3. Refuge Resources and Current Management

This chapter provides a detailed description of the Complex, its habitats, the species that occur, how habitat and species are managed, and the recreational opportunities it offers. It is divided into six major sections: Landscape Setting; Physical Environment; Biological Environment; Socioeconomic Environment; Archeological, Cultural and Historic Resources; and Current Management.

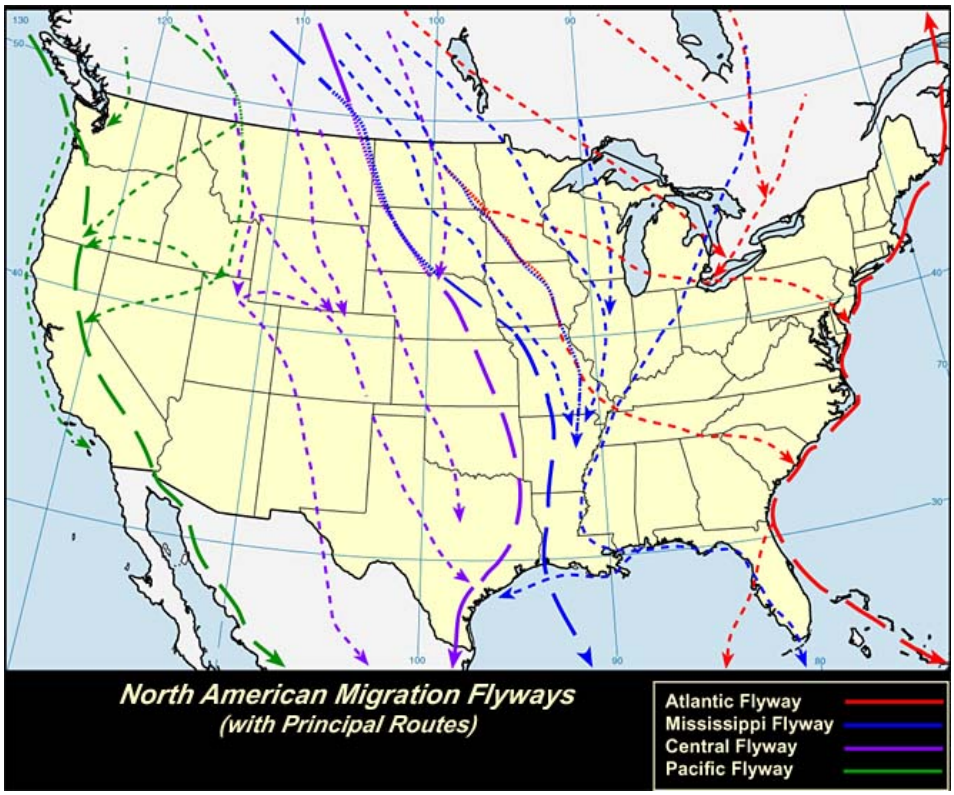
3.1 Landscape Setting

In order to effectively achieve the Refuge System mission of conserving fish, wildlife, plant resources and their habitats, the Complex took a landscape-scale approach identifying resources, issues, and management direction. The Complex is one small portion of land within a larger landscape, and as such, looked beyond its boundaries to determine its role in the larger conservation effort. This section describes the landscape setting where the Complex is located (Map 3-1. Landscape-Scale Conservation).

3.1.1 Central Flyway

Bird migration is the seasonal movement of birds between summer nesting habitat in Canada and the northern U.S. and wintering habitat in the southern U.S., Central, and South America. These movements generally follow regular routes called flyways. There are four administrative flyways in North America: the Atlantic, Mississippi, Central, and Pacific (Figure 3-1).

Figure 3-1. North American Migration Flyways

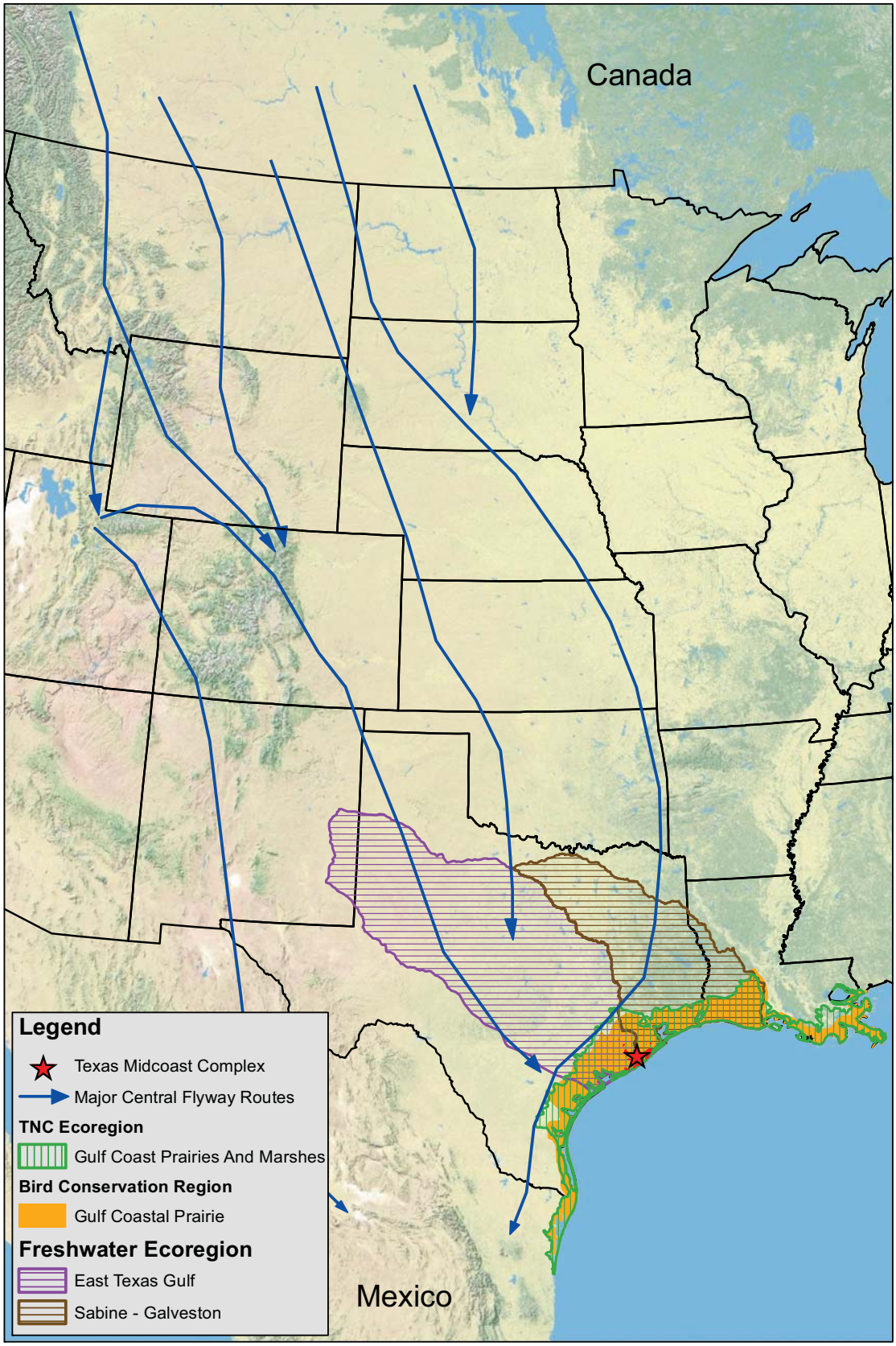


U.S. Fish & Wildlife Service

Texas Mid-coast National Wildlife Refuge Complex

Brazoria, Fort Bend, Wharton and Matagorda Counties, Texas

Map 3-1. Landscape-Scale Conservation



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LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
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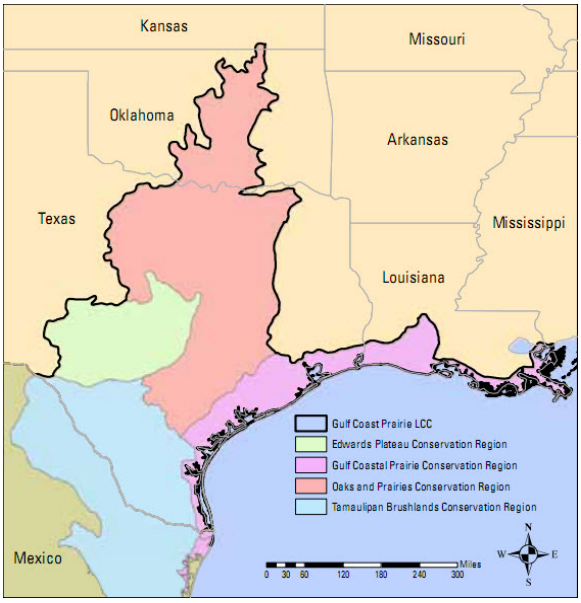
It is along these four flyways that tens of millions of migrating birds travel seasonally. The Service established refuges along these flyways to provide resting and nesting habitat for migrating birds. The Complex is located within the Central Flyway, which spans the Canadian Northwest Territory, two Canadian provinces (Alberta and Saskatchewan), ten U.S. states (Montana, North Dakota, South Dakota, Wyoming, Nebraska, Colorado, Kansas, New Mexico, Oklahoma, and Texas), and numerous countries in Central and South America. There are over 100 national wildlife refuges and/or waterfowl management units located in the ten states found within the Central Flyway. The Service's Southwest Region manages 36 of these, in the states of New Mexico, Texas, and Oklahoma. The Complex has three of the 18 refuges located within the state of Texas. All three refuges provide quality winter habitat for migratory birds which is necessary to sustain a healthy condition for spring migration and reproductive success.

