regulations similar to those currently governing public uses on the Refuge Complex would be in place to protect natural resources and public safety. The USFWS would maintain closed areas on portions of newly acquired lands to provide undisturbed habitats for migratory birds and other wildlife.

(1). Impacts to Waterfowl

(a). Waterfowl Hunting

The most direct effect of hunting on newly acquired lands would be the mortality of harvested waterfowl species resulting from the hunting activities. However, because regulations governing harvest in the Central and Mississippi Flyways are developed annually under the USFWS' national migratory bird hunting regulation frameworks and are designed to ensure that viable waterfowl populations are sustained over the long-term, waterfowl hunting on newly acquired Refuge lands will not have any measurable effect on overall populations and the long-term viability of these populations.

Many studies have documented the effects of hunting on intensity on the number of birds utilizing an area (Reichholf 1976, Madsen *et al.* 1992 as cited by Fox and Madsen 1997, Wolder 1993). These studies have shown that relatively light hunting pressure can reduce waterfowl abundance in hunted areas. Distribution and habitat use, feeding patterns, and the nutritional status of waterfowl have also been shown to be affected by hunting activities. Hunting activity can cause birds to alter habitat use, change feeding locations (Madsen 1995), feed more at night (Morton *et al.* 1989) and reduce the amount of time spent feeding (Korschgen *et al.* 1985, Madsen 1995). Collectively, these changes in behavior have the potential to adversely impact the nutritional status of waterfowl (Belanger and Bedard 1995).

Means of access to and within new hunt areas would include motorized boating, non-motorized boating, motorized vehicles, and walking and bicycling. Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use, but these impacts are likely less than those caused by motorized boating.

Monthly aerial surveys of wintering waterfowl on the Refuge Complex have documented the disproportionate use of established sanctuary areas by waterfowl, as compared to the areas open to hunting. This further supports the above studies and indicates that hunting affects the overall distribution of wintering waterfowl on the Refuge Complex. The size, location and habitat quality of sanctuary areas on the Refuge Complex remains critically important to ensure that migrating and wintering populations of waterfowl maintain sound nutritional and physiological status.

The USFWS would establish sanctuary areas on newly acquired lands to ensure that wintering populations of waterfowl maintain sound nutritional and physiological status in advance of migration and nesting. Providing waterfowl with predictable undisturbed sanctuary areas likely increases the ability of birds to meet the obligations of their annual cycle. Waterfowl undergo considerable physiological demands during winter. Heitmeyer (1988) estimated that prebasic molt in female mallards required and additional three grams per day of protein over base metabolic rates. These demands approach the estimated five grams per day associated with reproduction. Pair formation for most North American waterfowl takes place away from the breeding grounds. Waterfowl must accumulate endogenous energy reserves to meet the demands of courtship (Baldassarre and Bolen 1994). Baldassarre and Bolen (1994) proposed that birds that do not accumulate energy reserves may have less time and energy at their disposal to initiate courtship and/or may be unable to maintain previously established pair bonds. Clearly, birds must meet high energy demands to successfully fulfill critical wintering components of their annual cycle. Further, Heitmeyer and Fredrickson (1981) build a scenario where endogenous reserves established on wintering grounds return mallards to breeding areas in better condition to begin nesting, leading to larger clutch sized and earlier nests, which tend to be more successful. Providing sanctuary

areas of adequate size, encompassing and/or adjacent to quality feeding areas, may contribute to the ability of birds to meet the physiological demands required during winter and possibly the subsequent nesting cycle.

It has been shown that sanctuary areas on the wintering grounds are effective in maintaining local waterfowl populations in a landscape subject to hunting pressure (Bellrose 1954, Madsen 1998). Heitmeyer and Raveling (1988) found that waterfowl used sanctuaries during the day and local rice fields at night. Similarly, Fleskes *et al*. (2005) found Northern Pintail used areas closed to hunting during the day and dispersed throughout the area at night. These data indicate that while sanctuaries are effective in maintaining local waterfowl populations through the hunting season, birds must disperse at night to feed.

Refuge-specific hunting regulations for new hunt areas on newly acquired lands would help mitigate the impacts of hunting activity-related disturbance to waterfowl. Waterfowl hunting in hunt areas would be allowed three days per week, and all hunting activity would be curtailed each day at noon. The non-hunted days and afternoon and evening closures would provide undisturbed periods within the hunt areas, facilitating waterfowl utilization of hunt area habitats for foraging and resting. Regulations would also govern means of access to hunt areas, including boat motor and horsepower restrictions, prohibition of airboat and all-terrain vehicle use, and establishment of areas in which only non-motorized boat access is allowed. While these regulations would be in place primarily to protect habitats and public safety, they would also reduce overall disturbance impacts to waterfowl and other migratory birds

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation

Primary means of access to areas on newly acquired lands for fishing and wildlife observation and photography would include motorized and non-motorized boating and motorized vehicles on roads open to the public. Motorized vehicles and walking would be used to access areas used for environmental education and interpretation. The USFWS would develop trails, boardwalks, observation platforms and fishing piers and boat ramps on newly acquired lands.

Motorized boating has been shown to affect the abundance, distribution and habitat use of waterfowl and other birds (Skagen 1990, Bauer *et al*. 1992, Dahlgren and Korshgen 1992). Non-motorized boats, vehicles on roads, and walking also have potential to disturb waterfowl and influence distribution and habitat use.

Disturbance of waterfowl by visitors would likely be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993). In wetland habitats, disturbance from “out of vehicle” approaches can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). While some species of waterfowl appear to acclimate to vehicular traffic, and even presence of visitors on trails, boardwalks, and observation platforms, other species are less tolerant of disturbance. Overall it is likely that species composition and abundance of waterfowl would be decreased in areas supporting these recreational uses.

(2). Impacts to other Migratory Birds - Shorebirds, Wading Birds, other Marsh and Waterbirds and Landbirds

(a). Waterfowl Hunting

Although the impacts of waterfowl hunting on newly acquired lands to other wetland-dependent migratory and resident birds which are not hunted is likely less than for waterfowl, studies have demonstrated that hunting (including accessing hunt areas) does affect abundance and distribution of these other avian species. The noise associated with shooting likely reduces habitat utilization by shorebirds, wading birds, other marsh and waterbirds, and landbirds using wetland habitats within hunt areas, at least while hunting is occurring. Motorized boating disturbs and displaces many waterbird species (Dahlgren and Korschgen 1992, Knight and Cole 1995), as will non-motorized boats, vehicles and walking through the marsh.

(b). Fishing, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach, and other Uses

Primary means of access to areas on newly acquired lands opened for fishing, wildlife observation and photography would be motorized and non-motorized boating and motorized vehicles on roads open to the public. The USFWS may also develop walking trails, boardwalks and observation platforms, boat ramps and fishing piers to support access for these uses on newly acquired lands. Motorized vehicles and walking would be used to access areas used for environmental education and interpretation.

Disturbance of migratory birds by visitors would likely to be greatest in concentrated areas of use, including along trails, boardwalks, observation platforms and along roads (Klein 1993) and shoreline areas regularly used for fishing. Along roads through wetland habitats, disturbance from "out of vehicle" approaches for observation and photography can reduce the time spent foraging by some waterbirds, or even cause avoidance of areas that are highly disturbed (Klein 1993). Walking on trails tends to displace birds and can cause declines in species richness and abundance (Riffell *et al*. 1996). Some generalist avian species such as house finches tend to increase near trails, while specialist species such as solitary vireo move away from trails. The zone of influence around trails appears to be approximately 75m for woodland areas adjacent to grasslands (Miller *et al*. 1998).

Disturbance impacts to birds from visitation are often magnified during the breeding season. Color of clothing worn can attract or repel different passerine species based on breeding plumages of those species (Gutzwiller and Marcum 1997). Primary song occurrence and consistency of certain passerines can be impacted by a single visitor (Gutzwiller *et al*. 1994), which could limit the number of breeding pairs and production by those species in disturbed areas (Reijnen and Foppen 1994). Predation on songbird, raptors, colonial nesting species, and waterfowl nests tends to increase near more frequently visited areas (Glinski 1976, Buckley and Buckley 1978, Boyle and Samson 1985, Miller *et al.* 1998).

(3). Impacts to Fisheries

(a). Fishing

The most direct effect of fishing on areas opened for this use on newly acquired lands would be the mortality of harvested freshwater and saltwater fish, blue crabs, and several fish and shellfish species caught for use as bait. Fishing and crabbing would occur under regulations promulgated by the Texas Parks and Wildlife Department. These regulations are designed to ensure that viable fish and shellfish populations are sustained over the long-term. Fishing and crabbing should not have any measurable effect on overall populations and the long-term viability of these species' populations.

b). Waterfowl Hunting, Wildlife Observation and Photography, Environmental Education and Interpretation, Beach and other Uses

No impacts to fisheries resources are expected to occur as a result of administration of these public uses on newly acquired lands opened for these uses.

(4). Impacts to Threatened and Endangered Species

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

It is likely that Bald Eagles, Brown Pelicans and Piping Plovers using newly acquired lands would be subject to the some level of disturbance by public use activities. These impacts are expected to be negligible. Bald Eagles are usually associated with large concentrations of wintering waterfowl that occur in refuge sanctuary areas which are not open to the public. Piping Plovers utilize beach, shoreline and intertidal mudflat habitats primarily during fall and winter, when use of these habitats by the public is lightest. Brown Pelicans readily forage and roost adjacent to human activity and infrastructure. The three

T&E avian species do not nest within areas identified under Refuge Boundary Expansion Alternatives B, C or D, their presence is transient in nature, and they are highly mobile and able to move to undisturbed areas. Overall, no impacts to Federally-listed or State-listed Threatened and Endangered species are expected to occur as a result of continued administration of these public uses on lands newly acquired under Refuge Boundary Expansion Alternatives B, C or D.

(5). Impacts to other Fish and Wildlife Species – Mammals, Amphibians, Reptiles, and Invertebrates

(a). Waterfowl Hunting, Fishing, Wildlife Observation and Photography, and Environmental Education and Interpretation

It is likely that mammals and amphibians and reptiles would be subject to some level of disturbance from public use activities occurring on newly acquired lands, but these impacts are expected to be negligible. Vehicles would occasionally strike and kill mammals such as Virginia opossum, armadillo, raccoon and striped skunk, and reptiles and amphibians including alligators, snakes and frogs.

(b). Commercial Alligator Harvest

The USFWS may administer an adult alligator harvest program as an economic use on newly acquired lands. This program would be administered under regulations promulgated by the Texas Parks and Wildlife Department. State regulations are designed to ensure that viable alligator populations are sustained over the long-term. In addition, the USFWS would regulate the alligator harvest program through issuance of a Special Use Permit which contains stipulations also designed to conserve alligator populations. For example, special regulations would be in place to restrict harvest of reproductive-aged alligators and maintain a natural age structure in the alligator population. Expanding the commercial alligator harvest program currently being administered by the USFWS on the Refuge Complex to newly acquired lands would not have any measurable effect on the long-term viability of alligator populations.

(c). Control of Muskrat Populations

Herbivory in areas of high density muskrat populations can cause or exacerbate conditions resulting in permanent conversion of vegetated marsh to open water. This is likely to most prevalent in areas affected by saltwater intrusion, land subsidence or other factors contributing to marsh loss. The USFWS would control muskrat populations on newly acquired lands in specific locations as deemed necessary to protect wetland habitats through issuance of Special Use Permits for trapping and removal by qualified individuals. Trapping and removal of muskrats under this program would have negligible if any impacts on overall muskrat populations and the long-term viability of these populations.

c. Impacts from Biological Program – Surveys, Monitoring, and Research

The USFWS would implement a variety of field surveys and new and expanded scientific monitoring and research on newly acquired lands.

Surveys, monitoring and research activities for waterfowl would include: 1) monthly aerial surveys of waterfowl (September through March);) annual Mottled Duck breeding pair surveys; 3) national, regional and local banding studies of waterfowl, including ongoing banding studies of Mottled Ducks and Snow Geese; 4) data collection from harvested waterfowl at check stations including body condition indices and lead shot ingestion rates; 5) participation in the annual Audubon Society Christmas Bird Count; and 6) coordination of research studies on Mottled Ducks and other priority waterfowl species through partnerships with the USFWS Division of Migratory Birds, universities and the U.S. Geological Survey Biological Resources Division.

Surveys, monitoring and research for shorebirds, wading birds and other marsh and waterbirds would include: 1) an annual nesting survey for colonial nesting waterbirds on Gulf shoreline of Texas Point NWR; 2) periodic spring and fall shorebird surveys in various representative wetland habitats;

3) participation in the annual Audubon Society Christmas Bird Count; and 4) research studies on priority species through partnerships with the U.S. Geological Survey Biological Resources Division and academic institutions.

Surveys, monitoring and research activities for resident and migratory land birds would include: 1) periodic surveys of selected land birds in marsh, prairie and woodland habitats; 2) participation in the annual Audubon Society Christmas Bird Count; and 3) coordination of research studies on priority species through partnerships with universities and the U.S. Geological Survey Biological Resources Division.

Surveys and monitoring activities for fisheries resources to continue under Refuge Management Alternative A would include: 1) coordination with the USFWS Fisheries Program for periodic fisheries monitoring in representative wetland habitats; and 2) coordination with USFWS Division of Ecological Services and other State and Federal agencies to conduct periodic monitoring and studies of contaminant impacts to fisheries.

Surveys and monitoring activities indirectly benefiting T&E species would include: 1) participation in the annual coast-wide wintering Piping Plover survey; and 2) coordination of research studies on sensitive and/or declining species through partnerships with universities and the U.S. Geological Survey Biological Resources Division.

Aerial basking surveys and nighttime spotlight surveys to monitor alligator population trends would be expanded to include newly acquired lands. Data collection from harvested alligators and coordination and information sharing with the Texas Parks and Wildlife Department on alligator harvest management, population monitoring, and research would occur.

Information on species composition and relative abundance of invertebrates would be collected through "BioBlitz" events and other surveys conducted in partnership with universities, the U.S. Geological Survey Biological Resources Division, and volunteer naturalists. The North American Butterfly Association's Fourth of July Butterfly Counts would be expanded. These monitoring activities would provide baseline information on invertebrate populations.

Surveys and monitoring/research activities are useful for tracking and documenting the impacts of various management strategies on fish and wildlife populations, distribution, movements and habitat utilization. This information would facilitate implementation of an adaptive management approach which allows continual refinement and improvement of management activities.

d. Impacts from Management of Oil and Gas Exploration and Development

Lands acquired under Refuge Boundary Expansion Alternatives B, C and D would be acquired subject to exploration and development of reserved and outstanding mineral interests. The USFWS would manage oil and gas exploration and development activities on newly acquired lands within the Refuge Complex through the issuance of Special Use Permits. Stipulations in the Special Use Permit would include those aimed at minimizing impacts to fish and wildlife resources, including timing of activities to avoid major periods of utilization, required use of specialized equipment, location and size of facilities, and required pollution controls.

The net effect of USFWS management of oil and gas exploration and development on newly acquired lands would be reduced impacts to fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnership Efforts

Under Refuge Boundary Expansion Alternatives B, C and D, the USFWS would continue to develop partnerships with private land owners to restore and enhance wetland and upland habitats on private lands in the project area by: 1) providing technical assistance on habitat restoration and management activities; and 2) facilitating development of partnerships under the USFWS Partners for Fish and Wildlife

Program and other private lands initiatives such as the Texas Prairie Wetlands Project. To date, projects developed through these efforts have resulted primarily in improved water management in coastal marsh habitats (including reducing negative impacts of saltwater intrusion) and restoration of shallow freshwater wetlands.

It is anticipated that continuation of outreach and partnership efforts would result in benefits to fish and wildlife resources as important habitats are restored and enhanced on private lands. Projects such as those implemented to date would enhance wetland habitats for wintering waterfowl, Mottled Ducks and other wetland-dependent migratory birds, and for resident wildlife including several species of reptiles and amphibians which depend on freshwater habitat.

B. Socioeconomic Resources Section

1. Economic Impacts

Economic impacts from Refuge Boundary Expansion Alternatives B, C and D can be associated with changes in land use which would occur with the transfer of land from private to federal ownership. The changes in land use would occur in the following segments of the local economy:

- Rice farming on acreage within the USDA farm program
- Cattle grazing
- Commercial hunting operations
- Reduction in potential development for areas near Taylors Bayou.

a. Rice Farming - Reduction in Agricultural Support Programs

A large number of acres in the proposed refuge boundary expansion areas within Chambers and Jefferson counties are in the USDA farm program as base acreage for rice. However, a large percentage of this acreage is no longer used for rice production and is either being converted to improved pasture or is fallow. The USFWS would expand its cooperative farming program on acquired acreage that is currently in rice production due to the habitat benefits rice provides for migratory birds and other wildlife. However, the USFWS would generally not attempt to convert fallowed areas to rice production due to the cost associated with restoring water delivery infrastructure and removal of exotic plant species (e.g. Chinese tallow). The USFWS will manage some formerly cropped areas as native prairie or moist soil units and use grazing to help achieve wildlife habitat objectives. The success of this cooperative farming program will largely depend on the availability of farmers willing to work within the guidelines of the program including: 1) limits on harvest of the second ratoon crop of rice; 2) restrictions on herbicide and pesticide use; and 3) prohibition of some rotational crops. Overall, market conditions affecting rice production throughout the project area will likely be the primary factor affecting the USFWS' ability to expand the cooperative rice farming program on any newly acquired lands.

The USFWS currently manages a cooperative farming program with approximately 1,700 base acres registered with the USDA Farm Service Agency (FSA). Rice producers in the cooperative farming program are eligible for farm support programs. As discussed earlier, the USFWS would try to extend the cooperative farming program for additional acquired acreage that is currently in rice production so that it would also be eligible for farm support programs through the FSA. However, base acreage that is not currently in rice production would be converted to native prairies or moist soil units and thus would not be eligible for support payments. Although private landowners are able to collect payments even if acreage is not currently in rice production, the same is not true for federal acreage within the Refuge Complex. For these areas, cooperative farmers, contracted by USFWS, must actually be producing rice or conducting approved maintenance on the allotted base acreage to receive payments. Thus, it is likely that economic impacts could occur within the study area from a reduction in farm support due to a change in land ownership.

To help ensure viable and strong rice production in the United States, the Farm Security and Rural Investment Act of 2002 provides direct payments and counter-cyclical payments to producers for rice

crops. Eligibility for direct and counter-cyclical payments requires producers to sign an agreement with the Farm Service Agency (FSA), which administers this USDA farm program. Producers must also report annually all crop acreage and comply with conservation and planting requirements to establish eligible base acreage payments.

(1). Direct Economic Impacts from Reduction in Agricultural Support Programs

(a). Loss of "Direct Payments"

Direct payments are similar to production flexibility contract payments as they help absorb market shocks that affect production and prices. **The direct payment for rice is calculated as follows**:[20]

Direct Payment Rate X 0.85[Base Acreage] X [Direct Payment Yield]

The direct payment rate for rice within the years 2002-2007 is set at $2.35 per hundredweight (cwt). Producers are limited to direct payments not exceeding $40,000 per crop year and payments are decoupled from both current production and prices on eligible acres.

This information was used to estimate the average direct payment rate per acre for eligible farms in Jefferson and Chambers counties. For Texas, 591,649 acres of rice acreage are enrolled in the program.[21] Of this amount, 85 percent (502,900 acres) are eligible to receive direct payments. The specific yield per acre for Texas as estimated by FSA is 4.947 hundredweight (cwt). Multiplying the direct payment yield by the number of base acres eligible for the program and the direct payment rate of $2.35 per cwt resulted in total direct payments to producers in Texas of $58.4 million. Dividing the total direct payments in Texas by the number of eligible acres resulted in an average payment per base acre of $116 per acre.

An estimate of the base acreage within the Refuge Boundary Expansion Alternatives was made with information from the FSA. FSA provided maps and acreage figures for cropland, base acreage and production acreage within the acquisition boundaries. Using this data and GIS software, base acreage and acreage in current production was estimated by alternative and is summarized in Table 4-42. There are only a relative few rice producers left in the acquisition area. This finding is expected, as the majority of rice production is located in northern parts of Jefferson and Chambers counties.

Table 4-42
Estimated Rice Acreage by Alternative

	Refuge Boundary Expansion Alternative			
Acreage Type	No Action	Alternative B	Alternative C	Alternative D
Crop Acreage	0	5,965	13,730	30,874
Eligible Base Acreage	0	3,026	3,506	13,290
Average Annual Production Acreage (2000 – 2004)	**0**	**197**	**421**	**2,457**

20 U.S. Farm Service Agency Online, Fact Sheet Electronic Edition, Rice Summary of 2002-2007 Program, April 2003, http: //www.fsa.usda.gov/pas/publications/facts/html/rice03.htm
21 Personal communication with Nathan Childs of the U.S. Department of Agriculture, (202)-694-5292.

Using the average direct payment per acre and the estimated base acreage, the total annual direct payments received by producers for rice acreage within the acquisition boundary was estimated for each alternative as summarized in Table 4-43.

Table 4-43
Estimate of Losses of Direct Payment for Rice by Alternative

	Refuge Boundary Expansion Alternative			
Refuge	No Action	Alternative B	Alternative C	Alternative D
Moody	$0	$0	$0	$0
Anahuac	$0	$315,647	$371,435	$1,171,163
McFaddin	$0	$36,161	$36,161	$374,133
Texas Point	$0	$0	$0	$0
Total	**$0**	**$351,808**	**$407,596**	**$1,545,295**

The direct payments summarized in Table 4-43 represent an upper bound estimate of the possible losses in direct payments if the USFWS were to acquire all historically cropped acreage within the boundary expansion area. It is likely that losses would not approach these upper end estimates because 7 to 20 percent of the base acreage is currently in production and would remain in production under USFWS ownership, and thus eligible for payments. Additionally, it is likely that current landowners would retain a certain percentage of the base acreage when farms are reconfigured after a portion of the farm is sold and included in the Refuge Complex.

(b). Loss of Counter Cyclical Payments

Counter-cyclical payments also are decoupled from current production. However, they are negatively correlated to current prices as the payments increase when market prices decline. **For rice, the counter-cyclical payment is calculated as follows.**[22]

Counter-Cyclical Payment Rate X 0.85[Base Acreage] X [Counter-Cyclical Payment Yield]

Counter-cyclical payments for rice are made when the target price for rice is above the effective price. The effective price is formulated from the direct payment price ($2.35) plus the higher of either the seasonal average farm price or the national loan rate[23]. For years 2002-2003 the rice crop target price is $10.50 per cwt and the rice loan rate is $6.50 per cwt. The counter-cyclical payment rate for 2003 was calculated by the FSA as follows because the seasonal average farm price ($3.85 per cwt) was below the loan rate.[24]

$10.50-[2.35+6.50] = $10.35-$8.85 = $1.65

Producers are limited to counter-cyclical payments not exceeding $65,000 per crop year. If the effective price is below the target price then producers receive counter-cyclical payments in addition to direct payments.

The information presented above was used to estimate a counter-cyclical payment that may occur on rice acreage in the areas under Refuge Boundary Expansion Alternatives B, C and D. The maximum payment would occur when farm prices are below the established rice loan rate of $6.50. If rice prices are above this rate, producers receive a smaller counter-cyclical payment. Therefore, a conservative

22 U.S. Farm Service Agency Online, Fact Sheet Electronic Edition, Rice Summary of 2002-2007 Program, April 2003, http: //www.fsa.usda.gov/pas/publications/facts/html/rice03.htm.
23 The National Agricultural Statistics Sevice determines the season average farm price.
24 U.S. Farm Service Agency Online, Fact Sheet Electronic Edition, Rice Summary of 2002-2007 Program, April 2003, http: //www.fsa.usda.gov/pas/publications/facts/html/rice03.htm.

estimate was used for this analysis and assumed that producers would receive the maximum counter-cyclical payment of $1.65 cwt produced on eligible acreage within acquisition boundaries.

The counter-cyclical payments were estimated by multiplying the counter-cyclical rate by the number base acres and the counter-cyclical payment yield (4.947 cwt). An estimate of the counter-cyclical payments that could be eliminated if USFWS were to acquire all rice acreage within the boundaries is summarized in Table 4-44.

Table 4-44
Estimate of Losses of Counter-Cyclical Payments for Rice by Alternative

	Refuge Boundary Expansion Alternative			
Refuge	No Action	Alternative B	Alternative C	Alternative D
Moody	$0	$0	$0	$0
Anahuac	$0	$224,052	$263,652	$831,314
McFaddin	$0	$25,668	$25,668	$265,566
Texas Point	$0	$0	$0	$0
Total	**$0**	**$249,720**	**$289,319**	**$1,096,880**

This is an upper bound estimate of the losses of counter-cyclical payments that could occur. However, like the direct payments discussed earlier, it is likely that only a percentage of these payments would be lost because some acreage would remain in production under the USFWS cooperative farming program and some of the base acreage would be retained by current landowners as farms are reconfigured.

(2). Indirect and Induced Economic Impacts of Reduction in Agricultural Support Programs

Farm support programs, such as direct payments and counter cyclical payments, have additional benefits beyond those realized by the individual producer. These programs provide income to producers that generate additional economic activity in the area, as this income is re-spent. IMPLAN was used to estimate the additional economic activity associated with the farm support programs for rice that could be lost if USFWS were to acquire all lands within the acquisition boundaries.

Additional economic activity that is generated by these particular programs will depend on how the additional income earned by producers is re-spent in the local economy. Because direct payments and counter-cyclical payments are decoupled from actual production, eligible producers are free to spend this additional income as they see fit. Therefore it was assumed that producers would re-spend this additional income in a similar fashion to other forms of income. To estimate economic impacts of this re-spending, total direct payments for the study area were run through the household income models in IMPLAN that correspond to Jefferson and Chambers counties.

Table 4-45 summarizes the additional economic activity that is estimated to occur due to the farm support programs associated with eligible acreage within the acquisition boundaries. The impacts to employment and income presented in this table represent upper bound estimates of losses in farm support programs if the USFWS were to acquire all acreage within the acquisition boundary. However, impacts are not likely to approach this upper bound due to a number of factors. First, this analysis uses the maximum payment available for the counter-cyclical program and thus represents the greatest impact if these payments were eliminated. If average prices received were to exceed the loan rate in future years, the payment would not be as great and thus the impact would not be as large as presented in this table. In addition, the direct payments are tied to farms instead of actual rice acreage. Therefore, it is possible for base acres to remain eligible after a farm is reconfigured upon the sale of certain acreage. Finally, a percentage of the base acreage would remain in rice production under the cooperative farm program and would be eligible for these farm programs.

Table 4-45
Indirect and Induced Economic Impacts of the Reduction in Farm Support Programs by Alternative

	Refuge Boundary Expansion Alternative			
	Alternative A	Alternative B	Alternative C	Alternative D
Labor Income	$0	$151,661	$175,710	$ 666,160
Employment	0	6	7	25

There may be additional economic impacts if the USFWS were to acquire croplands within the boundary expansion area. This is due to the fact that rice production may decline with a change in ownership. While the USFWS plans on continuing their cooperative farming program in areas that are historically important for rice production, the program's success is dependent on individuals' willingness to meet the requirements of the program. It is possible that some acreage could be taken out of production with a change in land ownership if producers lack interest in the USFWS cooperative farming program.

However, declines to the rice industry are likely to continue in the study area following recent trends with or without the USFWS Refuge boundary expansion and subsequent land acquisition program due to several factors including:[25]

- Texas producers have higher cost of production than other states
- unfavorable climatic conditions (e.g. high average temperature and late season hurricanes),
- difficulty in growing rotational crops in south Texas
- impacts from waterfowl migration
- problems with red rice
- development encroachment

All these factors will continue to affect the viability of the rice industry in Texas and will have a substantially larger impact than those expected to occur due to the refuge boundary expansion proposed by the USFWS.

b. Cattle Grazing Operations

Changes in land ownership may also cause impacts to grazing operations within the study area. While USFWS will continue to use controlled grazing for habitat management, it is likely that grazing operations on acreage managed by the USFWS will differ from those on private lands. Differences between grazing practices on USFWS lands and on private lands result from differing land use objectives. Grazing on the refuges is used as a tool to enhance wetland and upland habitats for wildlife, while economic objectives generally dictate grazing programs on private lands. In general, stocking rates and duration of use will be less on refuge lands than private lands. The difference in management techniques will affect the productivity of the acreage for cattle production. In addition, it is anticipated that grazing activities on lands managed by the USFWS will be more costly due to more frequent rotations. Although changes in grazing operations under USFWS management in upland prairie areas are expected to be notable; changes in marsh areas are expected to be relatively minor. Therefore, it is not expected that expansion of refuge boundaries and subsequent land acquisition will cause significant changes in the cattle industry in the study area though some local impacts may occur.

c. Commercial Hunting Operations

(1). Commercial Hunting Operators

Waterfowl and dove hunting are widely available, usually through a lease, on private lands in the study area. Several commercial guiding outfitters operate in the study area with services for waterfowl hunting,

25 Personal communication with Nathan Childs of the U.S. Department of Agriculture, 202-694-5292.

charter fishing, alligator harvest, and birding. The project area is probably best known in the community for waterfowl hunting, which also provides a source of revenue in the local community for two weeks during the September teal season and from November to January for waterfowl. Approximately six outfitter-guiding services and three landowners who leased their property to outfitters or hunt clubs were identified within the areas identified under the Refuge Boundary Expansion Alternatives. In addition, many rice farmers are currently transitioning from rice to cattle, hunting or a combination of these activities. In general, most outfitters that were contacted operate near current refuge boundaries.

Pricing and packages for guide services vary by outfitter. However, on average waterfowl hunting varies between $50 a day to $150 a day. Many outfitters also provide meals and lodging, which may average around $35 a night for lodging and $50 a day for meals. Outfitters noted that many clients also visit the local establishments while they are in town.

Most outfitters have operated in the area for decades and are either from the local community or are seasonal residents from in-state metropolitan areas. Outfitters contacted during this study employ an average of 13 guides seasonally from the local communities and average between 700 to 2,500 clients annually. The client base mostly includes people from outside the project area. According to the interviews, guided hunting is not a high priority for most local residents, with only a few interested in outfitter services from the Beaumont area. Depending on the marketing of the hunting outfitter, most clientele are from either out-of-state or metropolitan areas within Texas (such as Houston, Dallas, or San Antonio). Some international clientele was also noted. Many clients are repeat customers.

Some outfitters noted that they have a good relationship with the USFWS and that the proximity of the refuges benefits their hunting business. In addition, many outfitters believe that USFWS programs provide support in making habitat improvements that increases hunting profitability. Private lands used for hunting are generally well maintained, including wetland projects, which provides high quality neighboring habitat to the refuges. Some outfitters noted that converting land from private to public ownership has already adversely affected their businesses and more land acquisition would further impair their business or cause their operations to cease. In addition, outfitters stated that hunting on refuges is generally less accessible due to the restrictions on mechanized transportation. Others noted that if the USFWS acquires remnants of private lands as they become available, established guiding services may benefit from the additional habitat protection. In general, most outfitters expressed interest in guided trips on refuges and noted that conservation easements are more desirable because they provide more flexibility.

(2). Hunting on Refuge Complex

There are approximately 37,300 acres currently designated for hunting on the Refuge Complex. Hunting of geese, ducks, and coots is permitted during the waterfowl and September teal seasons on designated areas of the Anahuac, McFaddin, and Texas Point NWRs. Hunting is permitted three days per week until noon with a valid permit (50 CFR 32.63). Moody NWR is privately owned property upon which USFWS holds a perpetual non-development conservation easement. Moody NWR is not open for hunting to the general public, but this privately-owned property is hunted through a commercial guide/outfitter service.

If additional lands were acquired for the Refuge Complex, designated hunting areas would be opened considering conservation objectives, access issues and the quality of hunting to be supported. A consideration for lands acquired with Migratory Bird Conservation Stamp (Duck Stamp) funds is the 40% statutory limitation on the maximum amount of lands which can be opened for hunting. For those lands, management at the Refuge Complex has traditionally strived to maintain areas open to hunting at or near the 40 percent maximum. Migratory waterfowl use of wetland habitats is generally related to the quality of habitat (presence of food resources, proper water levels, etc.) and is influenced by factors such as disturbance. Establishment of sanctuary areas on any newly acquired lands would occur in areas of high quality habitat and low susceptibility to disturbance, which would ensure benefits to wintering and migrating waterfowl and other migratory birds, consistent with Refuge establishment purposes.

(3). Impacts to Commercial Hunting Operations - Acquisition of Private Land

The expansion of Refuge boundaries and subsequent land acquisition by the USFWS is likely to result in some impact on hunting activities within the study area. However, it is unclear at this point if the impact will be positive or negative on the local community. Some commercial hunting operations and local hunting guides may be negatively impacted if the USFWS purchases lands where current hunting leases are held. If the terms of these purchases restrict hunting guides from operating, then it is likely that individual operators would realize a reduction in business. However, areas opened to hunting by the USFWS on newly acquired lands would increase the amount of land available to the general public for hunting, and may actually increase hunting opportunities in the project area. The following section discusses these potential impacts in more detail.

General information on hunting activity was obtained through interviews with local stakeholders; however, there is a lack of detailed information on private activities and exactly where these activities may occur in relation to areas within the Refuge Boundary Expansion Alternatives. Since some private hunting activities may occur through informal agreements with private landowners, the information regarding the extent of these activities and income generated is unknown. Therefore, this analysis is primarily qualitative and based on interviews and maps of the acquisition alternatives. Two local hunting guide services and three landowners who provide hunting leases were interviewed in May 2003.

For the purposes of this analysis, it is assumed that all lands would be acquired in fee simple title. It was also assumed that hunt areas on refuges would be designated at or near the 40 percent maximum and will primarily include desirable and historically hunted areas. Open water areas and impoundments as well as rice acreage were considered desirable hunting areas for waterfowl. These desirable areas were also based on vegetation habitat maps prepared by the USFWS. Desirable hunting areas slated for acquisition are primarily located near McFaddin and Anahuac NWRs, with some acreage near Moody NWR and no acreage near Texas Point NWR. Although lands will be acquired over time from willing sellers as funding becomes available, this analysis focuses on the greatest possible impact scenario to define potential long-term impacts. Estimates of the number of acres within desirable hunting areas that may be converted from private to public ownership if the USFWS were to buy all properties at once within any of the Refuge Boundary Expansion Alternative are shown in Table 4-46.

Table 4-46
Estimate of Desirable Hunting Acreage within Refuge Boundary Expansion Alternatives

	Refuge Boundary Expansion Alternative			
Acreage	No Action	Alternative B	Alternative C	Alternative D
Desirable Hunting Acreage	0*	4,265	6,423	17,071
Total Acreage	**0**	**33,590**	**64,260**	**104,120**

*Alternative A would result in no land acquisition and would not affect current hunting operations. However, indirect impacts may occur over time such as decreased hunt quality from lack of adequate sanctuary areas.

Most outfitters are reliant on the leases provided by the private landowners for locations where they can provide hunting opportunities. If landowners sell to the USFWS rather than provide hunting leases, the quantity of prime areas where guide services operate will decline. Since most outfitters identified operate near Refuge boundaries, lands acquired near refuge areas would directly impact those hunting outfitters. Some outfitter services that depend on leases may cease to operate as a result. As commercial outfitters cease to operate, the limited employment offered by the business will no longer be available and the surrounding community may be indirectly affected. However, those outfitters that operate on land they already own would benefit if they retain their land. Those remaining establishments would have less competition for commercial guide services and the quality of the hunting opportunities may improve.

It is important to note that other factors may have important impacts on hunting outfitters regardless of any actions implemented by the USFWS under Refuge Boundary Expansion Alternatives B, C or D. This includes such things as natural phenomenon, stricter hunting regulations, changing land uses and land ownerships, or decreased interest in hunting. Natural phenomenon, including climatic conditions (e.g. drought in nesting areas), disease, and predation, may reduce continental waterfowl populations. . Lowered continental waterfowl populations would result in implementation of more restrictive harvest regulations. Reduced bag limits and shortened seasons would negatively impact commercial hunting operations. Changes in habitat quality and quantity (for example, the recent decline in rice production) in the project area can greatly impact local waterfowl numbers. Changing land uses such as the conversion of former rice fields to pasture or improved pasture or to residential development and changes in land ownership will also impact the waterfowl outfitter businesses in the project area. Finally, human factors, such as poor economic conditions or reduced hunting interest, may result in fewer hunters and less business for outfitter services.

d. Potential Development

For most of the area within the Refuge Boundary Expansion Alternatives B, C and D, future potential development appears low, at least in the immediate future. However, urban sprawl from the greater Houston area is already resulting in rapid development in western Chambers County, and ultimately development pressures are expected to increase in the relatively undeveloped portions of mid and eastern Chambers County.

Some lands within the expanded refuge boundaries proposed in Refuge Boundary Alternative D were found to have some development potential based on current activity. The area in question is commonly known as Taylors Bayou and is located north of Highway 73 in Jefferson County. Much of the acreage in and around the bayou was formally used for rice production with the remaining acreage comprised of bottomland hardwoods. There is already some residential development near the boundary expansion area. This includes a well established country club and residential neighborhood to the east of Taylors Bayou. Adjacent to the country club is a new development, which consists of single-family residential properties. Additionally, scattered residential development is also occurring to the south of the refuge expansion boundary.

Evaluation was conducted to determine the development potential of the Taylors Bayou area. This included interviews with the Jefferson County Tax Appraisal office[26] and review of tax assessment records on properties in this area. Tax records contain information on market values of individual properties. These market values will reflect the value of the parcel in its highest and best use even if it is not being used for this purpose. For instance, agricultural lands, which have high potential for development, will show a higher market value compared to other agricultural areas. The market values associated with a select sample of properties in and around Taylors Bayou were examined to determine if development potential is being reflected in market values obtained by the Tax Appraisal Office. The results are summarized in Table 4-47 on the following page.

The most significant development in the area is the Lake Estates residential development just south of Taylors Bayou overlooking the Belle Oaks Golf Course on Country Club Road (east of Labelle Road). The development consists of 60 home sites on 80 acres of land, 23 of which are wetlands and unusable for development. Pre-construction lots begin at $70,000 and finished lots begin at $300,000. Lot sizes range from one-half to one-acre in size.[27]

Market values of parcels in and around Taylors Bayou do reflect that development is possible in this area and is occurring. However, further interviews with the Tax Appraisal District and the Southeast Economic

26 Personal communication with Larry Harrington of Jefferson County Tax Appraisal District, Beaumont, Texas 409-840-9944.
27 Personal communication with Jerry Braxton of Excavators & Constructors, Inc., Beaumont, Texas, 409-721-6030.

Table 4-47
Estimated Market Values of Parcels near Taylors Bayou

Location of Parcel	Market Value ($/acre)[1]	Comments
Fishcamp Area - Subdivision East of Jap Road	$1,200 - $1,500	Lots are available in this area but values reflect lands values only. This area is low in elevation and would require any structures to be built on stilts.
Fishcamp Area - West of Jap Road	$300	This area is very low in elevation and marshy; little potential for development.
West of Jap Road and North of Taylors Bayou	$500	Area is a bit higher in elevation which is reflected in market value.
Rice acreage south of Highway 73	$500	Low elevation; marshy.
Acreage south of new development to the east of boundary expansion area	$500	Low elevation; these areas will need a fair amount of work before development can take place.
New development area; east of current country club	$70,000 per lot[2]	Higher elevation but still requires a fair amount of work before development can take place

[1] Market values were obtained from the Jefferson County Tax Appraisal District.
[2] Lot sizes range from one-half to one-acre in size.

Development Association[28] indicate that the development is limited due to certain challenges. First, much of this area is low in elevation and would require development modifications, which increase the cost of construction. Additionally, this area is located some distance from urban areas (Port Arthur) which limits the demand for development due to the long commuting distance. Officials interviewed felt that while this area does have development potential, it is still quite speculative at this point and will remain so in the future unless significant changes were to occur.[29]

At this time, if the USFWS were to acquire acreage in the Taylors Bayou area, there is potential that it could limit some future development. The likelihood of this impact is dependent on the development potential. For instance, development potential in the low-lying floodplain adjacent to Taylors Bayou itself appears low, thus potential impacts to development would be low as well. However, areas that are somewhat higher in elevation do appear to have development potential which could be lost if these areas were acquired by the USFWS.

2. Fiscal Impacts to Local Governments

Fiscal impacts to local government jurisdictions may occur if the USFWS acquires land within the study area that is currently owned by private parties. Impacts arise since the federal government would not pay property taxes on acquired acreage; therefore, the property taxes that are currently paid by private landowners would no longer accrue to the affected local government jurisdictions. To gain an understanding of how local government entities may be impacted, a model was developed to evaluate changes in tax revenues if lands were acquired by the USFWS. The model is based on several assumptions as follows.

- Changes in tax revenues are estimated for acquisition of all acreage in fee simple title under each Refuge Boundary Expansion Alternative.
- Only taxing jurisdictions within Galveston, Jefferson and Chambers Counties would be impacted by the acquisition actions of the USFWS.
- Lands to be acquired are assumed to be in agricultural production and are currently taxed at a reduced rate from other types of property (e.g. industrial and commercial).

28 Personal communication with Mike Foster of the Southeast Texas Regional Planning Commission, Beaumont, Texas 409-899-8444.
29 Development potential for this area could increase with the completion of a large drainage project which is planned by Drainage District #6.

The following steps were used to develop the model in detail:

Step 1: Identify Acreage by Taxing District and Land Use Category

The first step in implementing the model was to estimate the acquisition acreage by taxing jurisdiction. For each county where lands may be acquired, all districts that were likely to be impacted were identified using maps provided by the tax assessors' offices and interviews with county officials. The jurisdiction maps were compared with maps of the Refuge Boundary Expansion areas prepared by the USFWS to identify which districts may be impacted. Table 4-48 summarizes these districts.

Table 4-48
Taxing Districts with Jurisdiction in Acquisition Areas

Chambers	Jefferson	Galveston
Chambers County, East Chambers ISD*, Anahuac ISD*, Chambers-Liberty Navigational District, Hospital District, Trinity Bay Conservation District	Jefferson County, Sabine Pass ISD*, Hampshire-Fannett ISD*, Drainage District 3, Drainage District 6, Port of Sabine Pass, Jefferson County Waterways & Navigational District	Galveston County, High Island ISD*, Galveston County Road and Flood District

* ISD – Independent School District

Next, USFWS vegetation maps, in a GIS format, were overlaid on the acreage within each of the impacted districts. The vegetation types in the acquisition areas were then converted to land use categories utilized for tax assessment purposes. The conversion used for this analysis is summarized in Table 4-49.

Table 4-49
Vegetative Type to Tax Category Conversion

Vegetation Types	Land Use Category for Tax Assessment Purposes
Non-Saline Prairie/Agricultural	Rice Acreage/Natural Pasture/Improved Pasture
Salty Prairie	Natural Pasture/Marsh Pasture
Fresh Marsh	Natural Pasture/Marsh Pasture
Intermediate Marsh	Natural Pasture/Marsh Pasture
Brackish Marsh	Natural Pasture/Marsh Pasture
Saline Marsh	Natural Pasture/Marsh Pasture
GIWW Spoil Areas	Barren
Contained Spoil	Barren
Forested Wetland	Rice Acreage/Natural Pasture
Inland open water	Natural Pasture/Marsh Pasture
Natural Lake - brackish marsh	Natural Pasture/Marsh Pasture
Natural Lake - intermediate marsh	Natural Pasture/Marsh Pasture
Prairie Grassland	Natural Pasture
Unclassified	Barren

Finally, the land use categories were overlaid on the Refuge Boundary Expansion Alternatives and the jurisdiction maps. From this information, we were able to estimate the acreage within each taxing district by land use category for all three of the expansion alternatives. Simplified summaries of the estimated acreage by land use category for each of the expansion alternatives are shown in Tables 4-50 through 4-52. (Note very small differences in acreage totals for each Alternative because of unrectified information on GIS maps).

Table 4-50
Land Use Categories by acres in Refuge Boundary Expansion Alternative B

Land Use Category	Chambers Co.	Jefferson Co.	Galveston Co.
Irrigated Agriculture	2,702	311	
Improved Pasture	6,570		
Natural Pasture	16,425	1,871	415
Natural Pasture/Marsh		5,007	48
Barren Land	106	42	
Total Acreage	25,803	7,231	463

Table 4-51
Land Use Categories by acres in Refuge Boundary Expansion Alternative C

Land Use Category	Chambers Co.	Jefferson Co.	Galveston Co.
Irrigated Agriculture	3,195	311	
Improved Pasture	16,794		
Natural Pasture	29,305	1,915	6,923
Natural Pasture/Marsh		5,546	334
Barren Land	106	42	
Total Acreage	49,400	7,814	7,257

Table 4-52
Land Use Categories by acres in Refuge Boundary Expansion Alternative D

Land Use Category	Chambers Co.	Jefferson Co.	Galveston Co.
Irrigated Agriculture	10,073	3,218	
Improved Pasture	25,867		
Natural Pasture	30,376	6,221	6,923
Natural Pasture/Marsh		21,040	334
Barren Land	243	42	
Total Acreage	66,559	30,521	7,257

Step 2: Estimate Assessed Values of Acquisition Acreage

Once the acreages and land use categories were estimated for each district under each Refuge Boundary Expansion Alternative, it was then necessary to determine how the local tax assessor values these acreages for tax purposes. Given the location and rural nature of the lands that would be acquired by the USFWS, it was assumed that all lands that could be purchased by the USFWS are now in agriculture production. This assumption is important because agricultural lands in Texas are appraised differently than other land uses. An agricultural appraisal considers the capacity of the land to produce crops, livestock, qualified wildlife or timber instead of its value on the real estate market.[30] Land must be principally devoted to agricultural use for five of the last seven years to qualify for this assessment. An agricultural appraisal is based on an estimate of the typical annual income during the five-year period proceeding the year before appraisal.

Table 4-53
Chambers County Land Assessments

Land Use Category	Value per acre
Irrigated Agriculture	$223
Barren Land	$36
Natural Pasture	$56

Source: Chambers County Appraisal District, 2003 Chambers County Ag & Timber Values, Anahuac, Texas.

Table 4-54
Jefferson County Land Assessments

Land Use Category	Value per acre
Irrigated Agriculture	$194
Natural Pasture	$34
Marsh Pasture	$9

Source: Jefferson County Appraisal District, 2003 Ag Schedule, Beaumont, Texas.

Table 4-55
Galveston County Land Assessments

Land Use Category	Value per acre
Natural Pasture and Hunting	$40
Natural Pasture, Marshy	$15

Source: Galveston Central Appraisal District, 2004 Agricultural Productivity Values, Galveston, Texas

The Texas Comptroller's Office was contacted for information on agricultural assessments for each of the three counties where acquisition would occur. Mr. Jesus Longoria of the Texas Comptroller's Office was able to provide data on total acreage and agricultural productivity values by agricultural land categories for the affected school districts in Chambers, Jefferson and Galveston Counties. This data was taken from the annual Property Value Study, conducted by the Comptroller's Office. This report summarizes information provided by the counties each year and is used to certify tax assessments for school districts across the state. Mr. Longoria provided data for 1998-2001.

The data on agricultural productivity values as well as information from the county appraisal districts was used to estimate an annual average value per acre for each of the land classifications. A summary of these estimates for each county is provided in Tables 4-53 through 4-55.

30 Texas Comptroller of Public Accounts, "Texas Property Taxes," January, 2003, Austin, Texas.

Step 3: Determine Property Tax Rates by District

The applicable tax rate for each impacted district was obtained from the counties as summarized in Tables 4-56 through 4-58. The tax rate will be applied to the total assessed value of lands per district to estimate total property tax revenues generated in the acquisition areas under current conditions.

Table 4-56
Chambers County Property Tax Rates by District

Code	Tax District	Tax Rate Per $100/Value
01	Chambers County	0.528645
33	East Chambers Cons. ISD	1.65
30	Anahuac ISD	1.5
60	Chambers-Liberty Navigational District	0.0285
49	Drainage District #6	0.200039
65	Hospital District	0.75
79	Trinity Bay Conservation District	0.4827

Source: Chambers County

Table 4-57
Jefferson County Property Tax Rates by District

Code	Tax District	Tax Rate Per $100/Value
01	Jefferson County	0.365
03	Hamshire-Fannett ISD	1.64
13	Sabine Pass ISD	1.689
35	Port of Port Arthur	0.131277
37	Port of Sabine Pass	0.295151
47	Drainage District #3	0.307738
49	Drainage District #6	0.200039
55	Jefferson County Navigational District	0.033023
79	Trinity Bay Conservation District	0.4827

Source: Jefferson County

Table 4-58
Galveston County Property Tax Rates by District

Code	Tax District	Tax Rate Per $100/Value
GGA	Galveston County	0.5939
S13	High Island ISD	1.5
RFI	Galveston Co. Road and Flood	0.0124

Source: Galveston County

a. Estimated Reduction in Tax Revenues

The model was then used to calculate the potential decrease in tax revenues that would occur if the USFWS were to acquire all lands within the proposed expanded boundary in fee simple title.

Refuge Boundary Expansion Alternative B

For Refuge Boundary Expansion Alternative B, the estimated loss in property tax revenues from removing lands from the tax rolls was estimated to be $47,278 as summarized in Table 4-59. Most of this reduction in tax revenues would occur in Chambers County based on the distribution of acquisition acreage. Within Chambers County, the largest impact would occur to the Anahuac ISD, which is estimated to lose $19,721. The next largest impact to Chambers County jurisdictions would accrue to the County and the Hospital District, with each losing an estimated $10,357 and $9,245 respectively. The largest impact in

Jefferson County would occur to the Hampshire-Fannett ISD, which would lose an estimated $2,470 in property tax revenues.

Table 4-59
Estimated Reduction in Property Taxes on Lands
in Acquisition Areas – Refuge Boundary Expansion Alternative B

Refuge Acquisition Areas	County		
	Chambers	Galveston	Jefferson
Anahuac NWR	$35,644	$15	
Moody NWR	$7,550		
McFaddin NWR	$277	$346	$3,237
Texas Point NWR			$189
Total	$43,471	$361	$3,426

Refuge Boundary Expansion Alternative C

Table 4-60 summarizes the tax implications for Refuge Boundary Expansion Alternative C. Removing 64,471 acres from the tax rolls has the potential to reduce tax revenues to all districts by a total of $99,054. As with Refuge Boundary Expansion Alternative B, the largest impact would occur in Chambers County with a reduction of $89,568 in tax revenues. Within Chambers County, the largest impact would occur to the Anahuac ISD, which is estimated to lose $43,850, while the Hospital District would lose $21,925, and the County would lose $18,177. Districts within Jefferson County are estimated to lose over $3,500 with the largest impact occurring to the Hampshire-Fannett ISD, which is estimated to lose over $2,470.

Table 4-60
Estimated Reduction in Property Taxes on Lands
in Acquisition Areas – Refuge Boundary Expansion Alternative C

Refuge Acquisition Areas	County		
	Chambers	Galveston	Jefferson
Anahuac NWR	$79,592	$5,590	
Moody NWR	$9,508		
McFaddin NWR	$468	$348	$3,237
Texas Point NWR			$311
Total	$89,568	$5,938	$3,548

Refuge Boundary Expansion Alternative D

Refuge Boundary Expansion Alternative D, the largest acquisition alternative, has the potential to reduce property tax revenues to all districts by an estimated $184,304 as summarized in Table 4-61. As with the other two alternatives, the largest impact would occur to taxing districts in Chambers County. Within Chambers County, the largest impact would occur to the Anahuac ISD, which is estimated to lose $76,890, while the Hospital District would lose $38,445 and the County would lose $30,409. The districts within Jefferson County are estimated to lose $21,485 with the largest impact occurring to Hampshire Fannett ISD ($15,567) and Jefferson County ($3,701).

Table 4-61

Estimated Reduction in Property Taxes on Lands in Acquisition Areas – Refuge Management Alternative D

Refuge Acquisition Areas	County		
	Chambers	Galveston	Jefferson
Anahuac	$146,944	$5,590	
Moody	$69,508		
McFaddin	$428	$348	$21,180
Texas Point			$305
Total	$156,880	$5,938	$21,485

A comparison of the estimated tax revenues that could potentially be lost due to a change in land ownership with current tax revenues earned by impacted districts in the study area indicates that no district would incur a loss greater than one percent of their current annual tax revenues.[31] Total estimated property tax losses for each alternative by government jurisdiction for the three counties are provided in Appendix A.

b. Offset from Refuge Revenue Sharing Payments

This analysis has not considered the annual Refuge Revenue Sharing payments that would be distributed to the counties from the USFWS if acquisition were to occur. The most recent data on these payments indicated that the USFWS has paid a minimum of $43,000 to Chambers County and $58,000 to Jefferson County in annual revenue sharing payments for lands currently owned. The dollar amount of past Refuge Revenue Sharing payments is substantial and significantly offsets the local tax losses. In some instances, largely for lands subject to the agricultural exemption, the past Refuge Revenue Sharing payments have been equal to or even greater than the amount paid in taxes while in private ownership. Future Refuge Revenue Sharing payments would be adjusted for any newly acquired lands using calculations described in Chapter 2, Part B, *Issues Common to all Refuge Boundary Expansion Alternatives*. It can be anticipated that these payments would offset at least a portion of the lost tax revenues estimated above and thus decrease potential negative impacts to the taxing districts.