3.1.2 Gulf Coast Prairie Landscape Conservation Cooperative (LCC)

The Gulf Coast Prairie region faces many challenges that threaten both nature and wildlife within this diverse landscape. The once extensive grassland system has been impacted by urban and agricultural development. Large rivers struggle to maintain integrity as base flows have declined. Coastal systems suffer from the effects of reduced freshwater inputs. Unprecedented drought, catastrophic wildfires, and climate-related impacts, as well as other threats such a pollution, invasive species, and disease also put a strain on native species and habitats.

From tall grass prairies to forested landscapes, across tidal flats and reef complexes, the Gulf Coast Prairie region boasts a beautiful and incredibly complex landscape. The area encompasses portions of five states (Texas, Oklahoma, Louisiana, Mississippi, and Kansas). The Gulf Coast Prairie region contains several large river systems, including the lower Rio Grande, Guadalupe, Brazos, Trinity, Nueces, Arkansas, Red, San Antonio, and Mississippi Rivers. The Region includes 4 subdivisions or ecoregions; Tamaulipan Brushlands, Oaks and Prairies, Gulf Coastal Prairie and Edwards Plateau (Figure 3-2). Each ecoregion contains a unique mix of habitats and priority populations of fish and wildlife. The Complex lies within the Gulf Coastal Prairie Conservation Region (ecoregion) but includes a unique ecosystem; the Columbia Bottomlands which occurs across the floodplanes of the Brazos, San Bernard and Colorado Rivers.

Figure 3-2. Gulf Coast Prairie Region Landscape Conservation Cooperative.



3.1.3 Ecoregion Setting

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing the spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance. Ecoregions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas (EPA Web site: http://www.epa.gov/wed/pages/ecoregions.htm).

The Complex is located within the Gulf Coast Prairies and Marshes (GCP&M) ecoregion as identified by TNC (Gould et al. 1960). The GCP&M Ecoregion is a region of contrasts and commonalities. The region encompasses two countries, two states, 22 primary bays, 19 major rivers, and nearly 600 miles of shoreline. Great biodiversity characterizes the GCP&M, a rich and vast ecoregion consisting of nearly 24 million acres. The number and species of birds in the ecoregion are among the greatest anywhere in the U.S. and Canada. The region is also renowned for its butterfly and reptile diversity. The region's productive bays and estuaries are virtual factories, producing fishes and shellfish upon which the people of the ecoregion depend economically, and that constitute important links in the food chain for many marine organisms. At the same time, the ecological diversity of the GCP&M faces drastic declines, with habitat loss and fragmentation posing some of the most serious threats to the ecoregion's biological health (Ricketts et al. 1999).

Pre-Settlement Landscape

Before European settlement, the GCP&M was composed of a mosaic of tallgrass coastal prairie, riparian bottomland hardwood forests, ephemeral freshwater wetlands, canebrake swamps, extensive coastal forests, chenier woodlands, freshwater tidal wetlands, brush mottes and corridors, barrier islands, estuaries, saltwater marshes, hypersaline lagoons, lomas, and associated Tamaulipan thornscrub habitats. This integrated matrix of habitat types combined to form one of the most productive and biologically rich ecosystems in the world (Smeins et al. 1991).

Humans in the GCP&M

Human inhabitants have always been drawn to the Gulf of Mexico. Nomadic native peoples took advantage of the bounty of food resources such as oysters, shrimp, fish, alligators, and birds available in the nearshore waters and coastal prairies (Ricklis, 1997). Today, industrial development and distribution, business infrastructure, agricultural production, tourism, and the appeal of a coastal lifestyle with associated recreational and aesthetic attributes fuel the attraction.

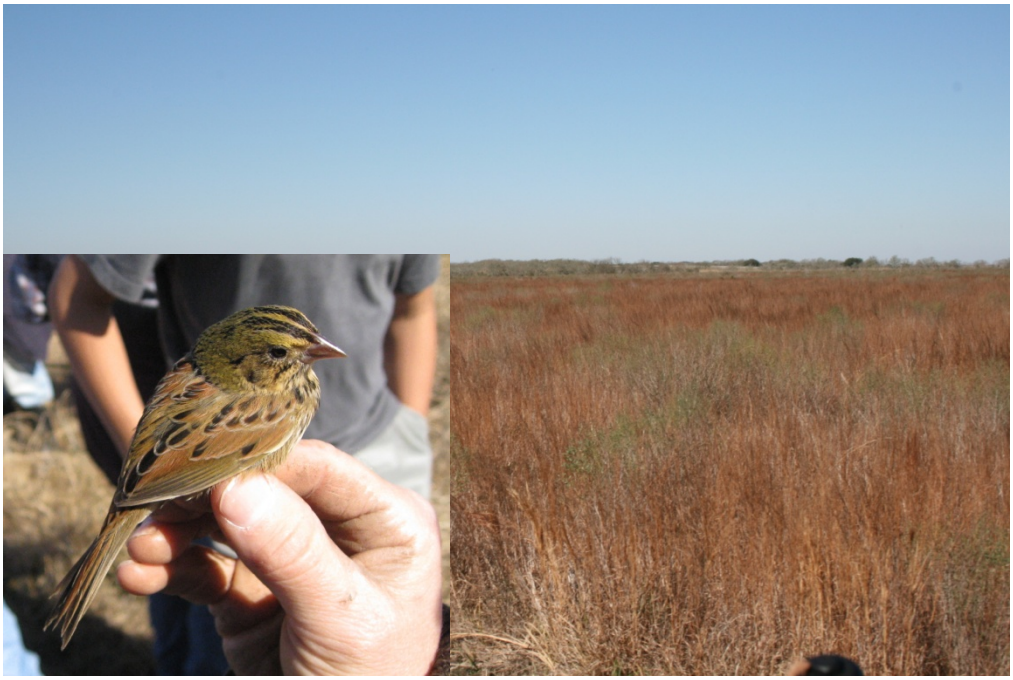
Although certain areas of the ecoregion are sparsely populated, other areas such as Houston, the fourth largest city in the U.S., and Harris County, the second most populous county in the U.S., locally impact biodiversity. On a somewhat larger scale, the ecoregion supports the world's second largest petrochemical complex and some of the nation's busiest port

facilities. In Texas, more than 1/3 of the state's population lives within 100 miles of the coast.

Alteration of the Landscape
The ecoregion has been transformed dramatically since the early 1900s. Freshwater wetlands have been reduced by 30 percent (Moulton et al. 1997), coastal forests have been cleared and fragmented (USFWS 1997), the chenier woodlands of the upper Texas coast are essentially gone (Gosselink et al. 1979), less than one percent of the tall grass coastal prairie remains (Smeins et al. 1991) and the Gulf Intracoastal Waterway has had significant impacts on coastal marshes. Remaining representative pieces of most habitat types are generally small, fragmented, and degraded in some way (i.e., exotic plants, disrupted hydrology, overgrazing, channelization, etc). Large landholdings are also becoming less common due to inheritance taxes and developmental pressures.

3.1.3.1 Terrestrial Description

Coastal Prairie
The prominent feature of this ecosystem includes the coastal prairies, which in many places contain small depressional wetlands. Coastal prairies once occupied over nine million acres, but today substantially less than one percent of original coastal prairie grasslands remain in relatively pristine condition. Estimates are that as little as 65,000 acres of high quality coastal prairies remain in Texas (Smeins et al. 1991). This ecosystem is now largely fragmented by agricultural, urban development, woody species encroachment resulting from fire suppression, overgrazing, and invading exotic species such as Macartney rose, Chinese tallow, deep-rooted sedge, and red imported fire ants.