3. Social Impacts

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, ecosystem management actions such as those made by the USFWS within the Refuge Complex. Additionally, the Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

31 Annual revenues for the Hospital District were not available.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them),

- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions),

- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability), and

- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others).

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Any social and/or lifestyle effects from implementation of Refuge Boundary Expansion Alternatives B, C or D on individuals and groups would be lessened because the USFWS would only acquire lands from "willing" sellers; it must be assumed that a willing seller has individually determined that any associated impacts from this land transfer to the USFWS is acceptable, or the transaction would not be made. Issues would also arise when USFWS management activities on any newly acquired lands are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and may have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships between the USFWS and Stakeholder Groups

General categories of stakeholder groups describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A description of the potential relationships between the USFWS and stakeholder groups is contained in the impact analysis for Refuge Boundary Expansion Alternative A, the "No Action" Alternative. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole. The following is a list of local stakeholder groups who could be affected by refuge boundary expansion.

- Residents and/or Employees
- Landowners
- Recreationalists
- Governmental or Quasi-Governmental Agencies
- Businesspersons and/or Business Owners
- Conservation or Environmental Protection Advocates

Overall, USFWS management activities on newly acquired lands may conflict in some cases with some of the goals, beliefs, and objectives of many of the local stakeholders. Some members of a stakeholder group may support refuge boundary expansion and future USFWS management of those lands, while other members oppose it. Different stakeholder groups may agree or disagree with the size or location of a particular refuge boundary expansion alternative; or, even the need for refuge boundary expansion. This situation will lead to the continued need for the USFWS to interact with the public (see next section) and address their concerns. However, socioeconomic issues would continue to exist among the various

stakeholder groups with regard to their opinion of the USFWS role, responsibilities, and actions: many of these issues would remain unresolved in the future as discussed later in this section.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. With new actions such as those proposed in Refuge Boundary Expansion Alternatives B, C and D, USFWS public outreach efforts would continue and may expand.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

The proposed USFWS refuge boundary expansion actions would have no major effect on the existence or resolution of current socioeconomic issues associated with USFWS activities at the Texas Chenier Plain Refuge Complex. Under any of the Refuge Boundary Expansion Alternatives:

- There would be points that continue to be in dispute or unsettled between different parties regarding the existence and/or management of the Refuge Complex

- Different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions

- Some people would continue to think positively about the role of the USFWS in the area; others would continue to think negatively about this role; and others would continue to have no opinion or be neutral about the USFWS role and activities within the area

- As with existing conditions, issues would be unresolved and one party could not be determined to be “right” and the other party “wrong” with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future.

Under the Refuge Boundary Expansion Alternative A (No Action), existing conditions and trends would generally remain the same. The management of the Refuge Complex land and the extent of land holdings would not change in substantive ways.

Under Refuge Boundary Expansion Alternatives B, C and D, management philosophies and priorities would change from current conditions, and the amount of USFWS land holdings would increase. The USFWS management of newly acquired lands would continue to be primarily oriented to support wildlife habitat management and enhance fish and wildlife values which may differ from current private land management actions. These different management approaches and philosophies have a relationship with social structures and lifestyle, but the differences among alternatives from a specific social structure/lifestyle perspective would not be substantial except on a localized or case-specific basis. Under all the action alternatives for refuge boundary expansion, the USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however the “appropriateness” of any chosen alternative would depend on individual and group values, beliefs, and goals.

While Refuge Boundary Expansion Alternatives B, C and D support different conservation priorities, and the differences among alternatives may be identifiable on a localized basis, the social structure and lifestyle conditions and trends within the project area would generally remain the same as current conditions. Because the USFWS would work only with willing sellers, the potential social and lifestyle concerns would lessen because changes in ownership would be a choice, not a requirement. Overall,

impacts to social structures and lifestyles would not be significant from any alternative considered in this EIS. No matter which Refuge Boundary Expansion Alternative was implemented, most socioeconomic issues would remain unresolved.

d. Environmental Justice

The need to conduct an environmental justice analysis for the Texas Chenier Plain Refuge Complex CCP/ EIS is based on Executive Order (EO) 12898. Several areas have been identified as having potential minority or low-income populations within the primary or secondary study areas. EO 12898 requires an assessment as to whether these populations might be disproportionately affected by the management alternatives.

Based on the results of the socioeconomic and environmental impact analysis conducted for this project, it can be concluded that those persons who reside in and around the Refuge Complex would bear both some adverse and some beneficial effects by the continued operation and/or expansion of the Refuge Complex. However, any identified socioeconomic or environmental impacts from continued operation of the Refuge Complex by the USFWS would not be localized nor be placed primarily on the identified minority and/or low-income population components. Overall, the identified minority and/or low-income populations would not be disproportionately affected compared to other segments of the general population in the area. Additionally, persons of all races and income levels were invited to participate in the public participation process for the EIS, and comments or input into the process from any minority or low-income persons were considered equally with all other persons. Therefore, implementation of any of the Refuge Boundary Expansion Alternatives would be in compliance with EO 12898.

III. IMPACTS ON CULTURAL RESOURCES FROM REFUGE BOUNDARY EXPANSION ALTERNATIVES

Impacts on Cultural Resources

Impacts on cultural resources can include inundation, destruction, damage, and/or disruption. Impacts can directly result from ground-disturbing activities or indirectly from human use or land use and management. Potential ground-disturbing activities include facilities construction, road construction, ditch digging, oil and gas activities, and water management projects (such as levee construction, repair, or removal). Human use activities include increased public access and watercraft wakes. Intense wildfires and cattle tromping may indirectly impact cultural sites. Natural phenomenon may also impact cultural sites through inundation, wind/water/wave erosion, subsidence, tree bioturbation, and animal burrowing.

Impacts on Cultural Resources from Refuge Boundary Expansion Alternatives

No additional lands would be identified for acquisition and the Refuge Complex would remain its current size under Refuge Boundary Expansion Alternative A. Seventeen known shell middens, one of which is NHRP eligible, and a potentially NHRP eligible historic shipwreck would be slated for acquisition as lands become available under Refuge Boundary Expansion Alternatives B and C. A total of 25 known shell middens, two of which are NHRP eligible, and the potentially NHRP eligible shipwreck would be slated for acquisition as lands become available under Refuge Boundary Expansion Alternative D. There is a potential for additional protection as well as impacts to federally acquired cultural sites under all of the acquisition alternatives; however, these impacts would not be considered adverse and most of the impacts would be considered minor in nature, unavoidable, or beneficial.

The transfer of lands with known cultural sites from private to federal ownership are not anticipated to impact known cultural sites, but would rather preserve the setting of the sites and may provide additional protections not afforded to the sites on private lands. Federal acquisition would provide additional protections under NHPA and associated regulations not afforded to cultural sites on private lands. Private lands acquired would also be subject to the actions and impacts identified for the preferred management alternative on existing Refuge Complex lands.

Natural impacts would continue to occur to the known cultural sites on acquired areas; however, additional protections may be afforded to the sites under Refuge Management Alternative D if water management projects extend to the acquired lands. The potentially eligible shipwreck has already experienced damage from waves and previous disturbance from U.S. Army Corps of Engineers jetty construction and repair; USFWS ownership would likely not result in any changes to the shipwreck site from its current condition.

Known cultural sites on federally acquired lands would be afforded additional protections from ground-disturbing activities through the Section 106 process. Any ground-altering projects proposed by the USFWS would have a new site-specific Section 106 consultation. Cultural sites on private lands may not experience ground disturbance as often as federal lands, but in some cases may be subject to more. The presence of cultural sites on private lands are typically unknown by the landowner and the sites have been subject to clearing, grading, or borrowed material that modified the condition of the original site. On occasion, private landowners may also collect and remove cultural materials from the sites for a personal hobby, which removes the cultural material from the benefit and knowledge of the greater public. The ground-truthing and the Section 106 consultation process may reveal more cultural sites previously undiscovered in private ownership and provide protection as appropriate.

The cultural sites on newly acquired lands may be subject to prescribed burning, cattle grazing, and recreation that may or may not have occurred previously in those areas. Regular prescribed burning or use of natural ignited fire on acquired lands would reduce the potential for higher intensity fires under Refuge Management Alternative D, and may reduce fuel loads that produce higher intensity fires that threaten the integrity of cultural items. The potential for inadvertent cattle tromping is likely to occur on

acquired lands slated for grazing under Refuge Management Alternative D. Cultural sites on newly acquired private lands may experience an increase in visitation as opposed to that occurred in private ownership. However, recreational activities typically occur in previously developed areas and access can be controlled as needed to protect sensitive cultural items. Boating restrictions on Refuge Complex lands would impose restrictions that may reduce the potential for damage to shoreline cultural sites from wake erosion.

IV. IMPACTS COMPARISON TABLE FOR REFUGE BOUNDARY EXPANSION ALTERNATIVES

The impacts discussed in detail in the preceding section, *Part B: Impact Analysis for the Four Refuge Boundary Expansion Alternatives*, are summarized and condensed in the following table. The impacts under the "No Action" Alternative A are the base of comparison for the other three "Action" Refuge Boundary Expansion Alternatives. The table is organized by resource area, the same way the detailed impact analysis in Part A is organized. The table allows for a quick comparison of the impacts in a specific resource area between Alternatives.

NO ACTION ALTERNATIVE	ACTION ALTERNATIVES
RBE Alternative A	**RBE Alternatives B, C, & D**
Impacts to Air Quality	
Smoke impacts to air quality from agricultural burning on private lands to improve forage for livestock and wildlife and control brush.	Smoke impacts to air quality from USFWS prescribed burning on newly acquired lands mitigated by strict adherence to prescription parameters.
Impacts to Geology and Soils	
Coastal land loss continues at existing or accelerated rates on private lands.	USFWS would expand interagency coordination to address threats from coastal land loss on newly acquired lands, with goal of implementing major erosion abatement projects implemented along Gulf, GIWW and East Galveston Bay shorelines. USFWS water management and prescribed burning on newly acquired lands may benefit soil formation and vertical accretion in marshes.
Impacts to Hydrology and Water Quality	
Economic considerations dictate type & scope of activities affecting large-scale hydrology on private lands. Less management of marshes resulting from trend to smaller ownerships.	Wetland management & hydrologic restoration by USFWS on newly acquired lands would help restore historic continuum of fresh, intermediate, brackish and saline marshes which support a natural diversity of native plant, fish, and animal communities. USFWS would increase efforts to improve water quality.

RBE Alternative A	RBE Alternatives B, C, & D
Impacts to Vegetation/Habitats	
Impacts from Habitat Management and Restoration Activities	
Water management on private lands primarily supports agricultural uses, primarily livestock grazing. Rice production is declining with former rice fields fallowed or converted to improved pasture. Burning, grazing and water management on some private lands enhance wetland habitats for waterfowl and other migratory birds. Many private landowners actively control invasive plant species, particularly Chinese tallow.	USFWS would use structural water management on newly acquired lands to control salinities and water levels within marsh habitats to mimic natural marsh hydroperiods and provide more productive habitats for fish & wildlife. Moist soil management would be expanded and cooperative rice farming would be maintained where possible on newly acquired lands to provide freshwater habitat for waterfowl and other migratory birds. Prairie restoration & management on newly acquired lands would increase the abundance of native prairie grasses & forbs, protecting Globally Imperiled plant communities. USFWS would increase protection and enhancement of woodlot habitats. USFWS would use prescribed burning, controlled grazing and exotic/invasive species control to enhance native habitats on newly acquired lands. Shoreline protection/restoration and marsh restoration on newly acquired lands would positively impact nationally-declining wetland habitats.
Impacts from USFWS Programs (Public Use, Biological, Oil and Gas Management, and Community Outreach/Partnerships)	
Some private landowners participate in USFWS and other agency conservation initiatives, particularly to restore wetland habitats. Oil and gas development would continue as currently administered on private lands.	Motorized boating for fishing and hunting can impact wetland vegetation; impacts from other public uses are localized & minimal. Biological program supports adaptive management approach and oil & gas management reduce impacts to vegetation/habitats. Continuation of outreach and partnership efforts would result in additional habitat restoration & enhancement on Refuge Complex and private lands throughout the project area.
Impacts to Fish and Wildlife Resources	
Impacts from Habitat Management and Restoration Activities	
On private lands, economic considerations dictate land uses & management practices and resulting benefits to fish & wildlife. Agricultural practices provide substantial benefits to waterfowl but may reduce wetland habitat available for other wetland-dependent avian species. Combinations of burning, grazing, & water management on private lands which provide benefits to waterfowl also benefit other species.	Marsh habitats on newly acquired lands would be managed to enhance habitat for waterfowl, shorebirds, wading birds & other wetland-dependent migratory birds. Moist soil management would be expanded and cooperative rice farming continued on newly acquired lands providing additional high quality wetland habitat for wintering and resident waterfowl and other migratory birds. USFWS would provide and enhance habitats specifically needed by Mottled Ducks. USFWS would focus management/restoration activities to obtain a mosaic of diverse habitat types benefiting a wide variety of avian species, including several Avian Species of Conservation Concern. Restoration and enhanced management of native prairie habitats would benefit many declining landbird species. Integrated burning, grazing, & exotic/invasive species control on newly acquired lands would maintain naturally diverse and productive wetland and upland habitats benefiting avian species, T&E species, and a wide variety of other wildlife species. USFWS management of water control structures on newly acquired lands would benefit fisheries by increasing fish passage.

RBE Alternative A	RBE Alternatives B, C, & D
Impacts from Public Use Program	
Dove and waterfowl hunting would continue as currently managed on private lands.	USFWS would open specific areas within newly acquired lands for public wildlife-dependent recreational uses. Waterfowl and dove harvest would not affect overall populations and their long-term viability. Sanctuary areas would be established on newly acquired lands to maintain local waterfowl populations & mitigate hunting pressure. Motorized boating can affect distribution & habitat use of waterfowl & other wildlife species. Impacts from other recreational activities are localized & minimal as to most species. No impacts to T&E species or long-term viability of fisheries resources.
Impacts from Biological Program, Oil and Gas Management, and Community Outreach/Partnerships	
Some private landowners allow wildlife surveys and studies (waterfowl banding), and participate in USFWS and other agency conservation initiatives which benefit wildlife, especially waterfowl. Oil and gas development would continue as currently administered on private lands.	USFWS would implement a variety of new/expanded surveys, monitoring, & research on newly acquired lands to facilitate adaptive management approach allowing continual refinement and improvement of management activities. Biological program would focus on priority wildlife species needing conservation action. Net effect of oil & gas management is reduction of impacts to fish & wildlife resources from these activities. Expanded outreach/partnership efforts would result in benefits to fish & wildlife resources as important habitats are restored and enhanced on private lands.
Economic Impacts	
There are direct, indirect and induced impacts from existing Refuge Complex operations, agriculture, and recreation **(same as impacts analyzed for Refuge Management Alternative. D in Part A of Chapter 4).**	New land acquisition results in losses of agricultural support programs for rice farming by Alt.: Direct Payments, B) $351,808 C) $407,596 D) $1,545,295; Counter-Cyclical Payments, B) $249,720 C) $289,319 D) $1,096,880; Indirect/Induced, B) $151,661 C) $175,710 D) $666,160. Represents maximum possible loss, more likely only a percentage of this because some acreage would be included in coop rice farming and some base acreage would be retained by current landowners as farms are reconfigured. New land acquisition not expected to cause significant impacts in cattle grazing industry or commercial hunting operations. Some loss of development potential in and around Taylors Bayou by new land acquisition under Refuge Boundary Expansion Alternative D.
Fiscal Impacts to Local Governments	
Refuge Revenue Sharing Payments made to local governments based on already acquired lands.	New land acquisition results in losses of tax revenues to local governments by Alternative: B) $47,258, C) $99,054, D) $184,303. Represents maximum possible loss if all lands were acquired within an expansion boundary. Refuge Revenue Sharing Payments on newly acquired lands would offset portion of loss in tax revenues.
Impact on Population and Social Impacts	
No impact on population or environmental justice. Social conditions remain generally the same with some unresolved issues.	Same as Refuge Boundary Expansion Alternative A.
Impacts on Cultural Resources	
Unavoidable adverse impacts from natural phenomenon are anticipated to continue to occur at cultural resource sites under all of the Refuge Boundary Expansion Alternatives. Acquisition of these sites would preserve the setting of these sites and provide additional protection through the Section 106 process from ground-disturbing activities.	

PART C: COMBINED AND CUMULATIVE IMPACTS

Overview

Parts A & B of this Chapter analyze the environmental impacts from the actions proposed in each of the two separate sets of alternatives presented in Chapter 2. The two sets of alternatives address the two separate but related federal actions: 1) management strategies for the Refuge Complex for the next 15 years in a CCP and 2) expansion of the refuge boundaries for the four refuges within the Refuge Complex. The USFWS has selected a Preferred Alternative for each action: Refuge Management Alternative D is the Preferred Alternative for management; and, Refuge Boundary Expansion Alternative C is the Preferred Alternative for the expanding the refuge boundaries of the refuges within the Refuge Complex.

This section of Chapter Four, Part C, addresses, first, the environmental impacts resulting from the combined proposed federal actions as described in the two Preferred Alternatives; and, second, the cumulative effects associated with the two combined federal actions. The environmental impacts for the combined actions are organized by resource area in the same way as the impact analysis for the two separate sets of alternatives in Parts A & B. The cumulative effects results from the incremental impact of the combined proposed actions when added to other past, present, and reasonably foreseeable future actions regardless whether undertaken by Federal agency, non-federal agency or private individuals.

The lands to be acquired under Refuge Boundary Expansion Alternative C would be managed in accordance with the management strategies prescribed for the existing Refuge Complex lands under Refuge Management Alternative D. A short summary for each of the Preferred Alternatives is presented in this section. The combined impacts of the preferred alternatives and cumulative impacts are discussed in the remainder of this section.

Refuge Management Alternative D – Preferred Alternative

Under this Alternative, the Refuge Complex would continue and expand current habitat management and native habitat restoration programs, with increased monitoring and research to assess management actions and facilitate a more effective adaptive management approach. Wetland habitat management activities for waterfowl, shorebirds and other wetland-dependent migratory birds including structural water management in marshes, prescribed burning, controlled grazing, and moist soil management would be refined and enhanced, and in some cases expanded through development of new infrastructure. Concurrently, additional restoration of native habitats including wetlands, prairie and woodlots would be undertaken to benefit a variety of native fauna, with a focus on priority species identified as in need of conservation through national and international conservation initiatives.

Efforts to address coastal habitat loss and degradation resulting from shoreline erosion along the Gulf, Galveston Bay and the GIWW and to restore emergent marshes would be intensified by increasing coordination among agencies and other stakeholders. Goals would include implementing large-scale partnership projects including barrier beach/dune restoration on McFaddin NWR, marsh and shoreline restoration on Texas Point NWR through the beneficial use of dredge material, and structural shoreline protection along the GIWW and East Galveston Bay. Ongoing interior marsh loss would be addressed by working with agencies and other stakeholders on watershed-scale hydrologic restoration projects that restore freshwater inflows and further restrict saltwater intrusion. The USFWS would also implement several smaller hydrologic restoration and shoreline protection projects on the Refuge Complex. Management efforts to control exotic and invasive plant and animal species would be expanded.

Through new partnerships with universities and other agencies, additional research and monitoring would be conducted to better assess impacts of relative sea level rise and to support future conservation planning to address these impacts. Additional monitoring of exotic/invasive plant species, including research to assess the efficacy of ongoing and new control techniques, would be conducted. Additional

baseline data on fish and wildlife populations and habitat use would also be collected, with an emphasis on documenting the status of several sensitive or declining species.

The Refuge Complex would also continue to provide and promote opportunities for all six of the National Wildlife Refuge System's priority wildlife-dependent recreational uses: hunting, fishing, wildlife observation and photography, environmental education and interpretation. The Refuge Complex would seek to provide additional recreational opportunities and improve the quality of visitor services and of the visitor experience through construction of additional public use facilities, expanding law enforcement efforts to protect public safety and natural resources, providing additional hunting and fishing opportunities, and developing additional educational programs.

Refuge Boundary Expansion Alternative C – Preferred Alternative

Under Refuge Boundary Expansion Alternative C, approximately 64,260 acres are identified for acquisition that would be acquired only from willing sellers, as funding is available, and added to the Refuge Complex. When approved, the refuge boundary expansions would provide USFWS with the authority to acquire interests in lands identified within the acquisition boundaries. This can include acquisition of both fee simple title as well as conservation easements.

Natural habitats within the acquisition area identified under Refuge Boundary Expansion Alternative C include coastal wetlands, low lying coastal prairies, and near coastal woodlands between Trinity Bay to the west and the Sabine River on the east. These habitats provide important and high quality habitat for waterfowl, shorebirds, wading birds and other wetland-dependent migratory birds, neotropical/nearctic migratory songbirds and other resident native fish and wildlife, including three Federally-listed Threatened and Endangered avian species, several State-listed T&E species, and several species of migratory birds which have been identified as needing conservation action under various national and international conservation initiatives. Upland areas under this Alternative including the largest remaining contiguous tracts of native coastal tallgrass prairie on the upper Texas Gulf Coast, an extremely rare but highly diverse habitat type which has been classified by the Nature Conservancy as "Globally Imperiled".

Assumptions

The same assumptions from Part B of this Chapter are used in the analysis of the Combined Impacts is this section.

- The impacts for the Refuge Boundary Expansion Alternatives are analyzed assuming that all of the lands within an expansion area would be acquired in fee within the first year following approval of the refuge boundary expansion. This assumption assures that the maximum possible impacts are addressed even though the proposed "willing seller" acquisition program and the availability of funding would obviously not produce this result.

- The impacts for the Refuge Boundary Expansion Alternatives are analyzed assuming that the lands acquired in the future would be managed according to the strategies contained in the Refuge Management Alternative D, the Preferred Alternative.

I. COMBINED IMPACT ANALYSIS

It is not the purpose of this part of the Chapter to simply repeat the detailed impact analysis for each of the Preferred Alternatives which are contained in the first two parts of the Chapter. Instead, relying on the earlier detailed impacts analyses, this part will discuss the combined impacts which can be expected from implementing these alternatives together and their interactions. These combined impacts could enhance or alter the impacts considered for each individual Preferred Alternative.

A. Natural Resources Section

The biological and ecological impacts that are anticipated to occur from the combination of Refuge Management Alternative D and Refuge Boundary Expansion Alternative C are discussed in this section by resource category.

1. Impacts to Air Quality

The predominant impact to air quality from USFWS management activities on the Refuge Complex and newly acquired lands would be from prescribed burning. Prescribed burning results in temporary, localized decreases in air quality by exposing local residents to low concentrations of smoke for short periods of time

Prescribed burning would be maintained at 12,000 - 15,000 acres annually in emergent marsh habitats on the current Refuge Complex. Burning would be conducted from late September to late November with limited burning in summer. Prescribed burning may slightly increase with the addition of limited summer burning to the current limited spring burning in prairie habitats to control invasive species. Increasing the total Refuge Complex acreage by about 60 percent would add over 29,000 additional acres of marsh, where burning has likely been conducted historically to support grazing and hunting operations, and on about 32,000 acres of prairie, which has been mostly subject to annual burning for grazing unless forage was greatly reduced by grazing. Prescribed burning by the USFWS on newly acquired prairie acreage may initially increase to move vegetation toward desired habitats, but would be greatly reduced on prairies over time as prairie burning would be primarily for maintenance of control invasive vegetation. Initially, prescribed burning on newly acquired lands may increase in marsh habitats requiring restoration, but the transition from an annual to a 2- or 3-year rotational maintenance schedule after areas are restored would reduce the amount of area burned concurrently and, therefore, annual concentrations of emissions would be reduced in the long-term.

Although temporary, localized decreases in air quality and increases in particulate matter would continue to occur during USFWS prescribed burning events, strict adherence to established prescriptions and monitoring and smoke management protocols by the USFWS would decrease overall adverse impacts to air quality in the project area.

2. Impacts to Geology and Soils

The combination of rising sea levels and land subsidence (relative sea level rise), and altered hydrological regimes have impacted coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem. These phenomena are impacting the region's soils and geological processes including soil formation. They are resulting in coastal land loss, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

The USFWS has been implementing shoreline protection and restoration activities on the Refuge Complex to address erosion and resulting wetland loss along shorelines and would increase restoration efforts on existing and newly acquired shorelines under the Preferred Alternatives. Approximately 68,000 linear feet of additional Gulf and bay shorelines under Refuge Boundary Expansion Alternative C have been subject to the same influences. The combination of increased shoreline erosion abatement (off-shore rock wavebreaks and breakwaters) in addition to vegetation management over a larger contiguous area would likely reduce shoreline erosion across the newly expanded Refuge Complex.

Under USFWS ownership of contiguous Gulf and bay shoreline, protection and restoration efforts would be more effective and protect larger contiguous areas. The USFWS would construct additional off-shore wavebreaks and shoreline armoring and restore additional dunes. Increasing emergent marsh plantings would further reduce wave erosion and increase sedimentation rates within vegetation stands. Reduction of saltwater intrusion and active management of water levels would benefit emergent marshes in

freshwater to brackish water areas by preventing conversion to open water habitat, reducing organic matter oxidation, and contributing to organic matter accretion that would contribute to a gain of land elevation. Coordination would increase between the USFWS and other agencies to implement large-scale projects to restore barrier beaches and dunes, beneficially use dredge materials, and develop and implement long-term inter-jurisdictional strategies to reduce erosion and wetland loss along the Gulf of Mexico, East Galveston Bay, and the GIWW. Increased dune restoration activities and the use of dredged material would increase contributions to sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994).

USFWS vegetation management activities, such as rotational prescribed burning and water management (including salinity management), would also improve soil stability, and may contribute to soil formation and elevation gain in marsh habitats. Increased monitoring of shoreline erosion, wetland loss, marsh accretion rates and effects of relative sea level rise on a newly expanded Refuge Complex would provide additional information on the effectiveness of various management approaches, allowing for real-time adjustments and evaluation of effectiveness for future applications.

3. Impacts to Hydrology and Water Quality

Modifications to the natural hydrologic regimes of the coastal marshes in the Chenier Plain region have resulted in saltwater intrusion, reduced or restricted freshwater inflows, and altered hydroperiods (wetting and drying cycles), which in some cases contributed to a net loss of emergent wetlands (Moulton *et al*. 1997). Due to the extensive changes to the natural hydrological conditions of the landscape throughout the area, management actions are required to restore and maintain biological integrity and biological diversity.

Under the combined Preferred Alternatives, the USFWS would expand coordination with other state and federal agencies to assess the feasibility of watershed-scale hydrologic restoration projects, which would be aimed at protecting and restoring coastal marsh habitat by reducing saltwater intrusion, increasing freshwater and sediment inflows, and maintaining natural marsh hydroperiods. Across the newly expanded Refuge Complex, existing water rights would be amended (and additional rights acquired, if possible) to facilitate increasing freshwater inflows, water management infrastructure would be enhanced and expanded, and barriers would be removed to restore marsh hydrology. Approximately 29,000 acres of newly acquired marsh areas, some of which may not have been managed to protect biological diversity, would receive attention under USFWS management. As a result, improving hydrological conditions over the newly expanded Refuge Complex would considerably improve the overall benefits intended with these management actions.