A once vast and diverse ecosystem, remnamt coastal prairies are being restored and managed across the Complex to provide habitat for resident and migratory wildlife including Henslow's sparrow (inset), a priority species. Photo Credit: USFWS

Tallgrass coastal prairie is found along the coast of Texas and Louisiana and is defined by the presence of little bluestem along with various compositions of numerous other tall grass species including big bluestem, bushy bluestem, brownseed paspalum, Indian grass, eastern gammagrass, switchgrass, longtom, and coastal species including marsh hay cordgrass.

Native coastal prairie grasslands, and their associated wetlands, are biologically the most impacted habitat type within the Gulf Coast Ecosystem (USFWS 1996). Natural forces that shape the system include prevailing southeast winds, tropical weather systems, and rainfall of more than 60 inches/year on the upper Texas coast. Fire and grazing by American bison were, prior to colonization, key factors influencing plant succession, particularly in the grasslands (The Nature Conservancy 2002).

Functional prairies and insects naturally go together. The result is a unique insect diversity including butterflies, dragonflies, and numerous species of bees, wasps, leafhoppers, ants, grasshoppers, beetles, and praying mantis. Many bird species rely upon remnant coastal prairie habitat where more red-tailed hawks, northern harriers, white and white-faced ibises reside than in any other ecoregion of North America (Gosse et al. 2002). There are also abundant numbers of waterfowl, wading birds, and shorebirds.

Many remaining stands of coastal prairie are under constant threat from habitat fragmentation, exotic species, overgrazing, and lack of fire (The Nature Conservancy 2002). The Brazoria NWR has a contiguous expanse of native prairie (16,000 acres) with 5,000 acres of mima mounds and natural potholes intact. The remaining prairie has been restored on old fields and pastures by controlling native brush and invasive species over the past seven years. Smaller acres of prairie are found on San Bernard, where the marsh grades toward bottomland forest in the Brazos and San Bernard river flood plains rather than upland prairie. Two notable additions to San Bernard, the Buffalo Creek Unit and Eagle Nest Lake Unit do contain expanses of former coastal prairie, near Daman, TX. The Service has been restoring 800 acres of coastal prairie from former pasture/field on the Buffalo Creek Unit for the past 5 years. Nearly 1,000 acres of field and pasture lands will be restored on Eagle Nest Lake in cooperation with NRCS over the next several years.

Bottomland Hardwood Forest (Columbia Bottomlands)

The bottomland hardwood forests that occur adjacent to the Brazos, Colorado, and San Bernard rivers of the upper Texas Gulf Coast are known regionally as the Columbia Bottomlands. These bottomland hardwood forests are among the most diverse of Texas ecosystems; they are also ranked as one of the most endangered ecosystems in the U.S. (U.S. Department of the Interior 2006). Bottomland wetlands are plant communities that have been created as a result of the actions of creeks, rivers, and floodplains. The bottomland hardwood forest is a part of a system that starts at a river's headwaters and ends in an estuary at the ocean. These hardwoods, particularly old-growth hardwoods (80+ years old), contribute to the biodiversity of the wetland system and also provide a significant amount of food and shelter for wildlife. Dominant tree species include water oak, green ash, sugar hackberry, live oak, Shumard oak, honey locust, cedar elm, pecan, box elder, black willow, American elm, cottonwood, and sycamore. The understory in undisturbed areas is frequently dense with shrubs, vines, palmetto, and young trees (USFWS 1997).

The Columbia Bottomlands (known locally as Austin's Woods), extend from the Texas coast, approximately 93 miles inland, and include parts of seven counties. It has been estimated that the Columbia Bottomlands, comprised over 699,308 acres at the beginning of the last century (USFWS 1997). In 1995 approximately 177,000 acres remained, and these remaining stands are highly fragmented and are threatened by residential and commercial development, agricultural conversion, timber removal, and infestation by non-native plants (USFWS 1997; Barrow & Renne 2001; Barrow et al. 2005). Recent studies utilizing Geographic Information Systems suggested a loss of approximately 17 percent between 1979 and 1995 (Webb 1997). Today it is estimated that only 150,000 acres of forest remain. An estimated 29 million Nearctic-neotropical migrant landbirds represented by 65-70 species migrate through the Columbia Bottomlands annually (USFWS 1997). The bottomlands form a broad corridor from the Gulf of Mexico inland, providing a passageway for migration in a strategic location of the Gulf.

3.1.3.2 Aquatic Description

Within this ecoregion, Texas has approximately 365 miles of open Gulf shoreline and contains approximately 2,361 miles of bay-estuary-lagoon shoreline. This is the most biologically rich and ecologically diverse region in the state and supports more than 601,000 acres of fresh, brackish and salt marshes (TPWD 2005).

Freshwater Wetlands
San Bernard and Big Boggy NWRs are located in the East Texas Gulf freshwater ecoregion of North America. The East Texas Gulf is an ecoregion of the Mississippi Complex located in the Arctic-Atlantic Bioregion. This ecoregion stretches from eastern New Mexico to southeastern Texas, defined by the watersheds of the Brazos and Colorado rivers and their tributaries. Other freshwater habitats in this karst area include caverns and springs (Abell et al. 2000). There are approximately 100 fish species, of which at least two are endemic - the burrhead chub and smalleye shiner (Conner and Suttkus 1986). There are 12 endemic hydrobiid snails, two endemic unionid mussels, and one endemic salamander, the Texas blind salamander (Bowles and Arsuffi 1993). This ecoregion is considered vulnerable, meaning that remaining habitat occurs in blocks or segments and established exotic species may be controllable (Abell et al.

One of several small waterways, Bastrop Bayou carries local runoff from the Columbia Bottomlands north of Lake Jackson, through the Dow Woods Unit of San Bernard NWR. Photo Credit: USFWS

2000). Of these endemic species, the smalleye shiner has been documented on the Complex.

The Brazoria NWR and units of the San Bernard NWR are located in the Sabine-Galveston freshwater ecoregion of North America. The Sabine-Galveston is an ecoregion of the Mississippi Complex located in the Arctic-Atlantic Bioregion. It covers central and southeastern Texas and western Louisiana and includes the watersheds of the Neches, Trinity, San Jacinto, and Calcasieu rivers (Abell et al. 2000). Wetlands dominate the ecoregion, although there has been a 30 percent decline in freshwater wetlands in recent decades. There are no known endemic fish species in this ecoregion (Connor and Suttkus, 1986). This ecoregion is considered vulnerable (Map 3-1. Landscape Scale Conservation).

*Marshe*s

Coastal marshes within this ecoregion and the Complex include: salt marsh, brackish marsh, and fresh marsh. Salt marshes near Texas estuaries are typically dominated by cordgrass, although black mangroves predominate in certain areas. They are subject to intermittent inundation due to tidal action and high levels of freshwater inflow. Fluctuations in temperature, salinity, water depth, and sediment composition can have a limiting effect on the number of plant species found (Armstrong 1987). The brackish-marsh community is a transitional area between salt marshes and fresh marshes. Brackish marshes are the dominant wetland communities in the Galveston Bay system (White and Paine 1992). They are widely distributed along the lower reaches of the Trinity River delta in the inland system west of the Brazos River and along the lower reaches of the Lavaca and Guadalupe River valleys (TPWD 2005). The environments in which fresh marshes occur are generally beyond the effects of saltwater flooding, except perhaps during hurricanes. Freshwater influence from rivers, precipitation, runoff and groundwater is sufficient to maintain a fresher-water vegetation assemblage consisting of such species as cattail and three-square bulrush. Fresh marshes occur on the mainland and barrier islands along river or fluvial systems.

Marine Environments

The northern Gulf of Mexico is a rich and productive subtropical environment that supports extensive wetland and seagrass habitats, oyster reefs, sponge and soft coral, marshes, mangroves, tidal flats, submerged freshwater grasses, and several distinctive species such as dwarf seahorse, Gulf sturgeon, diamondback terrapin, and fringed pipefish. Coastal marine environments in this ecoregion are ecologically inseparable from the terrestrial and freshwater environments. The Complex is located within the western subregion of the northern Gulf of Mexico which extends south from Galveston Bay. This area is characterized by low freshwater input, sandy sediments, and clear waters: ideal conditions for the growth of seagrasses. In general, freshwater input decreases southward, and in the southern portions of this subregion evaporation is greater than freshwater input. The total drainage basin for the northern Gulf of Mexico contains nearly 60 percent of the land area of the continental U.S., including some of the most fertile lands in the world (Lovejoy 1992). This productive drainage makes the Gulf one of the primary producers of finfish and shellfish in the U.S. (TNC 2002). The Gulf of Mexico is a productive environment - ranking as the number one region for seafood harvest in both poundage and monetary value. Much of the productivity of this region is believed to have its origins in the productivity of the nearshore marshes and seagrasses (Duke and Kruczynski 1992), because these habitats serve as

nurseries for juveniles, and/or simply because they are a large source of carbon and nutrients (Deegan 1993).

3.1.4 Protected Areas in the Gulf Coast Prairies and Marshes Ecoregion

The International Union for Conservation of Nature (IUCN) defines a protected area as "a clearly defined geographical space, recognized, dedicated, and managed through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008). Protected areas serve a variety of purposes for society. They are an expression of our community's goals to maintain the value of biodiversity and to ensure that we pass these values on to future generations. They represent the diversity of the earth's history and the current natural processes, and provide many environmental services such as clean air, water, and nutrients. They are treasured landscapes reflecting the inherited cultures of many generations and they hold spiritual values for many societies (IUCN 2005).

Protected areas cover over 13 percent of the earth's land surface (IUCN 2005). In the U.S., over 10,480 protected areas, including state level protected areas, account for 27 percent of the land area (1,006,619 sq. mi) (UNEP 2008). Within the GCP&M Ecoregion there are approximately 135 conservation and recreation areas set aside by federal (51.3 percent of total acres), State of Texas (5.8 percent of total acres), State of Louisiana (39.3 percent of total acres), or privately owned/managed conservation and recreation units (3.6 percent of total acres). Appendix D identifies conservation and recreation areas within the GCP&M Ecoregion. These protected areas total 1,599,366 million acres (6.6 percent) of the entire GCP&M Ecoregion (Map 3-2. Ecoregion Map).

Within the Texas Mid-coast Complex area there are several protected areas. These include the Nannie M. Stringfellow and Justin Hurst Wildlife Management Area near San Bernard NWR. Further inland, Texas Parks and Wildlife also manages the Brazos Bend State Park which includes riverine and bottomland forest. The Christmas Bay Conservation Preserve, adjacent to the Brazoria NWR are Texas waters leased to Texas Parks and Wildlife Department under the Texas Coastal Preserve Program. The Preserve is designed to protect unique coastal areas and fragile biological communities. In addition to State lands, several non-profit organizations hold fee title or conservation easements on parcels within the Mid-coast area including Gulf Coast Bird Observatory, Galveston Bay Foundation, Houston Audubon, Bayou Land Conservancy and Ducks Unlimited.

3.1.5 Conservation Corridors

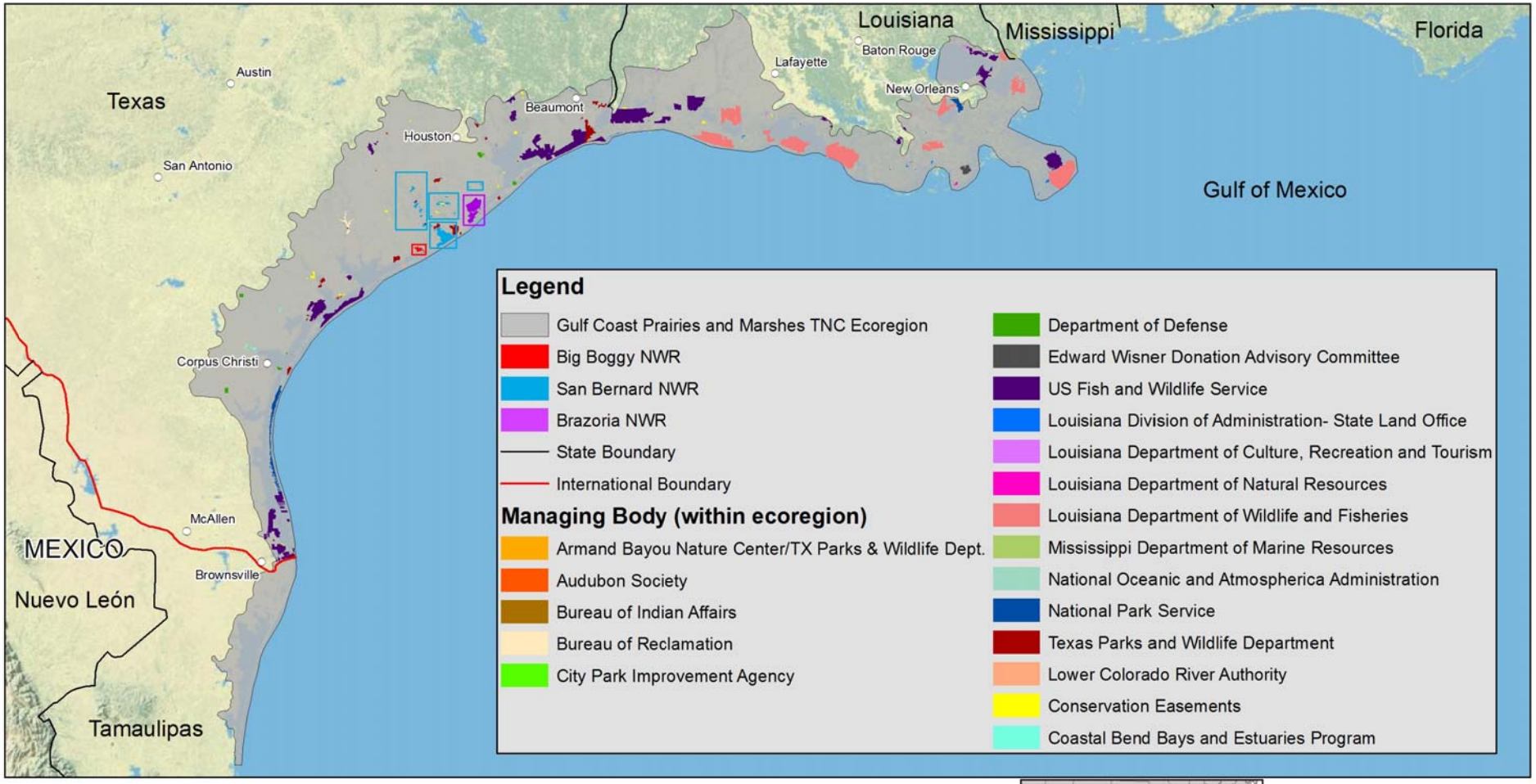
Conservation corridors are physical connections between disconnected fragments of plant and animal habitat. Without such connections, some species would be unable to reach necessary resources like food, water, mates, and shelter. The Complex will continue to work with its partners to identify key conservation corridors and crucial habitats necessary to meet the needs of an array of wildlife species.

U.S. Fish & Wildlife Service

Texas Mid-coast National Wildlife Refuge Complex

Brazoria, Wharton, Fort Bend and Matagorda Counties, Texas

Map 3-2. Ecoregion Map



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MERIDIAN: N/A
FILE: tmc_ecoregion8_22_2012sk

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0 55 110 220 Kilometers

UTM ZONE 14
NAD 83

The Complex contains a vast expanse of bottomland hardwood forest tracts that serve as intermittent corridors. Woodland corridors can support a large diversity of species, sometimes the highest in the landscape (Stauffer and Best 1980), and can enrich the ecological opportunities for mammals (Jones et. al. 1985) and birds. Songbirds in Canada were twice as likely to move through woodlands than clearings, and the majority of birds selected wooded routes over cutting across a clearing, even though the wooded routes may have been three times as long (Desrochers and Hannon 1997). On the Complex, the Columbia Bottomlands serve as stopover corridors for songbirds during spring and fall migration. The periodic occurrences of excellent stopover habitat where these birds can stop and refuel are definitely beneficial to them on their journey.

The Columbia Bottomlands in association with riparian areas may be very important for migratory bat species as they provide tree roosts, an abundance of insect prey, a constant source of water, landmarks to follow during migration (Cryan and Veilleux 2007), and protection from predators. Less obvious wildlife species such as box turtles and timber rattlesnakes also benefit from the presence of solid corridors in the bottomland system. As they move overland to find mates and denning sites, fragmentation of these corridors by roads and features that expose them to greater mortality risks work against them.

Endangered species such as the whooping crane may also benefit from the riparian and wetland habitats on the Complex. Suitable stopover habitat is necessary for whooping cranes to complete their migration. Yet, wetlands suitable for overnight roost sites may be limited along this route (Stahlecker 1992), further increasing the importance of wetland habitats like those within the Complex that may eventually be part of the whooping crane migration corridor.

In a similar fashion, the Complex expects coastal prairie and salt marsh habitats to serve as part of a migration corridor for a wide range of species of concern. Examples are Henslow's and LeConte's sparrows, yellow rail, and the white-faced ibis.