Potential impacts to water quality in the project area include fertilizer and pesticides used in agricultural practices, accidental releases of petroleum and petrochemical products, and non-point source pollution from storm run-off. Under USFWS management of newly acquired lands, herbicide use to control invasive plant species could increase initially but would decrease over time as sites are restored and IPM strategies combining chemical use with prescribed burning, mechanical removal, and controlled grazing are implemented. The USFWS would limit the types and amounts of herbicides and pesticides used for rice farming and would seek to increase the use of organic farming on newly acquired lands (given there are willing participants). Increased water quality monitoring on the Refuge Complex and in newly acquired areas would help identify and alleviate threats to fish and wildlife from contaminants.

4. Impacts to Vegetation and Habitats

Greater than 500 plant species occur on the Refuge Complex due to the diversity of soil types and ecological communities. Vegetation is heavily influenced by saltwater in the Gulf of Mexico or inland bays. Overbank flooding happens often enough that 77 percent of the Refuge Complex is composed of salt tolerant species. Vegetative habitats of the Refuge Complex primarily consist of marshes, prairie (non-saline and saline); coastal woodlands; and beaches, ridges, and dunes. Emergent marsh is the most prominent vegetative type on the Refuge Complex and within the area under Refuge Boundary Expansion C. Marshes comprise a continuum of wetlands based on salinity gradients from fresh,

intermediate, brackish, and saline marsh. Remnant prairie habitats are generally inland of coastal marsh habitat and located on drier upland sites such as coastal ridge, elevated flats, and short, steep, natural levees. Upland forest habitat or coastal woodlots generally occur on higher elevation uplands. Beach habitat includes dunes that are above mean high tide, although in this region the dune system is not extensive and much of it has been lost through onoing shoreline erosion and retreat along the Gulf of Mexico. The complete range of vegetation types is critically important to the region's biological diversity.

USFWS management activities affecting vegetation and habitats on the Refuge Complex and newly acquired lands under the Preferred Alternatives would include habitat management and restoration activities in wetland and upland habitats. These include structural water management in coastal marshes, marsh restoration, rice farming, moist soil management, native prairie restoration, and coastal woodlot restoration and protection. Habitat management and restoration activities with impacts to vegetation in both wetland and upland habitats include prescribed burning, controlled grazing, exotic/invasive plant and animal control, shoreline restoration and protection and mowing/haying.

a. Impacts from Habitat Management and Restoration Activities

USFWS management activities would be expanded on existing acreage and into newly acquired areas, thereby increasing overall benefits to the health of the habitats and dependent wildlife. Habitat management activities (including water management, prescribed burning, and controlled grazing) for waterfowl, shorebirds, and other wetland-dependent migratory birds would be refined and expanded through development of new infrastructure. To the extent feasible and appropriate, many of the management actions would be integrated for maximum benefit to the environment across the expanded Refuge Complex. Importantly, the over 64,000 acres of marsh, prairie, coastal woodlands, and beaches and dunes added to the Refuge Complex would be protected from development in perpetuity under USFWS management. In addition, the USFWS would implement an integrated management approach across a larger area. As a result, a continuum of diverse habitats and landscape mosaics would be achieved in the long-term.

(1). Wetland Specific Management and Restoration

(a). Water management

Across the newly expanded Refuge Complex under the two Preferred Alternatives, the USFWS would increase efforts to restore natural hydrology by ensuring adequate freshwater inflows and reducing saltwater intrusion through expanded interagency coordination, enhancing water management infrastructure, and acquiring additional water rights. Water management activities over a larger area would protect and enhance wetland habitats by maintaining diverse and productive emergent and submergent plant communities and a diverse mosaic of these communities. Approximately 39,000 acres of coastal wetlands (or 90 percent of wetlands in the newly acquired areas) recognized to be nationally declining wetland types by the National Wetlands Inventory would be protected in perpetuity.

(b). Moist Soil Management

Moist soil management would be increased on the Refuge Complex and substantially increased on newly acquired lands under the combined Preferred Alternatives.

Expanded moist soil management activities over a larger area would provide important additional freshwater wetland habitat for waterfowl, shorebirds, wading birds and other wetland-dependent fish and wildlife. Expanded moist soil management would increase biological diversity, as moist soil impoundments more closely resemble natural wetland habitats and provide required habitat parameters for a larger variety of game and nongame wildlife species than monotypic agricultural row crops (Fredrickson and Taylor 1982). Water management and mechanical soil manipulations in new moist soil units would promote conditions for germination and growth of waterfowl food plants, including annual grasses such as millets and sprangletops and several forbs including smartweeds, Delta duck potato, and

purple ammenia. Additional moist soil units would be flooded throughout the summer to provide brood rearing habitat for Mottled Ducks and whistling ducks. This management regime would favor the establishment of perennial wetland plants, including several species of floating and submerged aquatic plants, including arrow head, white water lily, and lotus. A substantial number and acreage of natural prairie pothole wetlands that were previously drained would be restored on newly acquired lands. In combination, management efforts would increase the amount of freshwater prairie wetland habitat across existing Refuge Complex lands and newly acquired areas.

(c). Cooperative Rice Farming Program

Conversion of native habitats to rice and livestock production has occurred on most lands that would support these uses in the project area. Rice farming provides an important food source and cover to a diversity of wetland-dependent resident and migratory birds and wildlife. Rice and grain production creates forage for waterfowl, spring habitat for migrating shorebirds, and summer water for breeding and brood-rearing habitat for Mottled Ducks. However, rice production has declined during the last decade in counties surrounding the Refuge Complex.

Under the combined Preferred Alternatives, the USFWS would administer its cooperative rice farming program over a larger area. Areas that are currently cropped and in the USDA farm program would remain in production under the USFWS cooperative farming program (assuming willing participates are available). Other formerly cropped areas would be restored to native prairie or moist soil units over time, Areas acquired would include 3,506 acres currently enrolled as base acreage for rice in the USDA farm program. However, only an average of 421 these acres have been actively cropped in recent years. In addition, USFWS will work with farmers participating in the program to increase the percentage of acreage that is organically farmed. Overall, the USFWS cooperative rice farming program under the two Preferred Alternatives on the expanded Refuge Complex would provide additional freshwater wetlands with high food value for migratory and resident waterfowl and other migratory birds.

(2). Upland Specific Management and Restoration

(a). Native Prairie Management and Restoration

Native coastal prairie is perhaps the most threatened habitat component of the western Gulf of Mexico coastal region. Under the two Preferred Alternatives, prairie management and restoration programs would be expanded on the Refuge Complex and newly acquired areas, with increased monitoring and research to assess management and restoration activities. Approximately 5,744 acres of non-saline prairie habitats on the existing Refuge Complex and over 32,000 acres of prairie habitats on newly acquired lands would be improved under the combined Alternatives over the long-term through application of prescribed burning, controlled grazing, invasive species management, and restoration using intensive restoration techniques. This would result in restoration of biological diversity and biological integrity in this highly threatened coastal prairie ecosystem. The long-term protection and management of the remaining largest contiguous tracts of native prairie on the upper Texas Coast will provide functional habitats to support many declining native plant and wildlife species, including plant associations classified as Globally Imperiled and many Avian Species of Conservation Concern. These actions will also help ensure the availability of viable native prairie plant seed sources and sources of plant material necessary to ensure the survival of this habitat.

(b) Woodlot Protection and Restoration

Although comprising a small percentage of the upland habitats on the in the project area, coastal woodlots help support a diverse avian community which includes several sensitive songbird species. Under the combined Preferred Alternatives, the USFWS would protect and manage coastal woodlots and near-coastal forests on newly acquired lands by: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts.

Overall, implementation of the USFWS management actions discussed above on the expanded Refuge Complex would protect and enhance coastal woodlot by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced woodland habitats would provide quality habitat for neotropical migratory birds and other wildlife that require native trees or understory for cover and foraging.

(3). General Habitat Management Activities

(a). Fire Management - Wildland Fire Suppression and Prescribed Burning

Natural fire and herbivory by native species now occur less frequently or at reduced levels in the project area due to human influences on the ecosystem. Lack of disturbance in this coastal ecosystem typically results in reduced biological diversity and productivity, as plant communities over large areas trend toward climax successional stages. Reduced plant community diversity results in poor quality habitat for migratory birds and other native fish and wildlife. Under the combined Preferred Alternatives, a rotational prescribed burning program would be maintained on the expanded Refuge Complex acreage to maximize the benefits of integrated burning/grazing/water management programs for manipulating wildlife habitat and to provide a mosaic of native plant communities. Suppression of wildfires by the USFWS would continue to consider protection of public and staff safety, property and natural resources.

Short- and long-term ecological fire effects monitoring would be used to guide an adaptive approach to implementing the program, which includes burning to stimulate native warm season grasses or delaying burning to allow seed production. Monitoring and adaptive management would be used to reduce potential negative impacts such as destruction of desirable vegetation and organic matter and wildlife mortality. In addition, ongoing and new research studies would be supported to determine fire effects on marsh accretion, soils, vegetation, and wildlife. Overall, the USFWS prescribed burning program would restore and maintain biological diversity in the long-term on approximately 61,000 acquired acres of marsh and prairie.

(b). Controlled Livestock Grazing

Under the combined Preferred Alternatives, the USFWS would use controlled grazing on the Refuge Complex and newly acquired lands (integrated with fire management and water management) to maintain and increase diversity (plant species composition and structural attributes) and productivity in wetland and upland habitats. Grazing strategies would include variations in stocking rates, timing (cool vs. warm season) and duration. Smaller grazing units would be grazed on a rotational basis, providing “rest” as needed to maintain plant diversity and productivity. Stocking rates and rotations would be determined annually according to management objectives for the various grazing units and the quantity and condition of forage and availability of fresh water in those units. Cool season and summer cattle grazing on various marsh and upland units would be used. The USFWS would expand the use of high intensity, short duration grazing on upland prairie habitats to mimic historic patterns of herbivory.

The controlled grazing program would be modified in selected marsh units across the expanded Complex to achieve desired habitat conditions. Grazing units would be reconfigured through additional fencing and development of additional watering sites to increase the effectiveness and efficiency of the controlled grazing program across the newly expanded Complex and protect sensitive habitats, such as woodlots. These modifications in combination with an adaptive management approach are also expected to reduce negative aspects of cattle grazing including excessive vegetation trampling, compaction of soils, reduced percolation rates, deposition of nutrients from feces in areas where livestock concentrate, and overgrazing.

(c). Invasive Species Management

Under the combined Preferred Alternatives, the USFWS would expand the scope of invasive species management activities on the Refuge Complex and newly acquired lands. An Integrated Pest Management (IPM) program would be implemented to control the following invasive plant species:

- Chinese tallow, Eastern baccharis, willow, deep-rooted sedge and King Ranch bluestem in freshwater marshes, prairies, woodlots and on levees and roadsides.

- Water hyacinth, alligatorweed, Salvinia, common reed, and cattail in waterways and managed wetland units.

- Red rice, coffeebean, barnyard grass, and other grasses in rice fields

- Invasive broadleaf weeds in restored prairies

Control of invasive emergent and floating plants in ponds would promote the growth of native floating and submerged aquatic plant species important to native fish and wildlife. The control of Chinese tallow and deep-rooted sedge in prairie and woodlots would result in increased diversity of native plants. In woodlots, reduction of Chinese tallow and increasing native tree and shrub abundance would likely increase abundance of forage insects for migrating birds (especially *Lepidopteran* larvae) (Barrow and Renne 2001).

The USFWS would also continue to control exotic animal species to conserve biological diversity and to maintain habitat quality for migratory birds and other native wildlife. Feral pigs are the primary species currently impacting habitats in the project area. Control of feral hogs would decrease damage to wetland, prairie and woodlot habitats and levees and roads from rooting and foraging, and reduce the creation of disturbed areas that enable establishment of Chinese tallow and other undesirable plants.
Although nutria have not reached population levels capable of damaging habitats in recent years in the project area, this introduced animal has been highly destructive in coastal wetlands in neighboring Louisiana and other coastal states. Control activities for nutria which could be implemented as necessary on newly acquired lands.

The USFWS would also expand monitoring programs for invasive species on newly acquired lands using GIS and GPS technologies to document and track infestations and evaluate the effectiveness of treatments. Additional research would also be supported through new and expanded partnerships with the U.S. Geological Survey and academic institutions.

(d). Shoreline Protection and Restoration

Under the combined Preferred Alternatives, the USFWS would continue involvement in several partnership efforts with other federal and state agencies and conservation organizations to address threats which are resulting in ongoing coastal land loss on the expanded Refuge Complex. Along the Gulf shoreline, these partnerships would continue to focus on augmenting coarse sediment supply along the Gulf shoreline through dune restoration and beneficial use of dredge material, respectively. Coordination with other agencies and conservation organizations would be expanded, with a goal of implementing a major project to restore the entire barrier beach/dune system on McFaddin NWR. Structural erosion abatement projects would also be implemented, including breakwater construction along the GIWW and East Galveston Bay shorelines.

Restoration of the barrier beach/dune systems and increased use of dredged material would contribute to increasing coarse sediment supply and reduced net erosion along shorelines (Chabreck 1976, 1994). If successfully implemented, large-scale restoration of the barrier beach/dune system on McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR would significantly reduce current rates of land loss. These projects would also restore historic elevations along the shoreline and protect inland marshes, and plant productivity therein, by reducing saltwater intrusion. Offshore rock breakwaters and shoreline armoring would also reduce the erosion of shoreline. Restoring emergent marsh by planting smooth cordgrass along shorelines will reduce land loss and increase sedimentation and vertical accretion within vegetation stands.

Shoreline protection and restoration activities under the combined Preferred Alternatives would continue to positively impact vegetation resources and habitats by restoring upland and protecting existing wetland habitats. Restoration of barrier dunes along the Gulf of Mexico would protect interior intermediate marshes and their plant communities from excessive inundation with saltwater during high tidal events, as well as restoring an upland native habitat type which has been almost completely lost in the project area. Use of dredged material along existing shorelines would protect existing marshes by reducing shoreline retreat and direct loss of these habitats, provide a substrate for reestablishment of marsh vegetation and restoration, and increase net sediment supply to marshes which provides nutrients and increases plant productivity (Chabreck 1976, 1994). Breakwaters would enhance marine habitat by functioning as an artificial reef, providing opportunities for oyster spat, barnacles, algae, baitfish, and predator fish utilization. Restoring emergent marsh by planting smooth cordgrass between the breakwaters and existing shorelines would restore vegetated wetlands that have converted to open water. The stands of smooth cordgrass would also provide habitat for snails, shrimp, crabs, insects, and numerous benthic organisms.

(e). Mowing and Haying

Under the combined Preferred Alternatives, the USFWS would continue to utilize mowing and haying in upland grassland habitats. Mowing and haying would invigorate growth of many native grasses, while reducing vigor of undesirable herbaceous weeds and woody plants. Reduction of herbaceous and woody cover often results in the “release” of native prairie plants.

b. Impacts from Public Use Programs

Under the combined Preferred Alternatives, the USFWS would provide enhanced public use programs on the existing Refuge Complex and on newly acquired lands. New opportunities for wildlife-dependent uses including hunting, fishing, wildlife observation and photography and environmental education and interpretation would be available to the public at large on the expanded Refuge Complex. Public use activities on the expanded Refuge Complex potentially could impact habitats, but management of these uses by the USFWS will minimize these affects such that the uses remain compatible with refuge establishment purposes and the National Wildlife Refuge System mission.

c. Impacts from Biological Program - Surveys, Monitoring and Research

Under the combined Preferred Alternatives, the UFWS would enhance GIS capabilities and other monitoring and research activities to help monitor habitat changes and assess management actions on the expanded Refuge Complex. Enhanced monitoring tools would improve the ability of Refuge Complex staff to track habitat conditions and adapt management strategies to enhance habitat benefits. Working with partners to study the impacts of relative sea level rise and to assist in addressing these impacts would be a focus for the USFWS.

d. Impacts from Management of Oil and Gas Exploration and Development

Lands on the expanded Refuge Complex would be subject to exploration and development of reserved and outstanding mineral interests. Under the combined Preferred Alternatives, the USFWS would continue to manage oil and gas exploration and development activities through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to waterfowl, shorebirds, wading birds, marsh and other waterbirds, including timing of activities to avoid major periods of utilization, offsets to avoid nests and concentrations of birds, required use of specialized equipment, location and size of facilities, and required pollution controls. The net effect of USFWS management of oil and gas exploration and development would be to reduce impacts to habitats from these activities.

e. Impacts from Community Outreach and Partnerships

Under the combined Preferred Alternatives, the USFWS would continue to work with private landowners in the project area to restore and enhance wetland and upland habitats on their properties. The USFWS would also expand partnerships with local communities, agencies, conservation organization, volunteers and other stakeholders, resulting in enhanced and more effective fish, wildlife and habitat conservation on the expanded Refuge Complex and throughout the project area.

5. Impacts to Fish and Wildlife Resources

The greatest benefit to wildlife populations and habitat under USFWS management is protection from development in perpetuity. Under the combined Preferred Alternatives, an integrated approach to wildlife and wildlife habitat management would be employed across the expanded Refuge Complex to maximize benefits to native fish and wildlife communities.

USFWS habitat management activities, wildlife species-specific management activities, and other USFWS programs under the combined Preferred Alternatives would have impacts on the fish and wildlife resources. This section will discuss the impacts from USFWS activities and programs on the following categories of fish and wildlife:

- Migrating and Wintering Waterfowl
- Resident Waterfowl - Mottled Ducks
- Shorebirds, Wading Birds, and other marsh and waterbirds
- Landbirds
- Fisheries Resources
- Threatened and Endangered Species
- Other Fish and Wildlife Species - Mammals, Reptiles, Amphibians, and Invertebrates

a. Impacts from Habitat Management and Restoration Activities

(1). Impacts to Migrating and Wintering Waterfowl

(a). Wetland Specific Management and Restoration

Wetland management and restoration implemented by the USFWS on the expanded Refuge Complex would likely increase use by wintering and migrating waterfowl. Management and restoration of newly acquired lands would benefit three wintering waterfowl species listed by the USFWS as Game Birds Below Desired Condition: Northern Pintail, Lesser Scaup and Ring-necked Duck. Increased active management of water levels and salinities (utilizing water control structures, levees, impoundments) in managed marsh units would increase abundance of plant species preferred by wintering and migrating waterfowl for food in brackish marshes (Chabreck 1976, Broome *et al.* 1995). Moist soil management acreage would increase across the expanded Refuge Complex, thereby providing additional habitat for wintering and migrating waterfowl. Maintaining rice production (assuming willing participates are available) on existing and acquired areas that are currently cropped and in the USDA farm program would provide valuable habitat for wintering and migrating waterfowl, shorebirds and other wetland-dependent migratory birds (Czech and Parsons 2002).

(b). General Habitat Management and Restoration Activities

Under the combined Preferred Alternatives, the USFWS would apply integrated prescribed burning, grazing and water management programs on the expanded Refuge Complex to promote of growth of target plant communities and overall habitat conditions which provide high quality habitat for waterfowl.

Expanded shoreline protection and restoration activities (i.e., shoreline armoring, plantings, and dune and marsh restoration) across existing and newly acquired shorelines and marshes on the Refuge Complex would protect and enhance coastal habitats important to waterfowl.

The USFWS would expand control programs for invasive plant species in marsh habitats on the newly expanded Refuge Complex (e.g., common reed, cattail, and California bulrush) to restore open water habitats and increase availability of submerged aquatic vegetation which provides valuable food for waterfowl. Invasive species control activities for Chinese tallow would be intensified in permanently fallowed rice fields under USFWS ownership, thereby indirectly benefiting waterfowl.

(2). Impacts to Resident Waterfowl – Mottled Ducks

Mottled Ducks are year-round residents of the Texas Chenier Plain region. This species prefers fresh and slightly brackish marshes (Gosselink *et al.* 1979), although a variety of marsh habitats, prairie, and rice fields are used for nesting. Stutzenbaker (1988) reports that the most serious threat facing Mottled Ducks is degradation and loss of habitat. In Texas, factors contributing to loss of habitat include agriculture, urbanization, drainage, marsh subsidence, saltwater intrusion, spread of introduced species (Stutzenbaker 1988), as well as increased pollutants (Cain 1988). The recent substantial decline in rice agriculture on the Texas Coast has significantly reduced wetland habitat important to Mottled Ducks. Saltwater intrusion into wetlands that range from fresh to moderately brackish probably affects growth and survival of ducklings (Moorman *et al.* 1991). Encroachment of Chinese tallow into nesting habitat probably leads to abandonment of nesting areas (Stutzenbaker 1988).

Under the combined Preferred Alternatives, the following habitat management and restoration activities would continue to be the primary management activities impacting Mottled Ducks on newly acquired lands. All would be expected to have positive impacts on this species, although the landscape level issues described above are likely to control population dynamics of the WGC Mottled Duck population.

(a). Wetlands Management and Restoration

Wetland management and restoration activities on the expanded Refuge Complex would provide and enhance habitats used by Mottled Ducks for foraging, resting, pair establishment, brooding and molting. Managing water levels and salinities in managed coastal marsh units would maintain fresh, intermediate and brackish marsh habitats, all of which are important to Mottled Ducks. Marsh management also would enhance diversity and productivity of submerged aquatic vegetation which provides important year-round food sources for Mottled Ducks. Moist soil management and the cooperative rice farming program would provide critical shallow freshwater habitat and nutritious food resources for use by Mottled Ducks year-round. The USFWS would manage selected moist soil units each year specifically to provide brood-rearing habitat for Mottled Ducks during summer.

(b). Uplands Management and Restoration

The historical prairie-wetland continuum of the upper Texas coast provided nesting cover and brood habitat for Mottled Ducks in close proximity. In a study of Mottled Duck nesting in agricultural lands in Louisiana, the habitat category that was most like native coastal prairie, permanent pasture with knolls, provided better nesting habitat than any other (Durham and Afton 2003). The dense nesting cover and mima mounds that are characteristic of native coastal prairie probably provided excellent nesting habitat for resident Mottled Ducks. Stutzenbaker (1988) identified shallow depressional wetlands found in the prairie zone, known as “sennabean ponds,” as valuable brood rearing habitat.

Under the combined Preferred Alternatives, native prairie restoration and management activities would benefit Mottled Ducks primarily by protecting, restoring and enhancing nesting and brood-rearing habitats. The native coastal prairie habitats within the proposed refuge boundary expansion areas under Refuge Boundary Expansion Alternative C (Preferred Alternative) has great potential to provide high quality nesting and brood-rearing habitat for this species. The USFWS would use integrated application of prescribed burning, controlled livestock grazing, herbicide application, and mowing/haying to restore the historic mosaic of prairie plant communities and the different structural characteristics of these habitats. Brush encroachment by invasive non-native and native plant species in prairie habitats would be reduced. Previously-drained shallow depressional “prairie wetlands” within extant stands of native prairie would be

restored. Additional native prairie and freshwater wetlands (using moist soil management) would be restored on adjacent fallowed agricultural fields. Restored and enhanced prairie habitats and prairie wetland habitats would likely increase overall reproductive success of Mottled Ducks in the project area.

(c). General Habitat Management Activities

Under the combined Preferred Alternatives, the USFWS would use prescribed burning, grazing, invasive species management, and shoreline protection and restoration activities on newly acquired lands. The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats would enhance wetland and upland habitats used by Mottled Ducks during all life history phases: pair formation, breeding, nesting, brood-rearing, molting and wintering. Invasive plant and animal control activities would also enhance wetland and upland habitats for Mottled Ducks, as would shoreline protection and restoration activities. If successfully implemented, large-scale restoration of the barrier beach/dune system on newly acquired lands within McFaddin NWR and additional beneficial use of dredge material projects on Texas Point NWR would significantly enhance wetland habitats for Mottled Ducks on these refuges. Offshore rock breakwaters and shoreline armoring on East Galveston Bay and the GIWW would protect habitats of high importance to Mottled Ducks.

(3) Impacts to Shorebirds, Wading Birds and other Marsh and Waterbirds

Because of the wide diversity of habitat requirements by this category of birds, USFWS habitat management and restoration activities on the expanded Refuge Complex which result in a mosaic of diverse habitat types (plant species composition, structural characteristics, water levels and salinities) would positively impact shorebird, wading bird, marsh and waterbird species found in the project area.

(a). Wetlands Management and Restoration

The USFWS would manage water levels and salinities (by utilizing water control structures, levees, impoundments, etc.) in structurally managed marshes on the expanded Refuge Complex to protect and enhance habitats used by many avian species in this group. In general, shorebirds and wading birds would benefit from moist soil management and rice farming activities on newly acquired lands that would result in increased abundance of invertebrates and plants that are a preferred food source (Chabreck 1976, Broome *et al.* 1995). Management of agricultural crops such as rice can increase nesting habitat as well as provide foraging opportunities for some bird species in this category (Czech and Parsons 2002). The timing and depth of flooding on managed agricultural fields would influence the type of and intensity of use by such birds (Huner *et al*. 2002). Targeted shorebird species would include several species identified as Avian Species of Conservation Concern and/or as needing conservation action under the U.S. Shorebird Conservation Plan, Gulf Coast Joint Venture All-bird Conservation Initiative and North American Waterbird Conservation Plan: Long-billed Dowitcher, Semi-palmated Plover, Black-bellied Plover, Black-necked Stilt, Whimbrel, American Avocet, Long-billed Curlew, Hudsonian and Marbled Godwits, and Semi-palmated, Western, Least, White-rumped, Baird's, Pectoral, Stilt and Buff-breasted Sandpipers.

(b). Uplands Management and Restoration

Under the combined Preferred Alternatives, restoration and enhancement of native prairie habitats on newly acquired lands would benefit some avian species in this category, primarily by providing improved habitat for migrating and wintering birds. Three Avian Species of Conservation Concern (USFWS 2005) (also listed as needing conservation action under the U.S. Shorebird Conservation and North American Waterbird Conservation plans) would benefit from these activities: Yellow Rail, Black Rail, and Buff-breasted Sandpiper.

(c). General Habitat Management Activities

Under the combined Preferred Alternatives, the USFWS would conduct prescribed burning, controlled grazing, and invasive species management, and shoreline protection and restoration activities on the

expanded Refuge Complex. The integrated combination of water level and salinity management, fire management and controlled livestock grazing in wetland habitats would enhance wetland and upland habitats used by many shorebird, wading bird and marsh bird species. Invasive plant and animal control activities would also enhance wetland and upland habitats for these species. The removal of invasive vegetation that forms dense, homogeneous stands resulting in pond closure, such as common reed, cattail, and California bulrush, would improve habitat conditions for wading bird and marsh and waterbird species that utilize open water habitats. Shoreline restoration activities including dune restoration and creation of emergent marsh and mudflats in intertidal zones behind breakwaters would benefit many shorebird and wading bird species.

Some USFWS management activities on newly acquired lands could negatively impact some species of shorebirds, wading birds, and marsh and waterbirds. For example, some species in this group have a relatively narrow range of optimal water depth for feeding and other activities, ranging from almost dry sediment to relatively deeper water (Skagen *et al*. 1999). Management activities that increase water depth may negatively impact those species that prefer shallow or no water, and those that prefer deeper water are negatively impacted when management activities lower water levels. Similar impacts could occur with management of vegetative cover, as some species prefer areas devoid of vegetation, while others prefer heavy vegetative cover. However, most avian species in this group (especially migrants) have evolved with unpredictable available resources, and are able to find suitable microhabitats in an adequately diversified landscape that contains a mosaic of microhabitats, both spatially and temporally. The USFWS strategy of management to maintain a mosaic of available habitats and resources should provide an adequate range of habitats for this group of avian species.

(4). Impacts to Landbirds

Landbird species found in the project area a wide variety of habitats. Many passerines are trans- and circum-Gulf migrants, and require coastal wooded areas as stopover habitat (food, cover, and water) as they make first landfall during spring on the Texas Gulf coast (Mueller 1981, Barrow *et al*. 2000). Some raptor species prefer intermingled field and forested areas (e.g., red-tailed hawks and owls). Other landbird species prefer grassland habitats including marshes and prairies (Peterson *et al*. 1995). In general, a mosaic of a variety of habitat types accommodates the greatest variety of species, as for most other bird and wildlife species.

All habitat management and restoration activities conducted by the USFWS on the expanded Refuge Complex under the combined Preferred Alternatives would benefit avian species in this group. Although comprising a relatively small portion of the overall habitats within the project area, restoration, management and protection of native prairies and coastal woodlots are of particular significance because of the importance of these habitats to many passerine species, including many neotropical migratory birds.

(a). Wetlands Management and Restoration

The USFWS would implement wetland management and restoration activities on the expanded Refuge Complex. Managing water levels and salinities in coastal marshes, marsh restoration, moist soil management, and cooperative rice farming program would benefit resident and migratory land birds which depend on wetland habitats. Several landbird species listed as Avian Species of Conservation Concern (USFWS 2005), including the Seaside Sparrow, Nelson's Sharptailed Sparrow, and Sprague's Pipit, would benefit from protection, restoration and enhancement of coastal marsh habitats on the Refuge Complex.

(b). Uplands Management and Restoration

Prairie Restoration and Management

Under the combined Preferred Alternatives, the USFWS would manage and restore native prairie habitats and adjacent fallowed agricultural lands on the expanded Refuge Complex to increase native plant species diversity and productivity. The USFWS would use integrated application of prescribed burning, controlled livestock grazing, herbicide application, and mowing and haying to restore the historic mosaic of prairie plant communities and the different structural characteristics of these habitats.

The native coastal prairie habitats within the proposed refuge boundary expansion area under Refuge Boundary Expansion Alternative C (Preferred Alternative) has great potential to provide high quality wintering and nesting habitat for several grassland songbird species. Native prairie and other upland grassland habitats on newly acquired lands would provide enhanced wintering and migrational habitat for several grassland songbird species including LeConte's Sparrow, and nesting habitat for species including Dicksissel and Eastern Meadowlark. Landbirds listed as Avian Species of Conservation Concern utilizing prairie habitats and which would benefit from conservation and management of native coastal prairie in the project area include LeConte's Sparrow, Henslow's Sparrow, Sedge Wren, Loggerhead Shrike, and White-tailed Hawk.

Many of the landbirds that would benefit from protection and management of native coastal prairie habitats under the combined Preferred Alternatives are species that are declining in the Coastal Prairies Region of Texas (Shackelford and Lockwood 2000), and/or are among several species recently listed by the USFWS as "Avian Species of Conservation Concern" in the Gulf Prairies Bird Conservation Region (USFWS 2005). For example, White-tailed Hawk, Northern Bobwhite, Yellow and Black Rail, Buff-breasted Sandpiper, Short-eared Owl, Sedge Wren, and LeConte's Sparrow are all Avian Species of Conservation Concern that would benefit from conservation of prairie habitats on the Refuge Complex.

Woodlot Restoration and Management

Although comprising a small percentage of the upland habitats in the project area, coastal woodlots help support a diverse avian community, which includes several sensitive songbird species. Six of the seven avian species listed as Rare and Declining within the coastal prairies region in Texas are present in the project area's coastal woodlots. Migratory birds also depend on coastal woodlots for cover and food. At least 63 species of migratory birds regularly use the wooded habitats of the Chenier Plain region prior to or immediately after crossing the Gulf of Mexico (Barrow *et al.* 2000). Trans-gulf or circum-gulf migratory songbirds use Texas coastal woodlots as stopover habitat (Mueller 1981), which is critical at a time when the birds are depleted of water and energy reserves (Leberg *et al.* 1996).

Under the combined Preferred Alternatives, the following USFWS management actions on newly acquired lands would have beneficial impacts on coastal woodlots: 1) native tree and shrub plantings; 2) invasive species management (primarily to reduce Chinese tallow and feral hog populations), and 3) fencing of selected woodlots to protect them from grazing impacts. Overall, implementation of the USFWS management activities on the expanded Refuge Complex would improve coastal woodlot habitat by increasing native plant abundance and diversity, creating additional understory, and allowing natural regeneration of native woody species. Restored and enhanced coastal woodlots would provide quality habitat for neotropical migratory birds and resident songbirds that require native trees or understory for cover and foraging. Species to benefit would include three neotropical migratory birds considered to be Avian Species of Conservation Concern: Swainson's Warbler, Prothonotary Warbler, and Kentucky Warbler. Since acreage of woodland habitat in the project area is small relative to its importance to migrating neotropical migratory birds and resident landbirds, such positive impacts for each acre protected are proportionately significant.

(c). General Habitat Management Activities

The USFWS would use prescribed burning, controlled grazing, invasive species management, and shoreline protection and restoration on the expanded Refuge Complex. The integrated combination of water level and salinity management, fire management and controlled livestock grazing would enhance wetland and upland habitats used by many landbird species. Invasive plant and animal control activities would also enhance wetland and upland habitats for these species, especially in grassland and coastal woodlot habitats.

(5). Impacts to Fisheries Resources

(a). Wetlands Management and Restoration

Estuarine coastal marsh habitats support over 95 percent of the Gulf of Mexico's commercial and recreational fisheries species during some portion of their life cycles. Tidal marshes serve primarily as nursery areas for many transient estuarine species that return to larger water bodies upon maturing. Densities of most organisms are highest within 3 m of the water's edge, indicating the importance of marshes to a diversity of species (Peterson *et al*. 1994). The flooded interior marsh was found to be more important for resident species. White and brown shrimp show a strong preference for marsh edges and limit use of flooded marshes to edges (Peterson *et al*. 1994). Blue crabs utilized the entire estuary with juveniles showing strong preferences for flooded marshes (Zimmerman & Minello 1984, Hettler 1989, Thomas *et al.* 1990, Kneib 1991, Rozas 1995).

Under the combined Preferred Alternatives, the USFWS would continue to structurally manage marshes, restore coastal wetlands, and conduct vegetative management activities including prescribed burning, controlled livestock grazing, invasive plant and animal control, marsh restoration through the beneficial use of dredge material, and shoreline restoration and protection. These management activities would protect, restore and enhance estuarine wetlands, and ensure wetland habitat diversity and productivity important to a variety of fish and shellfish species. The continuum of fresh to saline aquatic environments in the project area support highly diverse aquatic vertebrate and invertebrate communities.

Managing water levels and salinities (using water control structures, levees, impoundments, etc.) in managed marsh units may restrict access of some finfish and invertebrate fisheries species to managed areas. Actively managing water levels may impede access for some aquatic organisms, such as fish and crustaceans (Rogers *et al.* 1992, Kuhn *et al.* 1999). Impacts of structural marsh management to fisheries resources would be reduced by the USFWS on the expanded Refuge Complex by incorporating design features into all new and existing water control structures such as vertical slots which allow passage of estuarine organisms, managing structures to facilitate ingress and egress by opening gates during key movement periods, and utilizing rock weirs to counter erosion and enlargement of tidal waterways (as opposed to traditional fixed crest weirs).

(6). Impacts to Threatened and Endangered Species

Three avian species occurring in the project area are Federally-listed as Threatened or Endangered: Bald Eagle, Piping Plover, and Brown Pelican.

The Texas Parks and Wildlife Department lists six avian species and three species of reptiles which occur or potentially occur on the Refuge Complex as Threatened or Endangered: Arctic Peregrine Falcon, Reddish Egret, Wood Stork, White-Faced Ibis, Interior Least Tern, American Swallow-tailed Kite, smooth green snake, alligator snapping turtle and the Texas horned lizard. Several additional species of reptiles and amphibians are listed in the Texas Natural Heritage Database, now maintained by the Texas Nature Conservancy's Texas Conservation Data Center.

Under the combined Preferred Alternatives, protection, restoration and management of coastal wetland habitats on the expanded Refuge Complex would benefit the three avian T&E species. Bald eagles are usually associated with large concentrations of wintering waterfowl. Brown pelicans utilize shorelines

tidal saline ponds for resting and foraging. Shoreline restoration and protection activities would provide improved habitat for Piping Plover and Brown Pelican. Conservation and management of both wetland and upland habitats aimed at ensuring biological integrity and biological diversity under the combined Preferred Alternatives would benefit Threatened and Endangered species and many other sensitive or declining native fish and wildlife species, including several State-listed T&E species.

(7). Impacts to other Fish and Wildlife Species – Mammals, Reptiles and Amphibians, and Invertebrates

In general, USFWS habitat management and restoration activities on the expanded Refuge Complex which maintain naturally diverse and productive wetland and upland habitats would benefit a broad array of wildlife species, including mammals, reptiles and amphibians, and invertebrates. USFWS management activities which maintain and restore freshwater wetland habitats (structural management of marshes, moist soil management, rice farming) are particularly beneficial to amphibians and reptiles. Reliable freshwater habitat is critical for most amphibians and reptiles found on the Refuge Complex, including frogs, salamanders, aquatic snakes, turtles, and alligators. Habitat conditions which increase the abundance of insects, crustaceans, and other small prey benefit most species of amphibians and reptiles during at least a portion of their lifecycle. Many reptiles and amphibians provide prey for mammalian predators.

b. Impacts from Public Use Programs

Under the combined Preferred Alternatives, the USFWS would provide enhanced public use programs on the existing Refuge Complex and on newly acquired lands. New opportunities for wildlife-dependent uses including hunting, fishing, wildlife observation and photography and environmental education and interpretation would be available to the public at large on the expanded Refuge Complex. Public use activities on the expanded Refuge Complex potentially could impact fish and wildlife resources, but management of these uses by the USFWS will minimize these affects such that the uses remain compatible with refuge establishment purposes and the National Wildlife Refuge System mission.

c. Impacts from Biological Program - Surveys, Monitoring and Research

Under the combined Preferred Alternatives, the USFWS would expand biological program activities across the expanded Refuge Complex. New surveys, monitoring and research activities across the expanded Refuge Complex would increase the ability of the USFWS to improve and expand existing management activities for priority fish and wildlife species, such as waterfowl, shorebirds, wading birds and other marsh birds, and landbirds identified as needing conservation action.

d. Impacts from Management of Oil and Gas Exploration and Development

Lands on the expanded Refuge Complex would be subject to exploration and development of reserved and outstanding mineral interests. Under the combined Preferred Alternatives, the USFWS would continue to manage oil and gas exploration and development activities through the issuance of Special Use Permits. Stipulations in the Special Use Permit include those aimed at minimizing impacts to waterfowl, shorebirds, wading birds, marsh and other waterbirds, including timing of activities to avoid major periods of utilization, offsets to avoid nests and concentrations of birds, required use of specialized equipment, location and size of facilities, and required pollution controls. The net effect of USFWS management of oil and gas exploration and development would be to reduce impacts to fish and wildlife resources from these activities.

e. Impacts from Community Outreach and Partnerships

Under the combined Preferred Alternatives, the USFWS would continue to work with private landowners in the project area to restore and enhance wetland and upland habitats on their properties. The USFWS would also expand partnerships with local communities, agencies, conservation organization, volunteers

and other stakeholders, resulting in enhanced and more effective fish, wildlife and habitat conservation on the expanded Refuge Complex and throughout the project area.

B. Socioeconomic Resources Section

1. Economic Impacts

a. Impacts from Changes in Land Use

Economic impacts are described as the changes in employment, income and indirect business taxes that occur in the regional economy. These impacts occur as a result of some economic stimulus such as expenditures made by the USFWS to manage operations at the Refuge Complex or expenditures made by recreationalists visiting the area. These direct expenditures create additional economic activity (indirect and induced impacts) as re-spending of the direct expenditures occurs. The combined impacts associated with the management and expansion of the Refuge Complex are discussed in this section. One potential stimulus that could lead to economic impacts associated with expansion and management of the Refuge Complex is a change in land use. The greatest changes in land use will occur in the acquisition area where USFWS will focus management activities that maximize benefits to wildlife. However, land use will also change in minor ways on the existing Refuge Complex as the USFWS adapts management to changing wildlife needs.

The following section discusses the potential socioeconomic impacts associated with changes in the following land uses.

(1). Rice Farming

A number of acres in Refuge Boundary Expansion Alternative C (Preferred Alternative) within Chambers and Jefferson Counties are in the USDA farm program as farm base acreage for rice. However, a large percentage of this acreage is no longer used for rice production and is either being converted to improved pasture or is fallow. The USFWS intends to extend their cooperative farming program to acquired acreage that is currently in rice production due to the benefits this management action has for migratory birds. The USFWS will not attempt to convert previously farmed areas to rice production due to the cost associated with restoring water delivery infrastructure and removal of Chinese tallow and other exotic and invasive plant species. The success of this program will depend largely on the availability of farmers willing to work within the guidelines of the cooperative farming program. Overall market conditions will also drive the desire to participate in this program. The USFWS will manage other formerly cropped areas as native prairie or moist soil units. In both areas, the USFWS will use grazing to help achieve wildlife habitat objectives.

(a). Changes in Agricultural Support Programs

Changes in land ownership from private to public could cause economic impacts through a reduction in farm support programs currently available in the study area. This is most relevant for areas historically important for rice production. The USFWS currently manages a cooperative farm program with approximately 1,700 base acres registered with the Farm Service Agency. As such, producers that participate within the cooperative program are eligible for farm support programs. Acquisition of additional acreage by the USFWS, which contains base acreage, would also be eligible for farm support programs through the FSA (USDA 2004). However, while private landowners are able to collect payments even if acreage is not currently in rice production, the same is not true for acreage owned by the USFWS. For these areas, cooperative farmers, contracted by the USFWS, must be producing rice and performing approved maintenance on the allotted base acreage to receive payments.

As discussed earlier, the USFWS would extend the cooperative farming program for acreage that is currently in production. However, base acreage that is not currently in rice production would be restored to native prairie or moist soil units and thus would not be eligible for support payments. It is thus likely

that impacts could occur within the study area from a reduction in farm support due to a change in land ownership. Two programs are of most interest in this situation, include: 1) direct payments, and 2) counter cyclical payments.

An estimate of the direct and counter cyclical payments that could be impacted by expanding the Refuge Complex is summarized in Table 4-62. The payments summarized in this table represent an upper bound estimate of the possible losses in direct and counter-cyclical payments if the USFWS were to acquire all historically cropped acreage within the refuge boundary expansion area. It is likely that losses would not approach these upper end estimates because 12 percent of the base acreage is currently in production and would remain in production under USFWS ownership, and thus eligible for payments. Additionally, it is likely that current landowners would retain a certain percentage of the base acreage when farms are reconfigured after a portion of the farm is sold to the USFWS.

Table 4-62
Estimated Impacts To Farm Support Programs

Refuge	Impacted Acreage	Direct Payments	Counter-Cyclical Payments
Anahuac NWR	13,730	$371,435	$263,652
McFaddin NWR	3,506	$36,161	$25,668
Texas Point NWR	0	$0	$0
Moody NWR	0	$0	$0
		$407,596	$289,319

Farm support programs, such as direct payments and counter cyclical payments, have additional benefits beyond those realized by the individual producer. These programs provide income to producers that generate additional economic activity in the area, as this income is re-spent.

Additional economic activity that is generated by these particular programs will depend on how the additional income earned by producers is re-spent in the local economy. Because direct payments and counter-cyclical payments are decoupled from actual production, eligible producers are free to spend this additional income as they see fit. Therefore it was assumed that producers would re-spend this additional income in a similar fashion to other forms of income. To estimate economic impacts of this spending, total direct payments for the study area were run through the household sector in IMPLAN that corresponds to Jefferson and Chambers counties.

The analysis indicated that the farm support programs provide an additional $175,000 in income and support seven jobs in the regional economy. It is possible that this additional economic activity could be lost if the USFWS were to acquire all acreage within the acquisition boundary. However, impacts are not likely to approach this upper bound due to a number of factors. First, this analysis used the maximum payment available for the counter-cyclical program and thus represents the greatest impact if these payments were eliminated. If average prices receive were to exceed the loan rate in future years, the payment would not be as great and thus the impact would not be as large as presented in this table. In addition, the direct payments are tied to farms instead of actual rice acreage. Therefore, it is possible for base acres to remain eligible after a farm is reconfigured upon the sale of certain acreage. Finally, a percentage of the base acreage would remain in rice production under the USFWS cooperative farm program and would be eligible for these farm programs.

There may be additional economic impacts that may occur if the USFWS were to acquire croplands within the acquisition boundary. This is due to the fact that rice production may decline with a change in ownership. While the USFWS plans on continuing their cooperative farming program in areas that are historically important for rice production, the program's success is dependent on individuals' willingness to meet the requirements of the program. Therefore, it is possible that some acreage could be taken out of production with a change in land ownership. However, declines to the rice industry are likely to continue following recent trends with or without the land acquisition program due to several factors (Childs 2003) including:

- Texas producers have higher cost of production than other states
- Unfavorable climatic conditions (e.g. high average temperature and late season hurricanes)
- Difficulty in growing rotational crops in south Texas
- Impacts from waterfowl migration
- Problems with red rice
- Development encroachment

All of these factors will continue to affect the viability of the rice industry in Texas and will have a substantially greater impact than those expected to occur due to the expansion of refuge boundaries and subsequent land acquisition proposed by the USFWS.

(2). Grazing

Much of the acreage within the Preferred Refuge Boundary Expansion Alternative is currently used for grazing operations in natural or improved pastures. This land includes marsh, upland prairies, woodlots, and formerly cropped areas. The USFWS is expected to continue to utilize grazing on the expanded Refuge Complex as a habitat management tool. Stocking rates, duration and season of use may change under USFWS ownership. Grazing permittees would be required to rotate livestock more frequently than is now occurring on private lands.

b. Impacts from USFWS Operations

Current operations at the Refuge Complex provide economic stimulus to the local economy. The largest economic contribution results from the direct expenditures made by the USFWS to support operations. These operations currently support approximately 45 FTEs per year of which 30 positions are directly employed by the USFWS. Current operations generate approximately $1.2 million in income and nearly $450,000 in indirect business taxes to local government entities. Agricultural activities managed as compatible refuge economic uses currently supported on the Refuge Complex support approximately 20 FTEs per year, $859,000 in annual income and $87,000 in indirect business taxes. Recreational activities also generate economic activity in the regional economy by supporting approximately 25 FTEs, and generating $883,000 in annual income and $136,000 in indirect business taxes.

Expanding operations at the Refuge Complex under the combined Preferred Alternatives are expected to cause increases in regional employment and income. This would be the result of an increase in expenditures associated with the Refuge Complex including increased staff levels, new construction projects and increased activities associated with expanding habitat restoration and management. In addition, management activities are expected to increase recreational activities at the Refuge Complex which will have a positive impact on employment and income. Slight increases are also expected to occur as a result of an increase in AUMs for the controlled grazing program.

Expansion and management of the Refuge Complex is expected to have some impacts on local area employment. However, the Refuge Complex is not considered a major employer in the area and thus would not support a significant proportion of the population. In addition, changes in land ownership are not expected of have significant impacts on population in the study area.

2. Impacts to Hunting and Commercial Hunting Operations

Lands acquired under the Preferred Refuge Boundary Expansion Alternative would most likely be purchased with Federal Migratory Bird Conservation Stamp (Duck Stamp) funds and subject to the regulations of the Migratory Bird Hunting and Conservation Stamp Act, as amended. According to restrictions under the Act, a maximum of 40 percent of the total land area of each refuge could be opened for waterfowl hunting. The USFWS has traditionally strived to maximize areas open to hunting at or near the 40 percent maximum on the Refuge Complex.

Expansion of the Refuge Complex through land acquisition by the USFWS is likely to result in some impact on hunting activities within the study area. However, it is unclear at this point if the impact will be positive or negative on the local community. T here are indications that local commercial hunting operations and their employed hunting guides may be negatively impacted if the USFWS purchases lands where current hunting leases are held. If the terms of these purchases restrict hunting guides from operating, then it is likely that individual operators would realize a reduction in business. However, the additional areas opened to hunting on the expanded Refuge Complex would provide additional hunting opportunities for the public at large.

3. Fiscal Impacts to Local Governments

Activities at the Refuge Complex could cause impacts to local government services in various ways. For instance, changes in demand for government services could vary with changes in population tied to the Refuge Complex and could cause undue strain on infrastructure (e.g. roads, utilities, schools, etc). Alternatively, changes in land ownership could impact the tax base in the local area which can affect various taxing districts. It is thus likely that the expansion and management of the Refuge Complex will have some fiscal implications to local government jurisdictions. This includes impacts to revenues as well as expenditures. The activities are expected to impact revenues in two ways. First, activities associated directly or indirectly with Refuge Complex operations are expected to generate over $9 million in indirect business taxes over the fifteen-year study period, which include excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses for government entities (e.g. county and state) (MIG 2000).

In addition, property taxes are expected to decrease if the USFWS expands the Refuge Complex with additional land acquisitions. Removing 67,565 acres from the tax rolls has the potential to reduce tax revenues to all districts by a total of $99,054, annually. The largest impact would occur in Chambers County with a reduction of $89,568 in tax revenues. Within Chambers County, the largest impact would occur to the Anahuac ISD, which is estimated to lose $43,850, while the Hospital District would lose $21,925, and the County would lose $18,177. Districts within Jefferson County are estimated to lose over $3,500 with the largest impact occurring to the Hampshire-Fannett ISD, which is estimated to lose over $2,470. This analysis does not include the fact that annual Refuge Revenue Sharing payments are made by the USFWS to the affected counties. The dollar amount of past Refuge Revenue Sharing payments is substantial and significantly offsets the local tax losses. In some instances, largely for lands subject to the agricultural exemption, the past Refuge Revenue Sharing payments have been equal to or even greater than the amount paid in taxes while in private ownership. Future Refuge Revenue Sharing payments would be adjusted for any newly acquired lands. It can be anticipated that these payments would offset at least a portion of the lost tax revenues estimated above and thus decrease potential negative impacts to the taxing districts.

4. Impacts on Social Conditions

Along with the fish, wildlife, vegetation, and the physical environment, people are an integral part of ecosystems. Lifestyles, attitudes, beliefs, values, social structure, culture, and population characteristics affect, and are affected by, management actions such as those made by the USFWS within the Refuge Complex. Additionally, the Refuge Complex lands and USFWS management of these lands have emotional meanings to many people.

a. Impacts to Social Structures and Lifestyles

Some of the social structure and lifestyle parameters that were examined as part of this analysis include:

- Community cohesion (the degree of unity and cooperation evident in a community as it defines problems and attempts to resolve them),
- Community stability (a community's capacity to handle change without major hardships or disruptions to component groups or institutions),
- Social organization (the structure of a society described in terms of roles, relationships, norms, institutions, lifestyles, infrastructure, and/or community cohesiveness and stability), and

- Lifestyles (patterns of work and leisure, customs and traditions, and relationships with family, friends, and others).

Overall, most people's lifestyles and social interactions (including community cohesion, community stability, and social organization) would essentially remain the same as current conditions. Any social and/or lifestyle effects from expansion and management of the Refuge Complex on individuals and groups would be lessened because the USFWS would only acquire lands from "willing" sellers; it must be assumed that a willing seller has individually determined that any associated impacts from this land transfer to the USFWS is acceptable, or the transaction would not be made. Issues would also arise when USFWS management activities on the expanded Refuge Complex are perceived to adversely impact adjacent landowners or reduce economic benefits to the community. Those management actions that would continue to be controversial and may have localized impacts include water management and prescribed fire activities.

b. Impacts to Relationships Between the USFWS and Stakeholder Groups

General categories of stakeholder groups in the Chenier Plain area were identified in Chapter 3, Affected Environment. These stakeholder group categories would continue to adequately describe those persons and/or groups that have an identified interest in or relationship with USFWS activities. A summary of potential future relationships between the USFWS and stakeholder groups follows. Please note that stakeholders can be either individuals, or formal or informal groups of individuals. Some of these categories can overlap, and therefore an individual or a group can be a member of more than one stakeholder category. Some potentially affected people are not members of any vocal or identified stakeholder group. Stakeholder groups seldom include a true representative sample of the affected population, meaning that any one stakeholder group can generally not speak for the population as a whole.

Residents and/or Employees – Those persons who live and/or work within the area would generally continue their existing relationships with the USFWS, with the possible exceptions of those persons who would sell land to the USFWS and/or live or work near newly acquired lands. The reactions of those persons to any changed relationship with the USFWS would be individualistic in nature, and could range from very positive to very negative feelings depending on the goals, values and beliefs of those affected.

Landowners – Those landowners who would be most directly affected by the combined Preferred Alternatives would be those who have the opportunity and choose to sell their land to the USFWS. There could be some level of animosity or negative feeling against those selling land to the USFWS from those persons not supporting USFWS refuge expansion.

Recreationalists – The lands and waters of the region have a rich heritage of public commercial recreational activity. While recreation plays an important part in the economy of the area, outdoor recreation opportunities are also a traditional and substantial part of the social structure and lifestyles of the area. The FUSFWS is constantly struggling to balance recreational opportunities with its goal of protecting natural resources. Under the combined Preferred Alternatives, this struggle would continue. There would continue to be major disagreement within the nearby population over the proper amount, locations, and access to recreational resources within the expanded Refuge Complex. Other recreationalists would be highly supportive of USFWS public use programs.

Governmental or Quasi-Governmental Agencies – Relationships between governmental or quasi-governmental agencies in the area would continue existing trends, with coordination of these agencies with the USFWS sometimes being difficult because of conflicting goals and objectives. The perception of the USFWS being "outsiders" who have a substantial influence on local residents and governments would continue to exist, and associated issues would likely not be resolved easily.