3.1.6 Refuge Location

Located along the upper Texas Gulf Coast in Brazoria, Matagorda and Fort Bend Counties, the Complex includes Brazoria, San Bernard, and Big Boggy NWRs. The Complex is approximately 50 miles south of Houston (Map 3-3. Texas Mid-Coast Refuge Complex Location).

Brazoria NWR - The Brazoria NWR is located approximately ten miles east of Freeport, Texas, in Brazoria County. The refuge is bordered by FM 2004, a prominent two-lane highway along the north and northwest; by Chocolate Bay along the east; by Bastrop, Christmas, and Drum Bays on the south and southeast; and by private land and Austin Bayou along the west

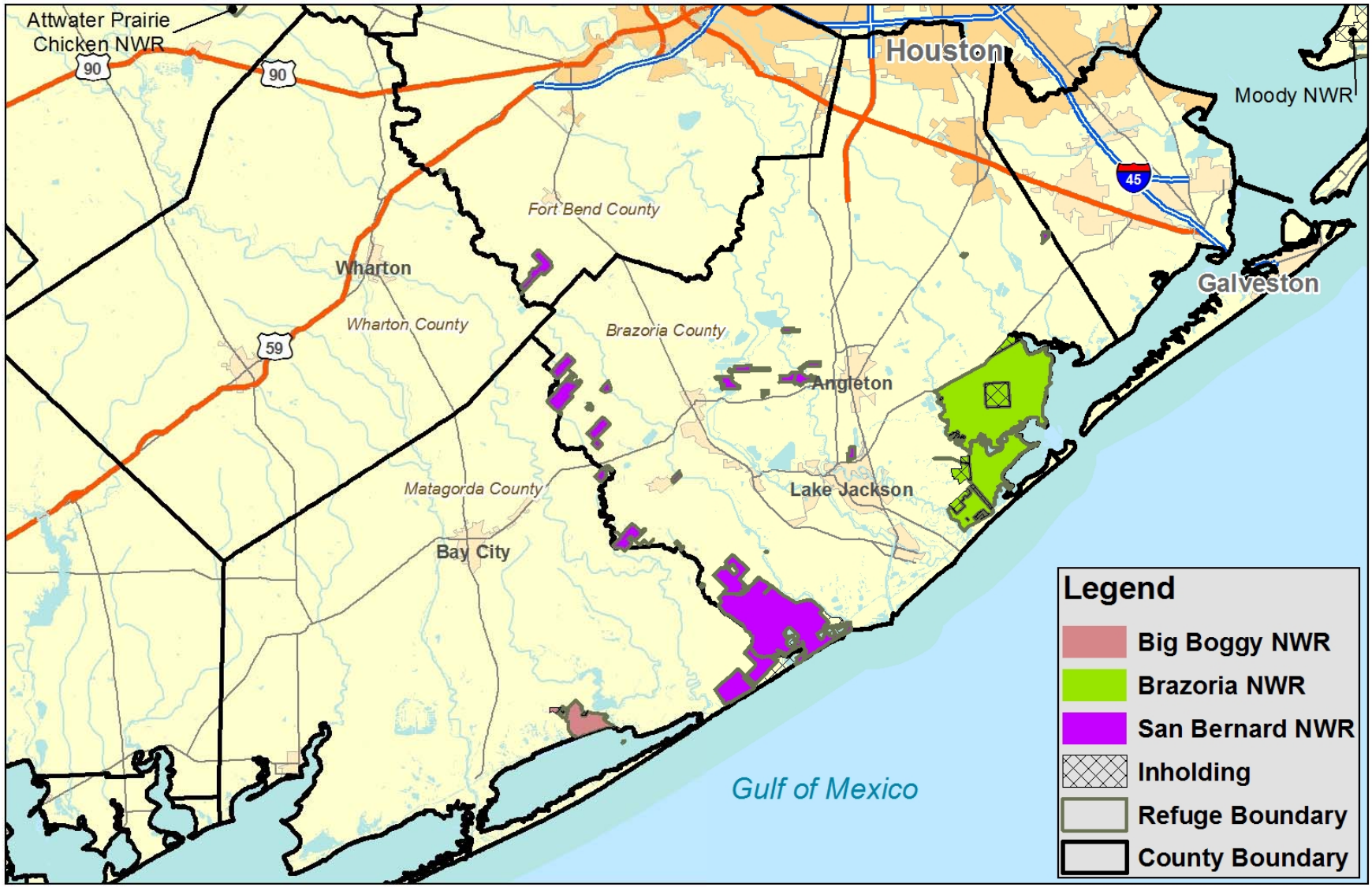
San Bernard NWR - The San Bernard NWR is located approximately ten miles southwest of Freeport, Texas, in Brazoria, Matagorda, and Fort Bend Wharton Counties. The Austin Woods Conservation Plan enables the expansion of San Bernard in to part of Wharton

U.S. Fish & Wildlife Service

Texas Mid-coast National Wildlife Refuge Complex

Brazoria, Fort Bend, Matagorda and Wharton Counties

Map 3-3 Location



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MERIDIAN: N/A
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UTM ZONE 15
NAD 83

County. The Gulf of Mexico bounds the core of the refuge on the south; on the east by FM 2918; on the north by adjacent private property near CRs 306, 317, and FM 2611; and on the west by Cedar Lake Creek and adjacent private property near CR 457 south of the town of Sargent. The Columbia Bottomland units of the refuge are located primarily along bayous, creeks, and rivers.

Big Boggy NWR - The Big Boggy NWR is located approximately 20 miles south of Bay City, Texas, in Matagorda County. East Matagorda Bay bounds the refuge on the south; on the west the refuge is bounded by Big Boggy Creek; and to the north and east by Chinquapin Road. The refuge also includes Dressing Point Island, approximately one and one-half miles south in east Matagorda Bay, which is a prominent colonial nesting bird rookery on the Texas coast.

3.1.7 Surrounding Land Uses

Land conservation on the Complex is just one of a variety of land uses found across the larger landscape. Industrial and urban development—as well as agricultural and livestock land uses—create an array of threats to fish, wildlife, and their habitats. Additional threats include invasive plants, feral animals, crop monocultures, habitat fragmentation, pathogens, and pollutants.

Rural communities, cattle ranches, and agricultural lands surround the Complex. Historically, much of the mid-Texas coast was contained within large ranches or prospected and developed for oil and gas drilling and extraction. While the oil and gas industry still maintains a strong presence, the trend is more towards the subdivision of large ranches for residential development (small ranch-ettes). Many of the agricultural lands remaining within the region continue to be used for grazing or crop production.

Table 3-1. Agricultural and Cropland Acreages in Brazoria, Matagorda, Fort Bend and Wharton Counties 1992-2007

Brazoria	563,993	221,812	528,957	186,201
Matagorda	562,612	225,372	577,594	234,688
Fort Bend	422,464	191,148	382,740	152,112
Wharton	644,730	396,009	615,851	376,001

Source: AgCensus 2007

In 1992, Brazoria County had 563,993 acres in agricultural lands with total cropland acreage of 221,812 acres. Top crops (in order of most to least acreage), were rice, hay, sorghum, cotton, corn, and soybeans. By 2007, total cropland acreage decreased to 186,201 acres, with forage (hay, etc), sorghum, corn, rice, and cotton being the top crops produced. In 1992, Matagorda County had a total land area in agricultural practices of 562,612 acres, with total cropland acreage of 225,372 acres; top crops were rice, sorghum, cotton, soybeans, hay, and corn. By 2007, total cropland acreage increased to 234,688 acres, with sorghum, rice, forage,

cotton, and corn being the top crops produced. In 1992, Fort Bend County had 422,464 acres in agricultural lands with total cropland acreage of 191,148; cotton, sorghum, hay, rice, corn, soybean, and wheat were the top crops being produced. By 2007, total croplands had decreased to 152,112, with cotton, sorghum, forage, corn, and rice being the top crops produced. In 1992, Wharton County had 644,730 acres in agricultural land with total cropland acreage of 396,009; sorghum, rice, corn, cotton, hay, soybean, and wheat were the top crops being produced. By 2007, cropland acreage decreased to 376,001 with corn, cotton, sorghum, rice and forage being the top crops produced.

The average market value of land and buildings in Brazoria and Matagorda Counties in 2007 was $2,188/acre and $1,380/acre, respectively. However, residential development is expanding from Houston and the associated suburbs. Find additional information pertaining to agricultural statistics on the U.S. Census for Agriculture (*AgCenus*) website at http://www.agcensus.usda.gov/.

Urbanization continues to expand from Houston, located approximately 50 miles northeast of the Complex and with a population estimated at more than 5 million people in the metropolitan area (Texas Comptroller's Office 2009). Residential and commercial development is concentrated along Interstates 10 and 45, as well as State Highways 288 and 59, with small towns and cities, such as Angleton, populating the corridor. However, both counties still retain a largely rural landscape, despite the expanding urban sprawl and the preponderance of personal incomes from non-agricultural economic sectors.