Businesspersons and/or Business Owners – As with current conditions, businesspersons and/or business owners would generally have economic development and growth as major future goals that could conflict with USFWS expansion and management of the Refuge Complex. Many persons

supporting economic growth as a high priority may continue to be frustrated with USFWS actions that could be perceived as limiting or preventing economic growth. Some business persons/business owners would support expanded USFWS activities in recognition that these activities could bring an expanded visitor base to the area, with the resulting expansion of the ecotourism industry providing economic benefits to at least some portion of local and regional business.

Conservation or Environmental Protection Advocates – Those supporting conservation of natural resources and environmental protection would generally be pleased with an expanded level of USFWS activity and land holdings. For many of these persons, having more land in USFWS control would generally mean a higher level of environmental protection for lands which could be considered "at risk" because of potentially conflicting land uses or misuse of land under private control. However, there would also continue to be instances where conservationists/environmental protection advocates may believe that the USFWS is not doing enough to preserve or protect natural resources within the Refuge Complex.

c. Impacts to USFWS Public Outreach Programs and Activities

In addition to informing the public of USFWS roles, responsibilities, and actions, one of the major goals of public outreach programs and activities conducted by the USFWS is to understand what people need, want, expect, and/or desire in regard to the management of the Refuge Complex. With new actions such as those proposed in the combined Preferred Alternatives, USFWS public outreach efforts would continue and may expand.

The future public outreach efforts would seek a mutually beneficial interaction between the public and the USFWS, although as noted elsewhere in this section, there would continue to be controversy about USFWS activities at the Refuge Complex under any of the alternatives being considered in this EIS.

C. Combined Impacts on Cultural Resources

Impacts on cultural resources can include inundation, destruction, damage, and/or disruption. Impacts can directly result from ground-disturbing activities or indirectly from human use or land use and management. Potential ground-disturbing activities include facilities construction, road construction, ditch digging, oil and gas activities, and water control projects (such as levee construction, repair, or removal). Human use activities include increased public access and watercraft wakes. Intense wildfires and cattle tromping may indirectly impact cultural sites as well. Natural phenomenon may also impact cultural sites through inundation, wind/water/wave erosion, subsidence, tree bioturbation, and animal burrowing. According to 36 CFR 800, Protection of Historic and Cultural Properties, any undertaking which may result in alteration to features of a property's location, setting, or use may constitute an impact depending on a property's significant characteristics. Adverse impacts can occur when prehistoric or historic archaeological sites, structures, or objects listed in or eligible for listing in the National Register for Historic Properties (NRHP) are subjected to the following:

- Physical destruction or alteration of all or part of the property
- Isolation of the property or alteration of the property's setting when that character contributes to the property's qualification for the NRHP
- Introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting
- Neglect of a property, resulting in its deterioration or destruction
- Transfer, lease, or sale of the property

Impacts would only be considered adverse if a site is listed, eligible, or potentially eligible for the NHRP. Sites that have not been assigned an NHRP status may experience impacts under the alternatives, but would not experience adverse impacts. In the following discussion, management and land acquisition alternatives are analyzed for adverse impacts to the following sensitive cultural items:

- Six potentially NHRP eligible midden sites on the existing McFaddin, Anahuac, and Moody NWRs.

- One NHRP eligible midden site in the Preferred Refuge Boundary Expansion area near East Bay Bayou.
- The historic shipwreck site in the potential expansion area near Texas Point NWR.

There is a potential for direct and indirect impacts to cultural sites on existing and newly acquired acreage under the combined Preferred Alternatives, however, avoidable impacts would not be considered adverse, but rather minor in nature. Unavoidable adverse impacts are anticipated to continue to occur at potentially eligible sites from natural phenomenon.

Seventeen known shell middens, one of which is NHRP eligible, and a potentially NHRP eligible historic shipwreck would be slated for acquisition as lands become available under Refuge Boundary Expansion Alternative C (Preferred Alternative). The transfer of lands with known cultural sites from private to federal ownership are not anticipated to impact known cultural sites, but would rather preserve the setting of the sites and provide additional protections not afforded to the sites on private lands. Federal acquisition would provide additional protections under NHPA, the Archaeological Resources Protection Act (ARPA), associated regulations, and agency policies for implementing the regulations not afforded to cultural sites on private lands. Section 106 and Section 110 of NHPA set forth the primary consultation requirements for Federal agencies to identify, evaluate, and protect significant cultural resources. ARPA protects archaeological materials on public lands from unauthorized removal or destruction and requires Federal land managers to develop plans and schedules to locate the most scientifically important archaeological sites. ARPA also allows the Federal land managers to issue permits for the excavation or recovery of archaeological resources and sets penalties and fines for destruction, defacement, or unauthorized removal of archaeological resources from Federal lands. Private lands acquired would also be subject to the actions and impacts identified for the management alternatives on existing Refiuge Complex lands.

Impacts to cultural resources would include the following:

- **Natural Phenomenon** - Natural impacts, including inundation, wind/water/wave erosion, subsidence, tree bioturbation, and animal burrowing, poses the greatest threat to shell middens. Due to the marshy, undeveloped nature of the newly expanded Refuge Complex and location of the shell middens along shorelines, full protection of the shell middens is not feasible without completely altering the site or removing the material from its context. Inundation of many of the sites has already occurred and the unavoidable adverse impacts are highly likely to continue. The eligible McFaddin beach site is already inundated by the naturally altered coastline and is subject to water erosion and loss of material. Cultural resource management actions are not proposed for the shell midden sites under the proposed management. Natural impacts would continue to occur to the known cultural sites on existing and acquired areas; however, additional protections may be indirectly afforded to the sites under the combined Preferred Alternatives if water management projects extend to newly acquired lands. The potentially eligible shipwreck that would be acquired has already experienced damage from waves and previous disturbance from U.S. Army Corps of Engineers jetty construction and repair; USFWS ownership would likely not result in any changes to the shipwreck site from its current condition.

- **Shoreline protection -** Existing and proposed shoreline protection projects and water control structures under the combined Preferred Alternatives would reduce wave fetch and intensity of wave action. Shoreline protection projects under the Section 227 National Shoreline Erosion Demonstration Project may indirectly benefit shoreline sites by reducing wave intensity. Offshore wave breaks may also reduce wave action at the McFaddin Beach site. Maintenance of existing shoreline protection projects and water control infrastructure as well as additional water management projects under the combined Preferred Alternatives may result in the identification of additional cultural resources sites and better protection of the sites from wake action. Because water management and facilities construction and improvements would be expanded, cultural resources may indirectly benefit on existing and newly acquired acreage.

- **Ground disturbing activities -** Ground disturbing activities, including facilities construction, road construction, ditch digging, oil and gas activities, and water management projects (such as levee

construction, repair, or removal), would be subject to a ground survey and consultation requirements with the State Historic Preservation Officer (SHPO) under the NHPA Section 106 regulations. Privately initiated oil and gas activities create the most ground disturbance in the Refuge Complex with road, pipeline, and well pad construction. Any dredge or fill projects in the Refuge Complex would be proposed and conducted by the U.S. Army Corps of Engineers. Shoreline protection projects would be subject the Section 106 process and potential impacts to the NHRP eligible sites. All ground-disturbing activities, whether initiated by the USFWS or other entities, would be subject to restrictions imposed on newly expanded Complex lands and consultation with the SHPO under Section 106 regulations. The potential for any ground-disturbing activities to impact known sites or undiscovered sites would be identified and resolved appropriately through the Section 106 process. Known cultural sites on federally acquired lands would be afforded additional protections from ground-disturbing activities through the Section 106 process. Cultural sites on private lands may not experience ground disturbance as often as federal lands, but in some cases may be subject to more. The presence of cultural sites on private lands are typically unknown by the landowner and the sites have been subject to clearing, grading, or borrowed material that modified the condition of the original site. On occasion, private landowners may also collect and remove cultural materials from the sites for a personal hobby, which removes the cultural material from the benefit and knowledge of the greater public. The ground truthing and Section 106 process may reveal more cultural sites previously undiscovered in private ownership and provide protection as appropriate.

- **Prescribed Burning -** The burn intensity of fires may affect archaeological and historical resources. Low-intensity burns are usually associated with lightly burned grasslands during prescribed burns. Low-intensity burns are not anticipated to affect cultural resources, but may cover the resources in soot. High-intensity burns are typically associated with wildfires in dry areas that have abundant litter accumulation due to unnatural fire suppression. High-intensity fires may char or consume cultural resources leading to a potential impact. There is very little likelihood of a high-intensity fire occurring since the Refuge Complex is primarily wet, has high soil moisture content, and was subject to burning by Native Americans, present-day natural resource managers, and lightning-ignited fires. According to the Refuge Complex Fire Management Plan (USFWS 2001), wildland fires on the Refuge Complex are rarely suppressed using direct attack tactics, construction of ground-disturbing firebreaks, or chemical retardants. Natural wildfires are suppressed when they threaten Refuge Complex facilities, adjacent private property, and/or public health and safety. Rotational prescribed burning considered under the combined Preferred Alternatives would reduce the potential for damage to cultural resources from intense wildfires across the expanded Refuge Complex. The cultural sites on newly acquired lands may be subject to prescribed burning that may or may not have occurred previously in those areas. Regular prescribed burning or use of natural ignited fire on acquired lands would reduce the potential for higher intensity fires, and may reduce fuel loads that produce higher intensity fires that threaten the integrity of cultural items.

- **Cattle grazing -** Cattle grazing may damage cultural resources by inadvertent tromping. Some of the shell midden sites recorded have already experienced damage by cattle. Cattle on the Refuge Complex typically feed as they disperse in the wet areas and congregate on higher, dry grounds, which typically include manmade dikes or berms. Shell middens are typically associated with undisturbed, wet areas and may be subject to occasional tromping from the dispersed cattle; however, damage by cattle is not likely to be exceeded by damage through natural erosion. The cultural sites on newly acquired lands may be subject to grazing that may or may not have occurred previously in those areas. The potential for inadvertent cattle tromping is likely to remain on acquired lands slated for grazing.

- **Recreation use** - Recreation visitors and activities may inadvertently damage cultural sites; however, recreation access in the Refuge Complex is largely limited to existing roads and waterways. Recreational activities including hunting, fishing, wildlife observation and photography, environmental education and interpretation would continue under proposed management and would typically occur in previously disturbed areas. Minor improvements to

recreation access, such as trails and boat launches would be constructed under the combined Preferred Alternatives, and would be subject to ground truthing for cultural items before disturbance. Wildlife observation is typically limited to easily accessible areas that comprise a small portion of Refuge Complex lands, where existing shell midden sites are typically not found. Fishing and hunting recreationalists may reach more remote areas by boat. Most of the recreational boat traffic occurs in bayous and constructed canals and ditches that have already been modified from their original landforms through straightening and dredging. Impacts to shell middens from wake action created by smaller boats is likely to be minor. Continuing and expanding environmental education and interpretation programs under the combined Preferred Alternatives may indirectly lead to improved public appreciation and awareness of Refuge Complex lands and resources contained therein. The cultural sites on newly acquired lands may be subject to recreation that may or may not have occurred previously in those areas. Cultural sites on newly acquired private lands may experience an increase in visitation as opposed to that occurred in private ownership. However, recreational activities typically occur in previously developed areas and access can be controlled as needed to protect sensitive cultural items. Boating restrictions on Refuge complex lands would impose restrictions that may reduce the potential for damage to shoreline cultural sites from wake erosion.

D. Summary of Combined Impacts

Overall, positive impacts to the newly expanded Refuge Complex are expected under the combined Preferred Alternatives. In general, the USFWS would maintain a mosaic of native habitat types to support diverse and productive plant and animal communities on the expanded Refuge Complex. Acquired lands would remain undeveloped and would be managed with the existing refuge lands to restore and maintain biological integrity, biological diversity and environmental health

Under the Preferred Alternatives, the USFWS would use water management, prescribed burning, controlled grazing, mowing and haying, prescribed burning, marsh restoration through the beneficial use of dredge material, shoreline protection and restoration, prairie management and restoration, exotic/invasive species control as primary habitat management tools on the expanded Refuge Complex. Biological program activities including surveys, monitoring and research would be focused on priority species identified as needing conservation action, and would guide an adaptive management approach for conserving these species. New initiatives would be focused on addressing threats from relative sea level rise, altered hydrological regimes, exotic and invasive species and contaminants. Additional and enhanced opportunities for wildlife-dependent uses including hunting, fishing, wildlife observation and photography, environmental education and interpretation would be provided on the expanded Refuge Complex.

Under the combined Preferred Alternatives, USFWS management and refuge boundary expansion and subsequent land acquisition would have no major effect on the existence or resolution of current socioeconomic issues. The existence and/or management of the Refuge Complex would continue to be in dispute or unsettled between different parties; people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to USFWS actions; and people would continue to hold mixed opinions about USFWS role and activities within the area. As with existing conditions, issues would be unresolved and one party could not be determined to be “right” and the other party “wrong” with their differing beliefs, values, and goals. For many persons in the area, important considerations affecting the continuation of existing issues would include their sense of personal freedom, self-sufficiency, and control over their future. The USFWS priority would continue to be the support of high quality, effective, and efficient fish and wildlife habitat management and enhancement of fish and wildlife values; however the “appropriateness” of the USFWS’ chosen Preferred Alternatives would depend on individual and group values, beliefs, and goals.

Under the Preferred Alternatives, management philosophies and priorities would change from current conditions, and the amount of USFWS land holdings would increase. While the Preferred Alternatives support different philosophies and priorities, and the differences may be identifiable on a localized basis,

the social structure and lifestyle conditions and trends within the expanded Complex would generally remain the same as current conditions. For the Refuge Boundary Expansion Preferred Alternatives, the concept of selling only to "willing" parties would lessen potential social and lifestyle concerns because changes in ownership would be a choice, not a requirement. Overall, impacts to social structures and lifestyles would not be significant as considered in this EIS.

There is a potential for direct and indirect impacts to cultural sites on existing and newly acquired acreage under the Preferred Alternatives; however, avoidable impacts would not be considered adverse, but rather minor in nature. Unavoidable adverse impacts are anticipated to continue to occur at potentially eligible sites from natural phenomenon. Natural impacts would continue to occur to the known cultural sites on existing and acquired areas; however, additional protections may be indirectly afforded to the sites under the combined Preferred Alternatives if water control projects extend to the acquired lands. The transfer of lands with known cultural sites from private to federal ownership are not anticipated to impact known cultural sites, but would rather preserve the setting of the sites and provide additional protections not afforded to the sites on private lands. Private lands acquired would also be subject to the actions and impacts identified for the management alternatives on existing Complex lands. Ground disturbing activities, including facilities construction, road construction, ditch digging, oil and gas activities, and water control projects (such as levee construction, repair, or removal), would be subject to a ground survey and consultation requirements with the State Historic Preservation Officer (SHPO) under the NHPA Section 106 regulations. All ground-disturbing activities, whether initiated by the USFWS or other entities, would be subject to restrictions imposed on newly expanded Refuge Complex lands and consultation with the SHPO under Section 106 regulations. The ground truthing and Section 106 process may reveal more cultural sites previously undiscovered in private ownership and provide protection as appropriate.

The potential for impacts to cultural resources from prescribed burning, cattle grazing, and recreational use would continue across the expanded Refuge Complex. Regular prescribed burning or use of natural ignited fire on existing and acquired lands would reduce the potential for higher intensity fires under the Preferred Alternatives, and may reduce fuel loads that produce higher intensity fires that threaten the integrity of cultural items. The potential for inadvertent cattle tromping of cultural sites is likely to continue on existing and acquired lands. Refuge visitors and their activities may inadvertently damage cultural sites; however, access to the Refuge Complex is limited to existing roads and waterways. Cultural sites on newly acquired private lands may experience an increase in visitation. However, recreational activities typically occur in previously developed areas and access can be controlled as needed to protect sensitive cultural resources.

II. CUMULATIVE IMPACTS ANALYSIS

Cumulative impact analysis is required by NEPA and CEQ regulations. CEQ's definition of cumulative impacts is as follows:

> *"… the impact on the environment which results from the incremental impact of the action when added to other past, present, or reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taken place over a period of time." (40 CFR 1500-1508)*

For this analysis, a reasonably foreseeable future action must be a project or activity that has been formally proposed by a specific project proponent. This cumulative impact analysis has been conducted with the following approach and analytical perspective:

- The focus of analysis is on identification and disclosure of potential cumulative impacts.
- The analysis is primarily qualitative in nature, and no additional quantitative modeling has been conducted.
- Projects included in the cumulative impact analysis are those that have the highest potential for having identifiable cumulative impacts.

- The analysis considered all potential projects and activities (e.g., Federal, other government, and private).
- The analysis considered impacts beyond the primary and secondary EIS study areas where appropriate.
- The analysis is based on the identified preferred management alternative and preferred refuge boundary expansion alternative.

For this cumulative impact analysis, the following projects or activities have been identified as having existing and/or potential future impacts that could collectively add to impacts from the Preferred Refuge Management and Refuge Boundary Expansion Alternatives:

- State Highway 87 Relocation and Reconstruction
- State of Texas Coastal Management
- Fish, Wildlife, and Habitat Management on Non-FWS Lands
- State of Texas Regional Water Planning
- Navigation and Waterway Projects
- U.S. Army Corps of Engineers Activities
- Drainage District Activities
- Big Hill Strategic Petroleum Reserve Site
- Regional Economic Development Activities

Each of these projects is summarized in the following section.

A. Description of Projects and Activities Considered

1. State Highway 87 Relocation

Texas State Highway (SH) 87 between Sabine Pass and High Island, locally known as "the Beach Road," has existed as a transportation route for more than a century. As far back as 1863, a Civil War map showed a "Road to Galveston" along the shoreline southwest of Sabine Pass. Since that time, ongoing and significant coastal erosion has repeatedly destroyed SH 87, requiring five complete relocations and reconstructions since 1933. Originally located 50 to 100 feet from the Gulf shoreline, this highway was closed in late 1989 due to storm damage from Hurricane Jerry. Currently, large portions of the roadway are damaged and some road sections are within the tidal zone.

In 1997, Jefferson County applied for Clean Water Act (Section 404) and USFWS Right-of Way permits to relocate and reconstruct 16.8 miles of SH 87. The requested permits proposed relocation of the highway to an alignment approximately 300 feet inland of the existing right-of-way.

In 1999, a Notice of Intent was published by the Federal Highway Administration announcing their intent to prepare an EIS for the SH 87 relocation/reconstruction project. The local project sponsors include Jefferson County and the Texas Department of Transportation. Development of the EIS is still ongoing.

Alternatives being evaluated in the SH 87 EIS include alignments along the Gulf of Mexico, close to the highway's historical location, and an alignment along the south shoreline of the Gulf Intracoastal Waterway. These alignments would cross the McFaddin NWR. One of the alternative alignments along the Gulf of Mexico is being seriously discussed as the likely Preferred Alternative in the EIS process. This alternative will include a shoreline erosion abatement component (potentially the restoration of the dune/beach complex using offshore sand deposits) in addition to rebuilding the highway. This would provide some protection for the highway from tidal surges associated with frequently occurring minor tropical storms and extent the life span of the roadway by slowing rates of Gulf shoreline retreat.

2. State of Texas Coastal Management

The Texas Coastal Coordination Act of 1991 led to the establishment of the Texas Coastal Management Program (CMP). The CMP was designed to meet requirements for participation in the federal Coastal

Zone Management Program. Once a state's program is federally approved, the state received federal coastal grant funding and may require federal activities in the coastal zone to comply with the program's policies through a process known as consistency review. The Texas program received federal approval in 1997. The CMP's designated coastal zone includes parts of Galveston, Jefferson, and Chambers counties, but excludes federal lands such as National Wildlife Refuges. CMP activities are administered by the Texas General Land Office (TGLO) and include a broad range of programs which include beach and dune management, annual Beach Clean-up, education campaigns, infrastructure improvement projects, and nature trails.

The Texas Coastal Erosion Planning and Response Act (CEPRA) was enacted by the Texas legislature in 1999 to address the erosion of Gulf beaches and bay shorelines through the funding of erosion response projects and through the study of coastal processes. The CEPRA program is also administered by TGLO. The CEPRA program also offers the forum for local governments to participate in a long-range, statewide comprehensive response plan to erosion problems. One of the major goals of the program is to take a regional, holistic view of erosion, instead of a piecemeal approach. Erosion control projects under CEPRA are coordinated with other state, local, and federal agencies to maximize efficiency. To date, two CEPRA funding cycles for 68 specific erosion control or study projects have been initiated by TGLO. Approved erosion projects and activities have included the following locations in the Texas Chenier Plain region:

- Rollover Fish Pass and Caplen Beach/Shores on the Bolivar Peninsula in Galveston County
- GIWW - McFaddin NWR Reach in Jefferson County (coordinated with the USFWS)
- Dune Restoration - McFaddin NWR (coordinated with USFWS)
- East Bay in Chambers County (including the entire eight-mile shoreline of the Anahuac NWR (coordinated with the USFWS)

In addition, TGLO is partnering with the U.S. Army Corps of Engineers (USACE) on several of their erosion studies and control projects (see the USACE projects section below for a description of the current and proposed USACE projects in the region).

"Coastal Texas 2020" is a long-term, statewide initiative to unite local, state, and federal efforts to promote the environmental and economic health of the Texas coast. To facilitate the work of Coastal Texas 2020, the coast of Texas was organized into five regions and advisory committees are being created for each region. The program will ultimately produce a strategic plan and report to the Texas legislature to lay out strategies addressing issues and challenges of the Texas coastal areas.

The Galveston Bay Estuary Program (GBEP), administered by the Texas Commission on Environmental Quality (TCEQ) under the U.S. Environmental Protection Agency's National Estuary Program. The GBEP supports habitat restoration and conservation education and research activities throughout the Galveston Bay system.

3. Fish, Wildlife, and Habitat Management on Non-FWS Lands

Much of the land in the area surrounding the Refuge Complex has been retained in fairly natural condition because of the obvious hydrological and vegetation limitations on use of the land for developmental uses. Some of this land is actively managed for fish and wildlife habitat.

Beyond USFWS management of the Refuge Complex, other nearby areas that are actively managed for fish and wildlife habitat/values include the J. D. Murphree, Candy Abshier, and Lower Neches Wildlife Management Areas (WMAs), and the Sea Rim State Park (SP). All of these areas are owned by the State of Texas and managed by the TPWD. Each of these areas is described below:

- **J.D. Murphree WMA -** This WMA is a 24,250-acre tract of fresh, intermediate and brackish water within the prairie-marsh zone. The WMA is highly diverse in coastal wetland vegetation communities. There are several rare/endangered/threatened vegetation species within the WMA and wildlife diversity is also high. The WMA is a key nesting and brooding area for Mottled

Ducks, with an increasing amount of nesting by fulvous and black-bellied whistling ducks. A large number of mammals live and forage in the WMA. The American alligator is the single most important reptile and predator in the WMA, with a dense population estimated at greater than one alligator per acre. Alligators have been hunted in recent years by special permit public hunts. The WMA is a principle stopover and staging area for much of the waterfowl of the Central Flyway and provides high quality winter waterfowl habitat. Recreational opportunities include hunting and fishing. The WMA is generally open for wildlife viewing at all times except during hunting seasons. Public access to much of the WMA is restricted to boats due to the lakes, bayous, and marshes associated with this property. Pipelines are common in the WMA. Long-term management of the WMA has been aimed primarily towards providing winter waterfowl habitat.

- **Candy Abshier WMA -** This 208-acre site is located in southern Chambers County, bordered on the north, east, and west by the community of Smith Point with East Bay to the south. FM 562 provides the only access to the area from Anahuac. The WMA was established in 1990, and consists primarily of coastal prairie habitat with important coastal woodlot or oak mottes. A wide diversity of bird species use Candy Abshier WMA as a stopover during migration in both the spring and fall. Management actions emphasize the habitat needs of neotropical migrant passerine species, while encouraging the utilization of the area for research, demonstration, and recreational uses. In addition to fish/wildlife management and recreation, the WMA contains oil and gas development and grazing as land uses.

- **Lower Neches WMA** - The Lower Neches WMA contains almost 8,000 acres near Bridge City in Orange County. It consists primarily of briny coastal marshland, and was acquired by donation. The low level coastal plains surrounding the rivers, bayous, and shoreline has an environment attractive to many migratory birds, game and non-game, that stop during their migrations to and from South America on the Central Flyway. Hunting for birds and alligators is permitted during scheduled special hunts.

- **Sea Rim SP** - The SP includes 4,141 acres of marshland with 5.2 miles of Gulf beach shoreline in Jefferson County. The land was acquired by purchase from Planet Oil and Mineral Corporation and Horizon Sales Corporation in 1972 and was opened to the public in 1977. The park is named for that portion of the Gulf shoreline where the marsh grasses extend into the surf in a zone termed Sea Rim Marsh. The park's coastline contains a biologically important zone, wherein salt tidal marshlands meet the Gulf waters. The SP is a prime wintering area for a variety of waterfowl, and the area also supports a variety of fish and wildlife. Recreation facilities include campsites with water (and in some cases electricity as well); approximately 2 miles of open beach primitive camping, an overflow camping area; picnic tables, restrooms with and without showers; a store, a visitors' center with exhibits; observation deck; nature trail; 6 miles of open beach for bike riding and hiking; and swimming. Additionally, the Marshlands Unit, which is accessible only by boat, has a boat ramp; observation blinds for bird watching, and airboat tours. While the SP is located on SH 87, the closure of this highway necessitates access to the SP only from the east via Highway 73.

The TPWD, in conjunction with other state agencies, has been especially active in recent years in the area of wetlands conservation and planning. Since the mid-1980s, a number of plans have been developed including the State Wetlands Conservation Plan for State-owned wetlands, the Texas Wetlands Plan, and the Texas Wetlands Conservation Plan. In one form or another, all of these plans address wetlands conservation and planning in the State, including the Texas Chenier Plain region.

In addition to governmental conservation/resource protection efforts, a number of private nonprofit groups have been involved in the stewardship of woodlots and other coastal habitats in the Texas Chenier Plain area. For example, the Texas Ornithological Society has established the Sabine Woods Sanctuary outside Sabine Pass; and the Houston Audubon Society and the Texas Nature Conservancy have been involved in protecting important woodlot habitat on High Island. Both of these efforts serve to protect important woodlots for the benefit of neotropical migratory birds. Houston Audubon also owns land on

Bolivar Peninsula (in Bolivar Flats and Horseshoe Marsh) as part of its bird sanctuary program. The Galveston Bay Foundation is involved with coastal marsh restoration and bay shoreline protection in the Galveston Bay system, and is also involved with regional conservation planning and environmental education. The Legacy Land Trust has acquired some conservation easements on Bolivar Peninsula properties to protect coastal dunes/swales, wetlands, and coastal prairie.

The cumulative impacts study area lies within the Central Flyway, which is a major north-south migratory bird route from the Gulf of Mexico through the central United States into Canada. Birds move from breeding grounds in the north to winter quarters in the south along this route in the fall, and vice versa in the spring. Lanes of heavier migration patterns follow coastlines, mountain ranges and major river valleys. The Texas coastal area is a major viewing site for these migratory birds.

In response to nature tourism opportunities along the Texas coast, the Great Texas Coastal Birding Trail (GTCBT) was established in 1996. The route includes more than 300 birding sites across more than 700 miles of Texas coastline, including Jefferson, Chambers, and Galveston counties. The GTCBT has become world-renowned as a birding/recreational destination. Many GTCBT sites are enhanced with boardwalks, observation platforms, landscaping, and avian species information.

The TPWD and Texas Department of Transportation jointly sponsor the GTCBT. The trail involves private landowners, businesses, conservation groups, and Federal, state, and local governmental agencies, all of which have coordinated to make the GTCBT both a positive economic driver and a sanctuary for birds and bird-watchers. The Houston Audubon Society sponsors bird counting surveys and other activities at its 48-acre Smith Oaks site. It is these efforts from the variety of private stakeholders, in combination with public sector natural resource conservation efforts from agencies such as the TPWD and USFWS, that make the GTCBT an effective public-private partnership.

4. State of Texas Regional Water Planning

The Texas Water Development Board (TWDB) is the state's major water planning and water project financing agency. The TWDB's main responsibilities include:

- Collecting and disseminating water-related data
- Assisting with regional water planning
- Preparing the State Water Plan for the development of the state's water resources (surface water and groundwater)
- Administering cost-effective financial programs for the construction of water supply, wastewater treatment, flood control, and agricultural water conservation projects.

With the signing of Senate Bill 1 in 1997, the TWDB began the process of leading a "bottom up" water planning process designed to ensure all future water needs are met throughout Texas. This effort has led to the development of 16 regional water plans in Texas, which must be updated every five years.
Within the regional water planning structure, Chambers and Galveston Counties are in Planning Region H and Jefferson County is in Planning Region I. Water supply and demand data, and other information such as population projections, are kept on both a county and planning region basis. Water demand patterns among these three study area counties are very different, with Chambers County water demand focusing on oil and gas and irrigation purposes, Galveston County water demand focusing on municipal and manufacturing purposes, and Jefferson County water demand focusing on manufacturing, irrigation, and municipal purposes. The TWDB works with the governments and other stakeholders in each region to provide for future water needs; therefore, the TWDB will influence regional water supply projects to meet projected demand.

Also, the TWDB and the TPWD jointly maintain a data collection and analytical study program focused on determining the effects of and needs for freshwater inflows to the state's bays and estuaries. TPWD and the TCEQ jointly evaluate the findings so that TCEQ can appropriately assess the effects of the issuance of water permits within 200 river-miles of the coast.

5. Navigation and Waterway Projects

There are a number of historic waterway, navigation, and drainage infrastructure projects that have affected the areas in and around the Refuge Complex. These include construction of navigation canals, infrastructure and road access for oil and gas activities, channelization and deepening of natural waterways for navigation, and inland drainage. Some of the public works projects that have occurred over the last century and their associated changes to natural conditions include:

- **Gulf Intracoastal Waterway (GIWW) -** The GIWW provides a waterway for transportation of petrochemical products and other goods along Texas and other southern states. It was constructed in 1933. It is connected to the Sabine-Neches Ship Channel allowing access to port facilities in Port Arthur and Beaumont.

- **Sabine-Neches Waterway (SNWW) -** The SNWW is a 79-mile long, deep draft ship channel that extends from the Gulf of Mexico through a jettied channel to Port Arthur and Beaumont via the Neches River Channel, and to Orange via the north part of Sabine Lake and the Sabine River Channel. This navigation channel connects the Gulf of Mexico at Sabine Pass to port facilities in Port Arthur and Beaumont.

- **Houston Ship Channel** - The Houston Ship Channel is a 54-mile long, deep draft waterway connecting the Gulf of Mexico to inland port facilities. It extends from Bolivar Roads near Galveston north through Galveston Bay, the San Jacinto River, and Buffalo Bayou to the Main Turning Basin in Houston, Texas.

- **Keith Lake Fish Pass** - This project, completed in 1977, is a water exchange pass connecting the Keith Lake system of lakes and marshes to the Sabine-Neches Waterway. It was built to enhance fisheries access and recreational fishing in the Keith Lake system.

- **Various levees, roads, cattlewalks, ditches, and canals** - These projects have been associated with the cattle industry, oil and gas development, and access improvements to support commercial and recreational activities throughout the project area.

Generally, these projects were constructed for economic reasons, and have been substantial contributors to the economic growth of the area. Their cumulative modification of regional hydrology has affected ecological and geological processes critical to the long-term integrity of coastal ecosystems in the region. These alterations have contributed to substantial and accelerated coastal land loss from shoreline erosion, and conversion of inland vegetated marshes to open water, and in the conversion of many fresh and intermediate marshes to brackish or saline marshes with a concurrent loss of the natural plant and animal diversity.

6. U.S. Army Corps of Engineers Current Projects

The U.S. Army Corps of Engineers (USACE), Galveston District, exists to fulfill its missions of navigation, flood control and hurricane-flood protection, while its regulatory office works to protect the nation's wetlands and navigation channels. Activities are ongoing with multiple projects and studies within or near the Refuge Complex, including the following:

- **Shoreline Erosion Feasibility Study, Sabine Pass to San Luis Pass -** The study encompasses approximately 90 miles of shoreline to address the severe shoreline erosion occurring along the upper Gulf Coast of Texas between the Sabine-Neches Waterway (Sabine Pass) and the Galveston Entrance Channel (Galveston Bay) and the entire Gulf shoreline of Galveston Island. The study area includes all of the Gulf shoreline within Texas Point and McFaddin NWRs.

- **Section 227, National Shoreline Erosion Control Development and Demonstration Program in Jefferson County -** The primary objectives of the project are to minimize erosion of the exposed cohesive sediment and to minimize sand overwash. The project was constructed in 2004 along 2,500 linear feet of severely eroding shoreline at the eastern end of the McFaddin NWR. The Research and Development project used geotubes to isolate sediment cells. After 3 years of detailed monitoring, the project was transferred to the TGLO..

- **Navigation Improvement Project, Sabine-Neches Waterway Feasibility Study - Channel Improvement to Beaumont -** This project is proposed to widen and deepen the Sabine-Neches Waterway (SNWW) from its entrance in the Gulf of Mexico to Beaumont, Texas. A feasibility study is being conducted to study if the ship channel can be deepened from its present 40 feet to a new depth of 50 feet. The study area includes approximately 65 miles (~13 miles offshore) of waterway along the Sabine River.

- **Section 216 Study, Improvements and Modifications to portions of the Gulf Intracoastal Waterway (GIWW) between High Island and the Brazos River -** The proposed improvements involve channel widening and deepening, construction and expansion of mooring areas, a sediment trap, and bank protection. The project involves approximately 85 miles of the GIWW in Chambers, Galveston, and Brazoria Counties, from High Island to the Brazos River. The improvements are intended to reduce delays and damages and the potential for a hazardous materials spill, providing a more efficient and safer transport artery.

- **Section 1135 Continuing Authority Program (CAP) Studies -** Two Section 1135 (CAP) projects are currently being evaluated in the Refuge Complex area. One project would replace the 1946 salt barrier structure at Taylors Bayou that is now failing. The damage to the existing structure was tied to salinity intrusion from the Sabine Neches Waterway. The second project consists of a proposed natural rock structure that would be located either within the Keith Lake Fish Pass or at the mouth of the Pass. The natural rock structure is intended to act as a reef to control salinity intrusion into Keith Lake and marshes in the eastern portion of the Salt Bayou watershed.

- **Wallisville Project** - Built on the Trinity River, the recently completed Wallisville multipurpose project provides for salinity infusion controls, water supply, recreation, and fish/wildlife habitat enhancement.

- **Navigation Channel Maintenance Dredging -** On-going maintenance and periodic dredging occurs to keep the GIWW, the SNWW, and the Houston Ship Channel clear and safe for navigation. The dredged material is typically stored in leveed dredge containment compartments. In recent years, the Galveston District has worked with other agencies on several beneficial uses of dredge material projects for marsh restoration and shoreline stabilization.

- **Texas DOT Emergency Action Permit For Fill Along the Sabine River** - The Texas DOT holds an emergency permit valid through 2008 to conduct shoreline stabilization activities, as needed, along nine miles east and west of the Port Arthur Ship Channel. The permit is valid for approximately nine miles along the east and west shorelines of the Port Arthur Ship Channel, along SH 87 from south of the GIWW to northeast of Keith Lake, and along SH 82 from east of the GIWW to east of Keith Lake, south of Port Arthur in Jefferson County.

7. Drainage District Activities

There are three Drainage Districts located within Jefferson County. Drainage districts were first authorized by the Texas legislature in 1905. Districts can be established with a two-thirds vote of qualified resident property tax payers in the proposed districts. They have been established to develop, design, and construct canals, drains, ditches, levees, etc. In addition, the Trinity Bay Conservation

District (TBCD) also conducts activities that affect local and regional drainage. Further information on Drainage District 6 and the TBCD is provided below.

a. Drainage District 6 (DD6)

DD 6 was established in 1920, and serves Beaumont, Bevil Oaks, China, Nome, the communities of Fannett, Northwest Forest, Hillebrandt Acres, Cheek, and Labelle, and farm and timber land in between these areas. DD 6 controls storm and floodwaters from rivers, streams and ditches, and drains and reclaims overflowed lands. DD 6 services about 40 percent of northern Jefferson County, including 750 to 900 linear miles of streams, ditches and outfalls. Due to its close proximity to McFaddin NWR, DD 6 activities can have direct interaction with USFWS management activities.

Its activities consist of the design and construction of flood control and drainage facilities, including diversion channels, detention ponds, ditches, etc. Activities are ongoing, and include development of a Master Drainage Plan for the entire district, a Taylors Bayou watershed project/study, a Walker Branch Improvements Project, and the potential for a future passive recreation complex. As part of the Taylors Bayou watershed study, three projects have been recommended in order to substantially lower floodwater surfaces, decrease inundation time, remove 51,000 acres from the 100-year floodplain, and accommodate future upland ditch improvement projects in the upper elevations of the watershed. The three projects proposed in the Taylors Bayou watershed study are:

- **Needmore Diversion Channel** - This channel would consist of a 63,000-foot long, 14-foot deep, 200-foot bottom channel from the North Fork/South Fork Taylors Bayou confluence south to the GIWW.

- **Green Pond Detention Basin -** A 9,000-acre, aboveground detention facility would be constructed, with a maximum water storage capacity of 15,000 acre-feet.

- **Winnie Diversion Channel** - This channel would consist of a 13,000-foot long, 10-foot deep, 50-foot bottom channel from the southernmost “horseshoe” of the South Fork of Mayhaw Bayou south to Spindletop Bayou. (This project is in cooperation with the Trinity Bay Conservation District).

b. Trinity Bay Conservation District

The TBCD provides drinking water, wastewater treatment, and storm drainage for most of east Chambers and part of west Jefferson counties. The District manages stormwater through construction and maintenance of drainage ditches throughout the District. The District constructs such structures as saltwater barriers, bridges, and crossings, and manages about 1,400 miles of ditches in the district. The District is proposing the Winnie Diversion Channel in cooperation with Jefferson County DD6.

8. Big Hill Strategic Petroleum Reserve Site

The U.S. Department of Energy's Strategic Petroleum Reserve (SPR) is an emergency supply of crude oil that was designed to be the nation’s first line of defense in the case of petroleum supply interruptions. The SPR oil is stored in four huge underground salt caverns along the coastline of Texas and Louisiana, and includes the Big Hill site about 20 miles southwest of Beaumont in Jefferson County. This region was chosen for the SPR because there are more than 500 salt domes (the preferred storage geological feature) along the coast and many U.S. refineries, pipelines, and ports are located in the area. The Big Hill storage facility is the SPR’s newest storage facility, with construction beginning in 1982 and completion in 1991. The site covers about 270 acres and is connected via pipelines with port terminals in Nederland and Port Arthur, Texas. A 48-inch brine disposal line from the Big Hill SPR runs across McFaddin NWR to the Gulf of Mexico. About 160 million barrels of oil are stored at the Big Hill facility out of the SPR's total storage capacity of 700 million barrels. The Department of Energy initiated an Environmental Impact Statement in 2005 for the expansion of existing SPR facilities and the potential

construction of a new SPR facility. Proposed expansion of the Big Hill SPR facility may include modification/expansion of the brine pipeline across McFaddin NWR.

9. Regional Economic Growth and Development

The three-county socioeconomic study area includes Jefferson, Chambers, and Galveston Counties. While each county has different characteristics, conditions, and traditions, each county has sought to expand its economic base by encouraging regional economic growth and development. Major industries in the study area include agriculture (including rice and livestock production), oil and gas production, refineries, petrochemical plants, and recreation. In recent years, major industrial development has included several liquefied natural gas facilities. Trend analysis indicates that agricultural activities are declining, while recreation and tourism activities are on the increase. Oil and gas exploration and production activities have increased recently, and the energy industry will continue to be very important in the regional economy. Recreation will continue to be an increasing focus of land use and governmental activities.

The locations and extent of future growth cannot be stated with any degree of certainty at this time. However, it can be assumed that much of any future economic development would take place with the continuing spread of urban growth. Growth patterns likely include west of Beaumont and Port Arthur in Jefferson County, and urban sprawl from Houston eastward into Chambers County is proceeding rapidly. Extensive residential and commercial development is already occurring in western Chambers County. Each county has governmental and/or quasi-governmental agencies responsible for supporting growth and development initiatives and goals.

10. Summary of Regional Actions Associated with Cumulative Activities

Actions taken by various stakeholders in the area in and around the Refuge Complex that affect the land and natural resources upon the land vary among the public (e.g., governmental agency) and private entities involved in projects and activities in the region. Collective action categories affecting land and natural resources in the region include:

- Habitat and fish/wildlife management and enhancement
- Water management
- Cropland management
- Grazing management
- Prescribed burning
- Exotic and Invasive species management
- Erosion control
- Restoration (of habitats, shorelines, etc.)
- Increased recreation/improved visitor experience quality
- Improved access (e.g., SH 87)
- Development of additional navigation/drainage infrastructure
- Repair and maintenance (e.g., dredging) of existing navigation/drainage infrastructure
- Economic development (including tradition oil and gas and agriculture development)
- Land management actions by the USFWS represent a substantial portion of this list of action categories.

While some landowners subscribe to an unmanaged, passive land approach, each governmental agency and many private landowners in the region have generally established land management goals, objectives, and actions. Some of these goals, objectives, and actions serve to make economic gain; others serve for ecological and natural resource preservation/conservation purposes; some are required by law, regulation, or policy; and still others have a mix of purposes and effects. For some land, management practice is non-existent and the result is passive, unfocused land management.

The USFWS, USACE, and State of Texas agencies have engaged in several cooperative programs with various other public and private entities for habitat enhancement and restoration projects, environmental

education programs, and expanding public recreational facilities and services. The benefit of these cooperative programs include the contribution of nonfederal funds to match federal dollars, the contribution of efforts of volunteers on many labor intensive projects such as habitat restoration, the contribution of volunteers to initiate and coordinate environmental education and outreach programs, and the contribution of various groups for materials and labor for improving public use facilities. Because of cumulative cost concerns and the realization that projects cannot be conceptualized and implemented on just an individual basis, use of cooperative programs for a variety of purposes would likely increase in the future.

B. Cumulative Impacts of Regional Projects and Activities with the Combined Preferred Alternatives

This section summarizes the potential impacts of the projects, activities, and management responses to environmental issues and problems identified above accumulated with the potential impacts from implementation of the combined Preferred Management and Refuge Boundary Expansion Alternatives. Impact discussions are somewhat general in nature because of the regional perspective of the cumulative impact analysis.

1. Natural Resources Section

a. Impacts to Air Quality

The major sources of air pollution in the region are oil and gas production, chemical production, shipping, agriculture, and automobile emissions. Jefferson County is within the Beaumont/Port Arthur (BPA) air quality region, while Chambers and Galveston Counties are within the Houston/Galveston (HGA) air quality region. Both of these regions have been designated as non-attainment areas for ground-level ozone. The EPA has classified the BPA non-attainment region as “severe,” while the BPA non-attainment region has been classified as “moderate.” Both regions must attain the one-hour ozone standard by November 15, 2007 according to the State Implementation Plan. To reach this attainment status, the BPA region needs to reduce nitrogen oxides (NOx) by about 31 percent. Attainment in the HGA area is especially challenging, due to the magnitude of reductions needed for attainment and the shortage of readily available control options – substantial decreases in NOx and volatile organic compounds must be achieved in the HGA to achieve attainment status.

Prescribed burning is conducted by the USFWS, State of Texas, and some private landowners as part of agricultural practices and habitat management. Prescribed burning is conducted by the government agencies only under specific meteorological conditions, and requires permits to burn. Some private landowners also conduct burning under specific meteorological conditions, but private prescribed burning can at times be unpredictable and some private landowners do not go through the proper regulatory processes before burning is conducted. Regional air quality is affected by prescribed burning only when many acres are burned concurrently on the same day. Each individual project or activity in the region that produces air emissions adds to the existing air problem. Through the permitting process, individual project approvals for air emissions are required in the vast majority of cases throughout the cumulative impact area. These permits processes assess the capability of each project to stay within required emission limits and support the terms of the State Implementation Plan.

Automobile traffic and associated emissions will continue to grow throughout the region. Relocation/reconstruction of SH 87 would produce only very localized additional air pollution from the new traffic of less than 1,000 vehicles per day that would use the new highway. Overall, air quality issues are a major regional issue, but air quality varies widely among specific locations in Chambers, Jefferson, and Galveston Counties. The Houston and Beaumont/Port Arthur areas have much more substantial air quality problems than those in and around the Refuge Complex.

b. Impacts to Geology and Soils

Major regional geological/physical process issues and concerns include coastal erosion and disposal/use of dredged materials, as summarized below.

(1). Coastal Land Loss

Relative sea level rise is the combination of land subsidence and eustatic sea level rise. Recently, the combination of rising sea levels and land subsidence and altered hydrological regimes have impacted many coastal processes, including geological processes such as erosion, sedimentation and soil formation. Coastal habitats in the Chenier Plain region and throughout the western Gulf Coast ecosystem are being heavily impacted. Accelerated coastal land loss is occurring, both from the periphery as Gulf and bay shorelines are eroded and retreat and in interior vegetated marshes which are converting to open water.

Most of the present Gulf of Mexico shoreline and shorelines of major bays and inland lakes in the Chenier Plain region are retreating. The existing beaches are eroding and being deposited back over marshes or bay bottoms. Former bay bottoms and incised river valleys provide the nearshore sources of coarse grained sediment and broken shell that make up the beaches. The scarcity of coarse sediments in this littoral system contributes to the relative scarcity of well-developed offshore bars and onshore beaches and dunes.

Although shoreline retreat and along the region's Gulf and bay shorelines has occurred over geologic time with fluctuations in sea level and sediment supply, several anthropomorphic factors may be influencing current rates of coastal land loss. Global climate change due to release of greenhouse gases appears to be impacting current rates of sea level rise. Land subsidence occurs naturally as recent geologic sediments compact, but also as a result of subsurface fluid withdrawal (groundwater and oil and gas) which has occurred extensively throughout the region (White and Tremblay 1995). Subsidence can also occur locally during periods of drought through surface dehydration, oxidation and shrinkage in the region's highly organic soils. Marsh fires during these conditions can also result in loss of surface elevation.

In addition to ongoing impacts, relative sea level rise poses a significant future threat to the region's coastal habitats. The mean sea level trend for Sabine Pass, Texas is 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration website, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise are underestimating future conditions. Of certainty is that the viability of the region's coastal wetlands will depend upon their ability to vertically accrete, or gain elevation, to keep up with relative sea level rise.

A coarse sediment deficit in the Gulf of Mexico's littoral system resulting from construction of navigation channels, jetties, and upstream dams on rivers has also accelerated rates of shoreline retreat and coastal land loss along the Gulf shoreline. This reduced sand supply has contributed to the loss of much of the region's low barrier beach/dune system, which formerly reduced shoreline erosion and retreat by buffering wave action and prevented inundation of inland freshwater marshes with saltwater during all but major storms and tidal surges. Shoreline erosion and retreat along the Gulf of Mexico in the project area is resulting in coastal land loss at rates as high or higher than those in coastal Louisiana. The historic barrier beach/dune system has been almost entirely loss on both the Texas Point and McFaddin NWRs. Average annual rates of shoreline retreat on most of Texas Point NWR are greater than 40 feet per year, and significant portions of the McFaddin NWR shoreline is eroding at rates of 10-15 feet per year (Bureau of Economic Geology unpublished data). Coastal habitats affected include wetlands, salty prairie and beaches and dunes. In addition to loss of beach and dune habitat, this loss of elevation along the Gulf shoreline has increased saltwater intrusion from the Gulf, as tidal overwash of the beach ridge is occurring much more frequently than historically. This increased saltwater intrusion is negatively impacting plant productivity and diversity and many fish and wildlife species in Refuge marshes. Loss of

plant productivity may decrease of the ability of these marshes to accrete vertically at a rate which keeps up with relative sea level rise, which may lead to submergence and a rapid loss of vegetated marshes as they convert to open water. (On McFaddin NWR, coastal erosion and damage from storm tidal surges have also destroyed a portion of Texas State Highway 87, a coastal highway that has been closed since 1989.)

Restoration of the historic beach and dune systems along the Gulf would slow erosion, protecting wetlands and infrastructure and restore rare floral and faunal communities. Effective implementation of dune restoration projects and dune protection activities requires extensive coordination among Federal and state governmental agencies, especially related to public education, outreach, signs, and law enforcement. Similarly, additional erosion abatement projects along the GIWW and the shoreline of East Galveston Bay are needed and require interagency coordination.

(2). Soils and Dredged Materials

Spoil banks developed from excavated canals and bayous consist of Made Land soils. The spoil materials of the 15-foot levees along the edge of the GIWW, the saltwater flats that adjoin the waterway, and salty prairie habitats are an example of Made Land soils. Made Land soils are a mixture of clay, sand, and shells. Soils comprising the salty prairie habitats are usually quite variable ranging from generally deep moderately saline clays to stratified clay and loamy materials that have been excavated from canals, ditches, or waterways. These soils are affected by salt spray, storm tides, and salty high water tables restricting the kind and density of plants present.

Dredging of materials from regional waterways and channels is a continuing modification of natural conditions, and has major effects on regional hydrology and habitats. Dredging activities by USACE are a regular occurrence in the region, and will continue into the foreseeable future. The USACE is looking at ways to avoid dredged material placement in waste piles on or near the shorelines of dredged areas, and to use dredged materials to reduce shoreline erosion and for storm damage prevention. For example, dredge spoil from the Sabine-Neches Ship Channel now deposited in offshore disposal areas could be deposited directly on beaches or in near shore littoral systems. The course sediment from the spoil would then be available for the natural processes of rebuilding beaches and dunes, reducing erosion rates, and coastal wetland loss. The replenishment of coarse sediments is one of the most critical needs for the restoration and long-term protection of valuable fish and wildlife habitats in this Texas coastal ecosystem, and appropriate use of dredged materials could help in this effort. Regionally, opportunities for beneficial use of dredged material include beach and coastal wetland nourishment and restoration, seagrass restoration, shoreline protection, and mangrove and saltmarsh wetland creation.

c. Impacts to Hydrology and Water Quality

Major regional hydrological issues include the historic and continuing modifications to natural hydrological conditions, water quality, water supply, and flood control. Each is discussed below.

(1). Modifications to Natural Hydrological Conditions

The natural pattern of hydrology in the Texas Chenier Plain region has been critical to the building processes that created and maintained the diversity of coastal wetlands and other elements of the ecosystem. Frequent flooding over low bayou banks and large volumes of rainwater flowing slowly across coastal prairies and marshes provided nutrients, sediments, and freshwater to marsh systems. Natural drainage allowed a cyclic pattern of drying and flooding under which wetland plants evolved and adapted. Historically, these ecosystems contained a continuum of coastal marsh types associated with a natural salinity gradient. This continuum of freshwater, intermediate, brackish, and saline wetlands supported a diversity of floral and faunal communities. Diversity of these communities decreased as tidal influence and salinity increased along the gradient.

However, past and continuing modifications of regional hydrology have substantially affected natural ecological and geological processes critical to the long-term integrity of these coastal ecosystems. In

general, the primary human induced activities that have affected this coastal ecosystem include construction of navigation canals, infrastructure, and road access for oil and gas activities, and channelization and deepening of natural waterways to promote inland drainage and navigation. Impacts from the construction and maintenance of these facilities include:

- Saltwater now reaches farther inland into historically freshwater marshes altering the plant species composition and plant productivity. Overall, biological diversity decreased through the conversion of fresh and intermediate marshes to more brackish regimes and salt-tolerant plant and animal communities. Saltwater intrusion also introduced sulphates to these freshwater marshes, which under conditions of high water temperatures during summer are reduced to hydrogen sulphide. Sulphide toxicity can cause plant die-offs and has been implicated as a contributing factor in the conversion of vegetated emergent marsh to open water.

- New channels and modifications of natural waterways introduced tidal energies into historically non-tidal or micro-tidal marshes, resulting in decreased plant productivity, plant mortality, peat collapse and erosive loss of organic marsh soils. All have contributed to the conversion of the vegetated emergent marsh to open water. Introduction of tidal influence also altered marsh hydroperiods or wetting and drying cycles. Non-tidal and microtidal marshes whose soil surfaces were exposed only seasonally or during periods of drought became subject to daily tidal fluctuations.

- Increased saltwater intrusion reduces plant productivity in plant communities adapted to fresher hydrological regimes. Plant productivity, especially below-ground biomass in root systems, is an important component of soil formation in the Chenier Plain region's fresher coastal marshes. Reduced plant productivity may reduce soil formation and limit marsh surface elevation gain.

- Alterations to the natural drainage systems in the region have resulted in a rapid transport of freshwater and sediments from inland areas directly to the GIWW, bays and the Gulf, and have generally eliminated the slower historic sheet flow of freshwater from the prairies into the marshes. Historic hydroperiods in the marshes have been altered as rapid drainage of inland flood waters has increased the frequency and depth of precipitation-driven flood events in downstream marshes. Conversely, drainage improvements in and adjacent to the marshes has promoted more rapid drainage and drying during normal or low precipitation cycles.