Development around the refuge has created Wildland Urban Interface (WUI); which must be incorporated in all refuge management issues, including prescribed fire. Photo Credit: USFWS

The Port of Freeport along with oil and gas reserves have enabled the development of oil and gas refining and chemical companies to be established. Freeport/Clute Industrial complex includes multiple large and integrated companies. Additional companies are scattered through the Mid-coast area including the Sweeny Complex and the Chocolate Bayou Complex. These industries provide a large number of jobs and influence local community development through expansions and jobs. Planned expansions at several plants will provide a large number of additional jobs in the near future, which will increase development around the refuges.

3.2 Physical Environment

This section describes the physical environment of the Complex. It includes a description of the climate, air quality, water resources, aquifers and groundwater, geology and soils, oil and gas occurrences, and potential environmental contaminants found at the Complex; and concludes with a short discussion about the Service's concerns pertaining to those physical resources.

3.2.1 Climate

Larkin and Bomar (1983) characterize the climate of the region as having predominant onshore flow of tropical maritime air from the Gulf of Mexico. A lateral decrease in moisture content from east to west across the state and intermittent seasonal intrusions of continental air modify this onshore flow. The Gulf of Mexico is a dominant geographical feature moderating temperatures along the Gulf Coast and, more importantly, providing the major source of moisture for the state. Average annual precipitation recorded at Lake Jackson, centrally located in the vicinity of all three refuges, is 50.66 inches annually (Figure 3-3).

Figure 3-3. Average Annual Precipitation of Lake Jackson, Texas

Temperatures within this region are fairly uniform, with hot, humid summers and mild winters (Figure 3-4). Annual average temperatures range from 70ºF to 74ºF. However, the Gulf Coast area, from Brownsville northward, can experience severe ocean-borne storms, including destructive hurricanes. The state has two principal seasons, with summer usually extending from approximately April to October, and winter beginning in November and lasting until March (Carr 1967).

Figure 3-4. Average Annual Temperature of Lake Jackson, Texas

The sub-tropical climate on the Gulf Coast ranges from average temperatures during the winter months of 55ºF to summer average temperatures of 91ºF. Humidity drops to low relative humidity values of 16 percent or lower during the winter months, yet the summer often sustains humidity values near 100 percent. These high humidities are generally associated with incoming pressure systems. Prevailing winds are from the southeast unless northern fronts pass through, which usually dominate the wind direction for several days. Annual precipitation can vary dramatically. During years of drought (most recent: 2008) annual precipitation was below 30 inches. During years of heavy rainfall, precipitation

approaches 60 inches. Rain may occur throughout the year and is typically associated with frontal passages during the winter and tropical disturbances during the summer months. The wettest months are typically September (>10 inches avg.) and March (>7 inches avg.). Hurricanes may occur at any time from early June through late November, but are most common in August and September. Rainfall amounts vary at different sites due to coastal influences and variability at individual sites. The remote area weather station (RAWS) records rain levels for the year from near Otter Slough Road on Brazoria NWR and Hunt Road on San Bernard NWR.

3.2.2 Air Quality

Pursuant to the Clean Air Act, as amended in 1977, the Service has an affirmative responsibility to protect air quality related values on national wildlife refuges, with special emphasis on Class I Wilderness Areas (areas in excess of 5,000 acres formally designated as Wilderness prior to August, 1977). Congress gave the Service the responsibility to protect the air quality and natural resources, including visibility of the area from manmade pollution. Polluted air injures wildlife and vegetation, causes acidification of water, degrades habitats, accelerates weathering of buildings and other facilities, and impairs visibility.

Under the Clean Air Act, the U.S. Environmental Protection Agency (EPA) has established primary air quality standards to protect public health. The EPA has also set secondary standards to protect public welfare. Secondary standards relate to protecting ecosystems, including plants and animals, from harm, as well as protecting against decreased visibility and damage to crops, vegetation, and buildings.

The EPA has developed National Ambient Air Quality Standards (NAAQS) for six principal air pollutants (also called “criteria pollutants”). They are ground-level ozone (O3), particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), and lead (Pb).

The ambient air quality within the boundaries of the Complex can vary considerably from impacts due to the Freeport/Clute industrial center. Contributing to this region’s air quality is the presence of extensive grasslands, marshes, and bottomland/riparian hardwood forest communities that provide beneficial nutrient cycling and the return of oxygen to the atmosphere.

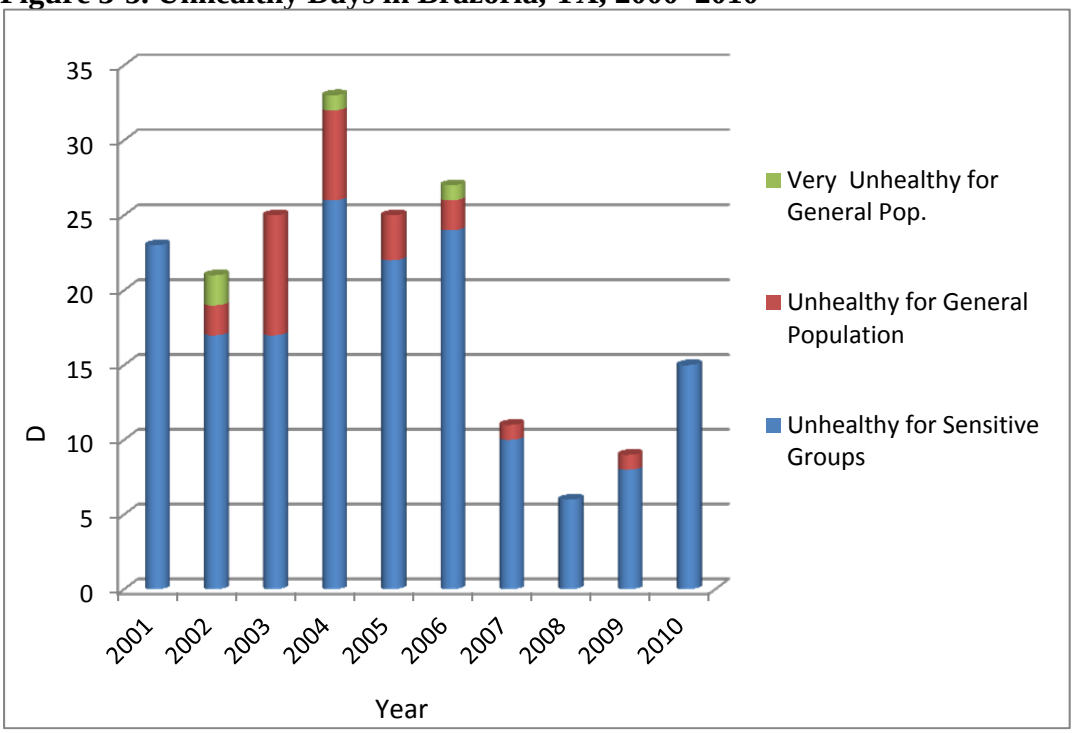
Air quality is monitored in 30 of the 254 counties in Texas, including Brazoria County. The EPA monitors oxides of nitrogen and ozone at four locations in Brazoria County. Three of the monitoring sites are within the Complex area: Lake Jackson, Danciger, and Mustang Bayou. Lake Jackson is located between the Brazoria and San Bernard NWRs; Mustang Bayou is in the vicinity of Liverpool and the Carolyn Davies Conservation Easement. Danciger is in proximity to the Big Pond, Bird Pond, and Dance Bayou Units. Table 3-2 shows ozone and oxides of nitrogen data for 2009 from the three monitoring stations.

Table 3-2. Ozone and oxides of nitrogen monitoring data for 2009

	Max. ozone (Parts per billion)	Avg. ozone (Parts per billion)	Max. Nitrogen Oxides (Parts per billion)	Avg. Nitrogen Oxides (Parts per billion)	Number of days with ozone in moderate concern	Number of days with ozone in health risk to sensitive groups
Danciger	104	25	75.5	3	10	5
Lake Jackson	113	26	95.1	3.8	5	3
Mustang Bayou	99	26	41.2	3.5	7	3

In comparing the 30 Texas counties with EPA registered monitoring stations, Brazoria County ranked 7th during 2008 for the greatest number of days where air quality was greater than the threshold for human health concerns for sensitive groups. However, annual records have shown a marked decrease in days exceeding the threshold since 2006. The following graph depicts the number of unhealthy days from 2000 to 2010 in Brazoria County, for sensitive groups (older adults and children) and the general population (AirCompare Report – www.epa.gov).

Figure 3-5. Unhealthy Days in Brazoria, TX, 2000–2010



Sources: AirCompare Report

3.2.3 Water Resources

Surface Water

The majority of project area is susceptible to at least periodic inundation due to numerous hydrologic resources in the area. Proximity to the Gulf of Mexico presents the threat of occasional Gulf storms, which can produce significant rainfall events. Forested wetlands, and open water areas exist within the project area. The San Bernard River, Brazos and Colorado River are the principle water courses within the project area. The headwaters for the Brazos and Colorado Rivers are in west Texas and along their courses to the Gulf of Mexico support numerous communities, including Austin and the Dallas-Fort Worth Metro Area. Both rivers have been dammed, which affects sediment flows to the Gulf. On the Coastal Plain, smaller bayous and creeks also move surface water across the landscape. These waterways; including Buffalo Creek, Dance Bayou, Linnville Bayou, Oyster Creek, Bastrop Bayou, Caney Creek and Live Oak Bayou, and are significant waterways which are important for draining the project area and surrounding lands following significant storm events. Today's topography was created by the meanderings of these watercourses over time. Oxbow lakes and swales hold significant surface water and are scattered across the landscape, during wet years. However during droughts, these shallow wetlands often dry up and freshwater resources become very limited.

Ground Water

Gulf Coast Aquifer (REPORT 163)

The project area is underlain by the Gulf Coast Aquifer, which forms a wide belt along the Gulf of Mexico from Florida to Mexico. The aquifer provides water to all or parts of 54 counties within the state of Texas. The aquifer extends from the Rio Grande northeastward past the Louisiana-Texas border (Mace, 2006). Municipal and irrigation uses account for 90 percent of the total pumpage from the aquifer. The Greater Houston metropolitan area is the largest municipal user, where well yields average approximately 1,600 gal/min. Earlier investigators in the Gulf Coast region of Texas attempted to delineate aquifer units based on geologic formations, but in the younger Gulf Coast sediments, the aquifers consist of parts of one or more geologic formations (USGS 1973).

The aquifer consists of complex interbedded clays, silts, sands, and gravels of the Cenozoic age that connect hydrologically to form a large, leaky artesian aquifer system. This system comprises four major components consisting of the following generally recognized water-producing formations. The deepest is the Catahoula, which contains ground water near the outcrop in relatively restricted sand layers. Above the Catahoula is the Jasper aquifer, primarily contained within the Oakville Sandstone. The Burkeville confining layer separates the Jasper from the overlying Evangeline aquifer, which is contained within the Fleming and Goliad sands. The Chicot aquifer, or upper component of the Gulf Coast aquifer system, consists of the Lissie, Willis, Bentley, Montgomery, and Beaumont formations, and overlying alluvial deposits. Not all formations are present throughout the system, and nomenclature often differs from one end of the system to the other. Maximum total sand thickness ranges from 700 feet in the south to 1,300 feet in the northern extent.

Water quality is generally good in the shallower portion of the aquifer. The Complex usually encounters ground water containing less than 1.76 oz./qt. dissolved solids to a maximum depth of 3,200 feet in the aquifer from the San Antonio River Basin northeastward to Louisiana. From the San Antonio River Basin southwestward to Mexico, quality deterioration is evident in the form of increased chloride concentration and saltwater encroachment along the Texas Gulf Coast. Little of this ground water is suitable for prolonged irrigation due to either high salinity or alkalinity, or both. In several areas at or near the Texas Gulf Coast, including Galveston Island and the central and southern parts of Orange County, heavy municipal or industrial pumpage had previously caused an updip migration, or saltwater intrusion, of poor-quality water into the aquifer. Recent reductions in pumpage here have resulted in stabilization and, in some cases, even improvement of ground-water quality.

Years of heavy pumpage for municipal and manufacturing use in portions of the aquifer have resulted in areas of significant water-level decline. Some areas of eastern and southeastern Harris and northern Galveston counties measured declines of 200 feet to 300 feet. Other areas of significant water-level declines include the Kingsville area in Kleberg County and portions of Jefferson, Orange, and Wharton counties. Some of these declines have resulted in compaction of dewatered clays and significant land surface subsidence. Subsidence is generally less than 0.5 feet over most of the Texas coast, but has been as much as nine feet in Harris and surrounding counties. As a result, structural damage and flooding have occurred in many low-lying areas along Galveston Bay in Baytown, Texas City, and Houston. Conversion to surface-water use in many of the problem areas has reversed the decline trend.

Evangeline and Chicot Aquifer (REPORT 163)
The Chicot and Evangeline aquifers are part of the Gulf Coast Aquifer system and are important sources of fresh groundwater around the Complex. The Evangeline aquifer is present in the subsurface everywhere in the county except for small areas where the salt domes pierce through the Evangeline and into the overlying Chicot beds.

The Chicot and Evangeline aquifer is the primary, and in some cases only, source of fresh water for many of the small towns and rural areas of the Texas Gulf Coast. The most widespread fresh-water aquifer in Brazoria County, and the only aquifer containing freshwater in much of the southern part of the county, is the upper unit of the Chicot aquifer. The principal source of the fresh ground water in Brazoria County is rainfall on the outcrops of the aquifers. It supplies all water for public supply and domestic use as well as part of the water used by industry in the Brazosport area. Industries and towns in the Sweeny and Old Ocean areas also use it. Because of the large drawdown in the area, the thin section of freshwater sand, and the proximity of water of poorer quality, the aquifer is fully developed and may be overdeveloped in the Brazosport area.

Brazoria and Big Boggy NWRs contain a network of irrigation ditches that connect to Chocolate Bayou Water Company and Lower Colorado River Authority, respectively. These connections allow both refuges to order water when available at a variable price. San Bernard and Brazoria obtain additional water by accessing ground water wells. Water wells at Brazoria NWR have averaged 200-300 feet deep and water wells at San Bernard NWR are

averaging 450 feet deep. In addition, the Wolfweed Complex on San Bernard NWR contains reservoirs that store water accumulated from rainfall, or water (brackish or fresh) pumped from the adjacent Cedar Lake Creek. There are no water wells on Big Boggy NWR.

Water Quality

Water quality is a measure of the suitability of water for a particular use based on physical, chemical, and biological characteristics. Natural water quality varies from place to place, with the seasons, climate, and the types of soils and rocks through which water moves. Human activities including, but not limited to, urban and industrial development, farming, mining, combustion of fossil fuels and stream-channel alteration, also affect water quality (U.S. Geological Survey 2001).

The Clean Water Act of 1977 (CWA) requires states to identify and prioritize waters that do not currently support designated uses. Each state's 303(d) list identifies water bodies that do not meet one or more applicable water quality standards and those that one or more pollutants threaten for a designated use. The 303(d) list includes waters impaired by both point and non-point source pollution. Point source pollution occurs when contaminants enter the waterbody from a distinct localized source, such as a chemical plant or equipment exhaust. Non-point source pollution occurs when contaminants enter the water body from indirect sources, such as residential development or agricultural practices.

The Brazos, San Bernard River and Colorado River Basins are monitored by the Texas Commission on Environmental Quality (TCEQ) for water quality. Significant urban and agriculture development occurs along all waterways in and above the refuges. The San Bernard River Above Tidal, San Bernard Tidal, Cedar Lakes, Caney Creek Above Tidal and Upper Oyster Creek (just above Austin's Woods project area) are all are on the Texas 303(d) List by TCEQ as impaired waterways (TCEQ, 2010). The San Bernard River Above Tidal - Segment 1302 of the San Bernard River is primarily rural with adjacent agriculture lands. San Bernard Tidal is primarily rural development with some agriculture. Cedar Lakes are shallow marsh lakes in the San Bernard outfall. Caney Creek Above Tidal - Segment 1305 through much of Wharton County and especially the city of Wharton is not well defined, tremendously disturbed, and essentially non-existent in places. The communities of Sugar Land, Stafford, and Missouri City align the Upper Oyster Creek. (http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/2008_303d.pdf).

3.2.4 Geology and Soils

In the region, the Lissie Formation consists of varying proportions of sand, silt, clay, and minimal amounts of gravel. Concentrations of calcium carbonate, iron oxide, and iron-manganese oxides are common in the weathered zone. Loamy prairie, sandy prairie, and coarse sand range sites predominate on the Complex, with interspersed claypan and lowland range sites. Geological characteristics of the virgin coastal prairie include small mounds or hills called "mima" or "pimple" mounds. Formation of these mounds is not exactly understood.