- Natural and human-caused subsidence has resulted in submergence or "drowning" of emergent wetlands and conversion to deeper, open water. Natural subsidence is the compaction of recent geologic sediments. Human-induced subsidence in the region occurs primarily from groundwater withdrawal and oil and gas extraction. Oil and gas extraction is believed to induce movement of near-surface geologic faults, causing a rapid drop in marsh elevation (White and Tremblay 1995). Subsidence also contributes to saltwater intrusion and is a causative factor in shoreline erosion/retreat and resultant coastal land loss along the Gulf, bays and larger waterbodies. The mean sea level trend for Sabine Pass, Texas is 6.54 millimeters/year (2.15 feet/century) with a standard error of 0.72 mm/year, based on monthly mean sea level data from 1958 to 1999 (National Oceanic and Atmospheric Administration, www.tidesandcurrents.noaa.gov)). Recent scientific information on changes in polar ice caps related to global climate change suggests that current projections of relative sea level rise are underestimating future conditions.

Land subsidence is an induced movement of geologic faults at the surface causing a rapid drop in marsh elevation. Subsidence has resulted in submergence or "drowning" of emergent wetlands and conversion to deeper, open water ponds. Much of the subsidence in this part of Texas is human induced, from groundwater withdrawal and oil and gas extraction. Subsidence is also attributed to natural compaction of geologic sediments. Subsidence contributes to saltwater intrusion (White and Tremblay 1995).

Conversion of vegetated marshes to open water has occurred throughout the region in areas where rapid land subsidence resulted in submergence of wetlands. Relative sea level rise is resulting in increased

saltwater intrusion further inland into both surface waters and underground freshwater aquifers. Increased saltwater intrusion due to relative sea level rise may decrease plant productivity and impact soil formation and marsh surface elevation gain, and future relative sea level rise threatens existing vegetated marshes with submergence and conversion to open water. Increased saltwater intrusion and introduction of tidal energies to historically non-tidal or micro-tidal freshwater marshes through the construction of navigation and drainage channels have caused plant mortality, peat collapse and erosional loss of organic marsh soils, also leading to conversion of vegetated marshes to open water. It is likely that these impacts have been and will be the most severe in areas subject to both saltwater intrusion and rapid subsidence. These human induced processes have resulted in various ecological responses, some of which are directly responsible for the onset of others (Stutzenbaker 1990, White and Tremblay 1995). This fact illustrates the interdependent relationship of natural resources and ecological processes in this complex ecosystem.

Water that is rich in nutrients, particularly nitrogen and phosphorous, enter East Bay via the GIWW from Sabine Basin. Groundwater withdrawal has impacted artesian well pressure, groundwater quality (saltwater intrusion), and caused land subsidence. The largest wetland losses in this basin resulted from fill placed in wetlands for the construction of impoundment levees and roads, disposal of dredged material from the GIWW, and construction of drainage canals for housing developments on Bolivar Peninsula. The construction of the GIWW, the Sabine-Neches Waterway, and Keith Lake Fish Pass (connecting Keith Lake to the ship canal) dramatically affected the lower 65,000 acres of Salt Bayou with a significant loss of intermediate and freshwater marsh and associated plant and animal communities (Stutzenbaker 1990). The Sabine-Neches Ship Channel, along the western edge of Sabine Lake, has had a strong influence on the tidal action and saltwater intrusion into the basin. Approximately 80% of the freshwater flows that historically moved into Sabine Lake from the two rivers now bypass Sabine Lake and flow into the ship canal directly to the Gulf. Some portion of the freshwater also flows through the GIWW toward East Bay. Freshwater and intermediate marshes had become brackish as far inland and westward as Clam Lake (13 miles from Sabine Pass). Direct tidal action now occurs at the south end of Sabine Lake. From these examples, it is clear that the cumulative effects from hydrological change are substantial and extensive. Furthermore, ecological responses to hydrological and other natural resource modifications are ongoing (e.g., changes are still occurring in response to alternations of natural conditions).

(2). Water Quality

Surface water quality is influenced by agricultural practices and saltwater intrusion. Saltwater intrusion is probably the water quality parameter of the greatest concern to the Federal and state land management agencies as it is a contributing factor to wetland loss through the conversion of vegetated wetlands to open water. The movement of saltwater from the Texas Gulf inland through the bayou and marsh systems varies depending upon tidal action, storms, and storm runoff. The GIWW, the Keith Lake Fish Pass, channelization of natural waterways, and the many canals associated with oil and gas development have facilitated the movement of saltwater further inland than what occurred historically or what would occur under natural conditions. The level and impacts of saltwater intrusion vary by area and requires site-specific investigations to evaluate the habitat conditions.

Agricultural lands supporting rice cultivation contribute nutrients and toxins to surface waters within coastal watersheds. The application of herbicides is used in the farming of rice, soybeans, sorghum, and hay. Concentrations of herbicides are generally greatest during May, June, and July with the lowest concentrations occurring in the fall and winter. Other potential sources of contaminants affecting regional lands and waters include oil spills, leaks, and contamination from oil production and transport areas (pipelines, barges, etc.), aerial deposits of airborne contaminants from refineries located at Port Arthur, malfunctions of waste water treatment plants, and developments of landfill sites. Water runoff after heavy rainfalls could contain point source and nonpoint source contaminants. A relocated/reconstructed SH 87 and increasing urbanization would add to regional stormwater runoff on a localized basis.

(3). Water Supply

Most drainage ditches and agricultural water delivery systems are owned and maintained by county navigation and drainage districts, or similar agencies. Lands that receive irrigation water either have water rights and pump from the creeks and bayous or purchase water from the above mentioned water purveyors. Wetland management generally requires less water per acre (approximately one-third the water) than what is required for rice farming. The non-urban demand for water has declined dramatically with the decrease in rice farming in the area, increasing the availability of irrigation water under average hydrologic conditions.

Groundwater is shallow in the region and in many cases groundwater levels are at the surface. The availability and quality of groundwater for domestic supply or recreational use throughout a majority of the region is generally unknown. The deeper Gulf Coast aquifer may yield large quantities of water, but there is little indication that large volume groundwater pumping is common or economically sound. The larger water wells generally are associated with domestic supply for the small communities in or adjacent to the Refuge Complex..

Water supply will continue to be a driving force of water management practices and further development of the region. The State of Texas' regional water planning processes currently underway by the TWDB will continue to match water supplies with water needs on regional bases. The regional water planning processes will also continue to drive some portion of water development projects such as water storage, drainage, or flood control.

(4). Flood Control

The average annual precipitation in the area is approximately 55 inches which includes many high and intense individual storm events. As a result, flooding is common in the region. Erosional scouring and saltwater intrusion associated with storms result in the loss of freshwater emergent and aquatic vegetation and an increase in open water habitat, particularly in areas subjected to long-term inundation with saltwater. The positive aspects of this type of flooding include the deposition of sediment into the coastal marshes, a necessity for marsh accretion. However, alterations of the natural topography, primarily to promote drainage (GIWW, levees, canals, and channeling) of the inland portions of several watersheds have exacerbated flooding in the downstream portions of the watershed.

Inland flooding can damage existing infrastructure (buildings, roads, levees, power poles, oil/gas wells, and storage tanks) depending on the level and extent of flood stage. However, freshwater infusion from flooding can be beneficial to the natural resources by recharging the freshwater wetlands and providing nutrient and sediment to these areas. The lands directly along the Gulf Coast are most susceptible to flooding from tidal surges.

In response to the adverse effects of flooding, flood control projects have been initiated throughout the region by local governments or drainage districts. The existing flood control infrastructure requires extensive repair and maintenance on a regular basis, and also after flooding and storm-caused erosion damage. The proposed Needmore Diversion Channel, sponsored by DD6 in Jefferson County, would continue the trend of large flood control projects in the region. The Needmore Diversion Channel has the potential to further impact regional hydrology, habitats and fish and wildlife resources.

d. Impacts to Vegetation and Habitats

Vegetation issues in the region around the Texas Chenier Plain Refuge Complex are similar to those faced by the USFWS. The major issues, concerns, and impact trends relevant to vegetation include habitat loss/fragmentation, and the increasing ecological harm from invasive plant species.

(1). Habitat Loss/Fragmentation

The vegetation communities within the Refuge Complex are representative of the region as a whole. Vegetation communities comprise the habitat that provide the food and forage for numerous fish and wildlife species in the region. If habitat is lost or fragmented, the direct impacts are not only to vegetation, but to fish and wildlife as well.

A major threat to the primarily freshwater and intermediate wetland habitats is saltwater intrusion. Freshwater and intermediate marshes are important for a variety of plants and for invertebrate diversity. Both plant and invertebrate diversity are essential elements for many species of wildlife. The alterations of hydrology have resulted in increased saltwater intrusion. Saltwater intrusion, in combination with other factors, has resulted in the conversion and loss of emergent marsh to open water. The intrusion of saltwater into primarily fresh and intermediate marshes has gradually converted these productive wetlands into brackish or saline marshes, decreasing the diversity of wetland habitats. With the loss of the freshwater component from the gradient of wetland types present in the coastal areas historically, the biological diversity has decreased and many resident and migratory species have been forced into fewer and smaller productive areas.

In addition to saltwater intrusion, habitat loss occurs from land use conversions, urbanization, invasive species, and hydrological modifications. Habitat fragmentation in the region occurs from projects such as pipelines, canals, ditches, and waterways. Habitat fragmentation breaks discrete habitat units into smaller pieces, and often cuts off or blocks freshwater inflows needed for habitat health. Regional water planning processes coordinated by the TWDB in the study area (Regions H and I) both identified maintenance of freshwater inflows into the bays and estuaries of the coastal areas as major regional concerns.

The management of regional habitats among the various public and private landowners ranges from active management (high intensity) such as that conducted by the USFWS and State of Texas, to haphazard or passive management (low intensity). The high intensity management practices of the USFWS and State of Texas are consistent with one another, and these management actions are directly intended to avoid or mitigate existing environmental or natural resource management problems.

While there are cooperative efforts among some of the other landowners in some instances, habitat management is often inconsistent and sometimes conflicting with other goals in the region. Some examples of regional habitat management issues are provided below.

- In most cases forested wetlands in the region receive minimal stewardship. These lands are generally not managed intensively for timber production or wildlife. Trees of commercial size are occasionally harvested and processed at mills approximately 30 miles inland. Typically, forested wetlands in the area have been cleared for farming and grazing. Disturbed sites are susceptible to invasion by Chinese tallow. Remnant forested wetlands usually consist of narrow strips of habitat along a river or bayou corridor; relatively large, undisturbed blocks of this mixed deciduous forest habitat occur along the Trinity River and in the Taylors Bayou watershed in the northern portion of the project area.

- The USACE owns a substantial area of forested wetlands along the Trinity River within the northwestern portion of Chambers County near Wallisville. Approximately 5,700 acres were purchased by the Corps for the Wallisville Project in the 1970's (south of Interstate 10). The Wallisville Project was initially established primarily for water storage and supply. The project is currently designed to prevent saltwater inflow into the Trinity River floodplain during the River's low-flow periods. Much of the land above the saltwater barrier will be unaffected by the Project and is likely to remain in a natural state.

- Stewardship of coastal marshes varies greatly across the region. In addition to the USFWS and Texas state agencies, certain private landowners are involved in stewardship activities to

maximize fish and wildlife benefits and production. Many of these landowners are enrolled in one or more of the cooperative programs currently available to private landowners with governmental agencies. These lands are generally leased for waterfowl hunting by both commercial and private interests, and waterfowl management is a primary focus of management activities on these lands. By default, many other migratory and resident species benefit from these management activities. In contrast, other private lands in the region are managed for other purposes, or receive no management. In general, this has resulted in loss or degradation of coastal marshes, especially in the freshwater marsh components. Reduced benefits to wildlife and negative impacts to natural biological diversity have resulted.

A few of the undeveloped woodland habitats are under some form of stewardship. If the structure and species composition of these habitats are maintained, they will continue to provide substantial benefits to wildlife, especially to neotropical migrants during spring and fall.

The USFWS, State of Texas, the USACE, and some private landowners have developed and implemented efforts to restore natural habitats in some areas of the region. These efforts, however, are often piecemeal and do not necessarily achieve the larger habitat restoration goals and achievements necessary to reverse existing trends or extensive habitat loss or degradation.

Restoring degraded marshes and maintaining adequate marsh building processes involve the reintroduction of freshwater and sediment, restoring adequate drainage to alleviate flooding stress, and restricting saltwater intrusion. Factors resulting in marsh loss are often complex in nature and differ between locations. In order to develop corrective measures and restore wetlands, factors impacting the marshes must first be analyzed through pre-project monitoring. Post-project monitoring is just as essential to evaluate restoration activities. Government roles in pre- and post-project monitoring of corrective measures are important in the region, and involve the USFWS, State of Texas, and USACE. An increasingly important restoration tool involves the use of dredged materials to augment sediment supply in sediment poor marshes. Methodologies such as terracing, which use dredged materials to artificially augment marsh elevation, may restore emergent marshes in areas which have been converted to open water. Other means of increasing accretion involve sediment diversions, water level, and salinity management. Backfilling submerged wetlands with fill from excavated areas are also options for directly restoring emergent wetlands lost through land subsidence. The use of wave barriers, installation of water control structures and low level dikes, and transplanting root stock has been used effectively to create emergent marsh along the East Galveston Bay and the GIWW.

The major step involved in restoration of native tallgrass coastal prairie habitat is restoring the natural hydrology of the area. This involves removing old levees and restoring the natural contour of the land. The next step is the introduction of native prairie plant seeds or plant materials. Many commercially available seed sources are not suitable and most of the seeds collected locally have the best survival. Prescribed fire and rotational grazing are used to maintain restored prairie areas.

(2). Invasive Species Management

Many non-native species exist in apparent harmony in environments where they were introduced. However, an invasive species is one that displays rapid growth and spread, establishes over large areas, persists, and often conflicts with or replaces native species of vegetation. Invasive species, sometimes also referred to as noxious weeds, is a major regional problem.

Lack of invasive species management on much of the land in the region makes regional invasive species control difficult. Without disturbance, both marsh and prairie habitats are subject to invasion by several woody plants. Public agency (e.g., State of Texas and USFWS) invasive vegetation species control efforts are directed towards the following species: Chinese tallow, deep-rooted sedge, baccharis, willow red rice, coffee bean, barnyard grass, Johnson grass, broadleaf weeds, and other grasses. Aquatic pest plants within the region include water hyacinth, alligator weed, common reedgrass, salvinia, and cattail.

These plants can choke inland waters, canals, reservoirs, and bayous throughout the area. Regional invasive plant control strategies include:

- Prescribed fire
- Mechanical
- Chemical
- Controlled saltwater inflows

e. Impacts to Fish and Wildlife Resources

Regional impacts to wildlife are primarily dependent upon the health and availability of wildlife habitat, and associated management of land and vegetation. Habitats provide the wintering, migrational, and breeding habitat for numerous migratory birds and other wildlife. Habitat serves as a source of food and shelter for fish and wildlife.

Wildlife protection and wildlife habitat protection is the highest priority of the USFWS, and is also a major priority of several other Federal and state agencies and conservation organizations. Habitat loss and fragmentation lead indirectly to decreasing wildlife health and to decreasing biological diversity.

Overall, wildlife is vulnerable on a regional basis to environmental and resource changes such as land use conversions, habitat loss/fragmentation, modifications of hydrology, etc. This vulnerability and potential direct, indirect, and cumulative impact to wildlife is mitigated to some extent through land and habitat management efforts by the USFWS, State of Texas, USACE, other agencies, private groups, and individuals. Without the land and habitat management efforts, impacts to wildlife would be more substantial.

f. Impacts to Land Uses and Land Conditions

Land use concerns from a regional perspective are generally the same as those faced by the USFWS at the Texas Chenier Plain Refuge Complex. Land uses and conditions have evolved substantially from natural conditions, and changes in access and land uses have resulted in substantial loss and/or fragmentation of natural habitats.

Major regional land uses are the same as those uses found in and around the Refuge Complex:

- Land conservation and wildlife/wildlife habitat protection use
- Agricultural use
- Recreational resource use
- Oil and gas use
- Developmental (residential/commercial/industrial) use

Intentional and unintentional land use and land condition changes are very evident throughout the region. In addition to the changes resulting from the construction and maintenance of navigation canals and other water-related infrastructure (discussed in detail within the Hydrology section below), examples of other land use/condition changes include:

- Larger areas of upland pine/hardwood habitats in the region have often been managed for timber production. Over the last several years a substantial acreage of this habitat in Chambers and Jefferson Counties has been harvested. Remnant native stands that are not managed as pine monocultures provide important benefits to a diversity of upland species.

- Conversion of natural habitats to agricultural uses in the area has occurred on most lands that would support these activities over the last century.

- Almost all of the historic native tallgrass coastal prairie in western Gulf Coast region has been lost. Agriculture, urbanization, and industrialization have directly replaced much of the native prairie. Extensive drainage impacted much of the remaining area. Naturally occurring wildfires were suppressed, native grasslands were overstocked with domestic cattle, and non-native plants and animals were introduced.

- Coastal land loss threatens extensive acreage of inland brackish and intermediate marshes as Gulf and bay shorelines retreat. Shoreline restoration/stabilization efforts in the region have been ongoing for the last 25 years.

- Substantial acreages of wetlands have been lost to both natural and human induced factors over a recent 25-year period.

- Regional navigation, flood control and drainage projects have changed natural hydrologic regimes, which subsequently changes land conditions and potential land uses.

- Oil and gas exploration on the Texas Gulf Coast has occurred since the early 1900's. Oil, gas, and mineral exploration, with intensive 3-D seismic survey activity, is continuing along the Texas Gulf Coast, both on-shore and off-shore.

Various land uses can conflict and compete in certain locations in the region. In response to these conflicts, management agencies such as the USFWS, USACE, and State of Texas often cooperate on resolution or study of natural resource problems. However, because of budget constraints and the scope and extent of regional environmental problems, these agencies are often only able to react to the “hot spots” requiring the most immediate attention. Proactive management efforts are difficult in these circumstances.

(1). Access

In addition to the general land use and condition changes identified above, access within the region is another major land use issue and concern. One of the major regional access issues is the potential relocation of SH 87. The USFWS has a dual role in SH 87 issues in that it is an affected landowner and is a cooperative governmental partner in resolving environmental issues related to the road relocation/reconstruction. Completion of the highway project would bring more visitors to the region, providing an opportunity for the USFWS and the State of Texas to reach a diverse audience with information on the coastal resources through interpretive displays, kiosks, and other educational facilities. A relocated/reconstructed highway would provide additional access for recreation in the area, particularly on the McFaddin NWR and at Sea Rim SP.

Other access issues include access to oil and gas resources, and access to recreational opportunities. For example, new roads and access infrastructure will continue to be a major part of oil and gas development in the region. Recreational access concerns center around the need to strike a balance between recreational use/visitation and conservation of natural resources.

2. Socio-Economic Resources Section

a. Recreational Impacts

Recreational uses of regional land occurs because of both economic and social/lifestyle reasons. The growth in ecotourism (e.g., wildlife viewing and photography) in the area supplements the traditional uses of land for hunting and fishing. Regional hunting opportunities for waterfowl are extensive, and involve large amounts of both private and public lands. The Texas Gulf Coast is the primary site for ducks wintering in the Central Flyway, with an average of 1.3 to 4.5 million birds, or 30-71 percent of the total flyway population. The area also winters 90 percent of the snow, Canada, and greater white-fronted geese in the Central Flyway. Additionally, the coastal marshes, prairies and prairie wetlands of the Texas

Chenier Plain region serve as a critical staging area for Central Flyway waterfowl migrating to and from Mexico and Central/South America. The government land management agencies and many private landowners understand this link from habitats to recreation, and therefore recognize the need to protect natural resources and natural ecological processes to protect their economic, cultural, and social ties to recreation. Recreational land use will continue to be important in both economic and social terms to those who live and work in the region; however, there are many ecological threats to these recreational uses, including habitat loss/fragmentation, hydrological modifications, and developmental/urbanization pressures.

b. Economic and Social Impacts

Economic and social life in the region has had a long history of ties to the land and water of the Texas Chenier Plain region. The land and water have a rich heritage of relationships with lifestyles and commercial activity. Regional economic activity is driven by agriculture, recreation, and oil and gas development. In addition, commercial transportation activity along waterways, such as the GIWW, provides substantial economic benefit.

Agricultural activity is still an important regional activity and land use, but is generally on the decline in regional economic importance. Many remaining farmers recognize the benefits of implementing farming practices that benefit waterfowl primarily through the gain of additional income through the lease of their lands for hunting purposes. Grazing management on private lands in the region is conducted for the economic gain associated with livestock production, often without the purposeful consideration of the habitat enhancement benefits of grazing.

Outdoor recreation plays a major role in contributing to the regional economy. Activities such as hunting and fishing and bird watching are major regional activities on both private and public lands, including refuge lands. Increasing and enhancing recreational facilities and opportunities in the region generally encourage more frequent visitation and attract more diverse groups of users.

Ecotourism has already become a substantial economic contributor to the communities along the Texas Gulf Coast. While the actual amount of economic impact from bird-watching in the area is difficult to estimate, it is clear that the GTCBT and other birding opportunities in the region are drawing a substantial number of visitors to the area, and this recreational opportunity is now recognized as an important regional economic force. Communities near the GTCBT generally take an active role in providing goods and services to birders, such as hotels/motels/B&Bs, campgrounds, restaurants, gift shops, etc. Birders will continue to seek “natural” recreational experiences. Therefore, effective land management and conservation efforts will continue to be important to the growth of ecotourism in the region. In recognition of this, and in keeping with their required policies and goals, the USFWS and other agencies have initiated cooperative efforts to provide high-quality recreational opportunities, which in turn help support the local economy.

Texas remains a leader in the oil and gas industry in terms of production, refining, and petrochemicals. There is extensive oil and gas activity in the region in terms of active wells, closed wells, oil and gas infrastructure including pipelines, and refineries. According to U.S. Census data, the petroleum and chemical manufacturing industries in Chambers County accounted for 37 percent of total private industry employment and 60 percent of total private industry annual payroll in 2000. In Jefferson County, 10 percent of the employment was in the petroleum or petrochemical industry with an annual payroll that represented 20 percent of the total private sector payroll in 2000. Generally, oil and gas production has shown increasing trends in recent years, and even with the cyclic nature of the industry, oil and gas production will continue to be a major regional force.

The GIWW and associated navigation/transportation channels are a major source of economic activity and revenue in the region. The GIWW is credited with contributing billions of dollars of direct and indirect annual economic impact from port revenues, payrolls, and revenues of the water transportation industries and maintenance expenditures on the canal system by the USACE. Indirectly, the GIWW is linked to

additional revenues generated by recreation, tourism, sports, and commercial fishing. Barge transportation along the GIWW is viewed as being economical, efficient, and safe.

Unlike other multiple-use agencies, economic uses of land and natural resources are secondary to the USFWS in their management of national wildlife refuges. The protection and enhancement of a refuge's natural resources always remain as a priority in decisions to permit or regulate activities. All economic uses on a refuge must be compatible with the purposes of the refuge and must support refuge purposes and the Refuge System mission. USFWS management of the Refuge Complex has and will continue to support cooperative economic ventures only under the above conditions. Environmental protection/conservation management priorities of the USFWS, the State of Texas, and other public and private parties can conflict with other regional economic interests in some areas.

As growth and development occurs in the region, there will always be issues and concerns with public infrastructure and services matching increasing demand. Budgets for certain local governments will be difficult to balance under some situations, and it will be up to these local governments to take appropriate steps in providing adequate infrastructure and services to their citizens.

From a social and lifestyle perspective, opinions about regional environmental, natural resource management, and economic issues would continue to vary among different people and groups. Federal and/or state of Texas governmental management of land in the region would continue to be controversial, and different people and groups would continue to have differing and sometimes conflicting beliefs, values, and goals with respect to use and control of the land. Resolution of regional issues and concerns will continue to be difficult into the future.

c. Environmental Justice

While there are low-income and minority populations in the region, there is no evidence of environmental justice issues or concerns associated with specific projects or with cumulative development. Any affected populations would generally be affected in the same ways as the regional population as a whole. As noted above, different people and groups will perceive the magnitude and scope of impacts in different ways, and the importance of any specific impacts will depend primarily on individual and group values, goals, and beliefs.

3. Cumulative Impacts to Cultural Resources

Less than one percent of the region has been systematically studied; therefore, the full extent of the cultural resources in the area has not been determined. Many potential sites occur along the Trinity River and along Galveston Bay and larger inland lakes in the area (USFWS 1994, Texas Historical Commission 1996). Several archaeological sites in Chambers County have been impacted from past mining and excavation. Future protection of cultural resources is enhanced because many proposed actions (especially those projects in which a governmental agency is the proponent) are required to undergo a cultural resource survey and/or clearance as part of permitting or approval processes before lands are disturbed. This serves to mitigate potential impacts associated with disturbance of unknown cultural resource sites.

4. Summary of Cumulative Impacts

Regional environmental and natural resource management issues in the Texas Chenier Plain Refuge Complex are substantial and complicated. Issues and concerns throughout the region are generally the same as those faced by USFWS, although the regional perspective to issues and concerns is broader in geographic scale:

- The coastal area of Texas is home to over four million people and this number continues to grow.
- Houston is the nation's fourth largest city and Harris County is the nation's second most populated county.

- The world's largest petrochemical complex and some of the nation's busiest port facilities are located along the Texas Gulf coast.
- Regional land uses can compete and may be incompatible in certain locations because of different economic and natural resource management goals.
- Urbanization, industrial development, and public works projects have eliminated or fragmented habitats in many areas, thereby adversely affecting vegetation, wildlife, and the general ecological processes of the region.
- Intentional and unintentional hydrological modifications to natural conditions are substantial in the region, exacerbating coastal erosion, habitat loss/fragmentation, and subsidence problems.
- Freshwater inflows have been reduced, saltwater intrusion has increased, and the GIWW and other dredging, navigation, irrigation, and flood control projects have had a major regional impact on historical hydrological regimes and associated natural habitats.

The activities and projects in the cumulative impact area have caused substantial harm to natural conditions, but have also provided substantial economic opportunity and growth. Environmentally, the Federal and state management agencies often can only respond to "hot spot" problems; e.g., those problems that are of greatest concern at any specific point in time. This approach is necessitated by the realities of budgets and ecological/economic tradeoffs. It is this delicate balance between regional ecology and regional economy that will continue be the major challenge for the future. Even with extensive rehabilitation and management efforts, the lands and waters of the region will never be returned to natural conditions, and any further alteration must be carefully considered from a cumulative impact perspective.

Overall, the issues and problems on the expanded Refuge Complex are also clearly evident on a regional, or cumulative basis. Public parties struggle on a regular basis to achieve environmental protection and natural resource management goals while balancing other, sometimes conflicting, goals and objectives. It is clear that balancing economic benefits with environmental change is, and will continue to be, a major challenge for all stakeholders in the 21st century.