Geology

According to the Physiographic Map of Texas (1996), the Complex lies within the Gulf Coastal Plains Physiographic Province (Gulf Coastal Plains). Each province or landscape reflects a unified geological history of deposition and erosion processes and characteristic geologic structure, rock and soil types, vegetation, and climate distinguish each physiographic province. The elevations and shapes of its landforms contrast significantly with those of landforms in adjacent regions. The geologic formations of the Gulf Coastal Plains slope gently toward the Gulf of Mexico and are the direct result of prehistoric alluvium and marine sediment laid down by ancient streams from the western U.S. These materials consist primarily of clay, sandy clay, clay loam, silt, and sand, which originated from a multitude of soils, rocks, and unconsolidated sediment that existed throughout the flood plains of the ancient streams. Three sub-provinces referred to as the Coastal Prairies, the Interior Coastal Plains, and the Blackland Prairies, further divide the Gulf Coastal Plains. The Complex lies within the Coastal Prairies sub-province.

Soils

Deep Non-Saline Soils

Soils within this region of the Texas Gulf Coast are primarily in the Vertisol soil order, with some regional inclusions of Alfisol soils (http://soils.usda.gov/technical/soilorders/). Vertisol soils are heavy and expansive clay soils that develop deep, wide cracks during dry periods of the year. Conversely, these soils have incredibly high moisture storage potential and swell tremendously as they become wet. Vertisol soils frequently underlie expansive grassland communities. Engineers know vertisols well because of their unique property limits and engineering uses. Alfisol soils result from weathering processes that leach clay minerals and other constituents out of the surface layer and into the subsoil, where they can hold and supply moisture and nutrients to plants. Alfisols frequently underlie forests or mixed vegetative cover. Additional descriptions of soil series may be found in the soil survey publication for the desired county (NRCS Soil Survey). Approximately 82 percent of the soils in Brazoria County are deep, non-saline soils. The major soils are Aris, Asa, Bernard, Brazoria, Edna, Lake Charles, Norwood, and Pledger series. They are on broad, nearly level areas that are far enough inland that they are not affected by salts from the Gulf of Mexico. With the exception of the Asa and Norwood soils, which are loamy throughout and well drained, all of the soils are somewhat poorly drained and have very slow permeable subsoil (USDA-SCS). Fort Bend County includes the Bernard, Edna, Kaman clay, and Lake Charles soils. The dominant soils in Matagorda County include the Dacosta, Edna, Laewest, Livco, Telferner, and Texana, which formed in the clayey and loamy sediment of the Beaumont Formation. Wharton County soils include Brazoria clay, Norwood silt, Asa silty clay loam, Clemville Norwood complex, Lake Charles and Pledger clay.

Deep Saline

The second soil series is the Harris-Velasco-Placedo. These soils are very poorly drained, nearly level, clayey, saline soils. These soils have weakly convex relief and a water table at or near the surface. Standing ponds of water, small bayous, and small drains break the relief. This soil generally occurs in the coastal marshes and is commonly flooded. Slopes are generally less than 0.5 percent. The natural vegetation consists mainly of low growing, salt-tolerant plants, yet occasionally the surface is barren of vegetation. The Harris, Velasco, and

Placedo soils are very deep with very slow permeability and generally have high clay content. Clayey and loamy sediments underlay these soils, which are poorly suited to uses other than wildlife habitat because of wetness, the hazard of flooding, salinity, and the clayey texture (See Map 3-4 Big Boggy NWR Soils, Map 3-5 Brazoria NWR Soils,Maps 3-6, 3-7, 3-8, and 3-9 San Bernard NWR Soils).

3.2.5 Mineral Resources

The Service does not own the mineral interest underlying most of the lands within the Complex and must provide reasonable access to mineral owners to explore and develop their mineral interests. Oil and gas activities are allowed to take place on refuges for a number of reasons. On the majority of refuges, oil and gas activities occur where private entities, states, or Native corporations, rather that the federal government, own the mineral rights. Owners of these mineral rights have the right to develop, produce, and transport the oil and gas resources located within a refuge (USGAO 2001). However, the Department of the Interior's regulations requires, "to the greatest extent practicable," that "all exploration, development and production operations" be conducted in such a manner as to "prevent damage, erosion, pollution, or contamination to the lands, waters, facilities, and vegetation of the area." Further, "so far as practicable, such operations must also be conducted without interference with the operation of the refuge or disturbance to the wildlife thereon" (50 C.F.R. Part 29.32).

Oil and gas exploration and operations are common across the landscape and require coordination and monitoring to ensure the protection of refuge resources during all operations.
Photo Credit: USFWS

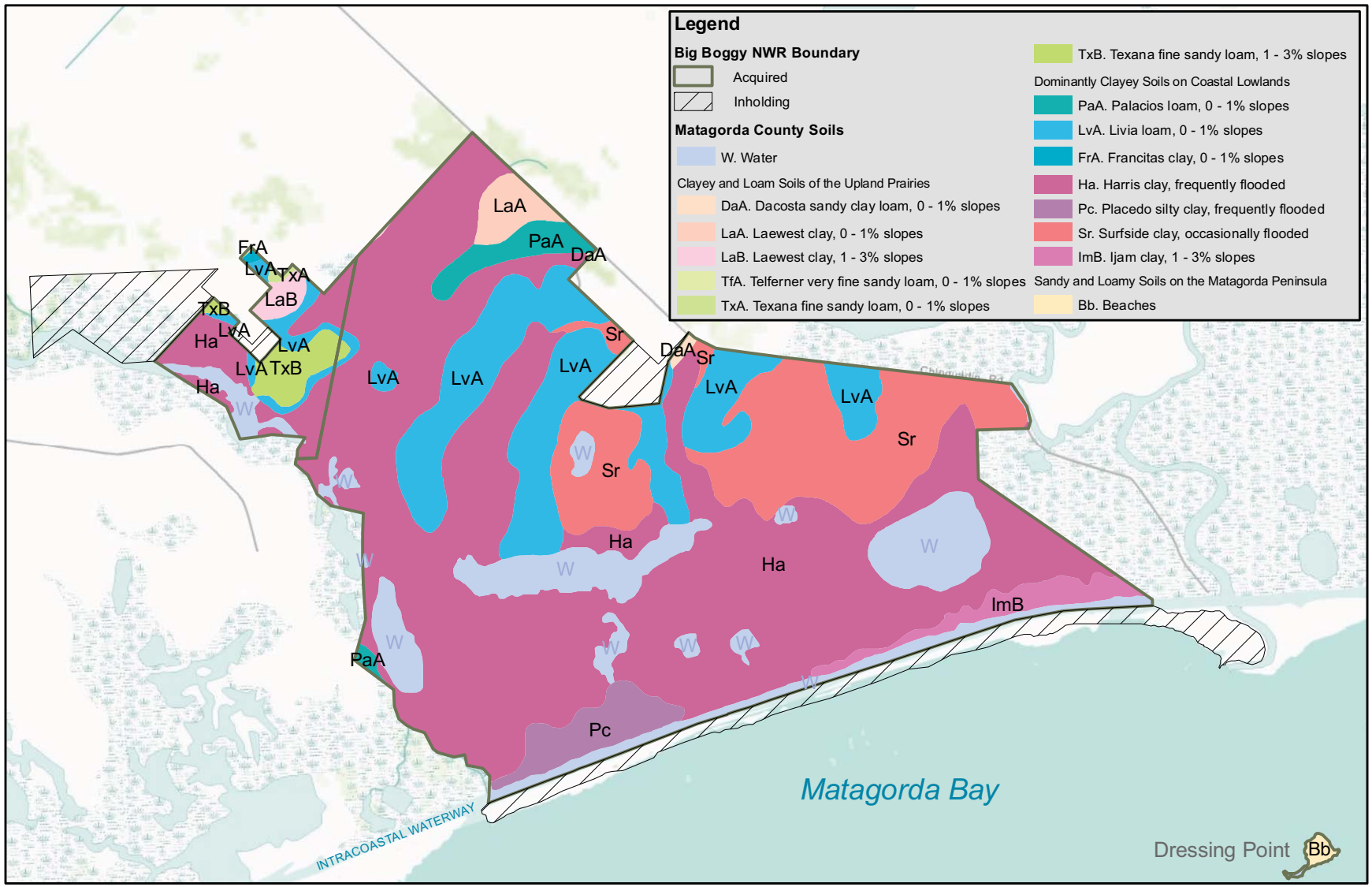
Under the National Wildlife Refuge System Administration Act of 1966, as amended, the Service is responsible for regulating all activities on refuges. The Service is required to determine the compatibility of activities with the purposes of the particular refuge and the mission of the Refuge System and not allow those activities deemed incompatible. However, the Service does not apply the compatibility requirement to the exercise of private mineral rights on refuges. Department of the Interior regulations also prohibit leasing Federal minerals underlying refuges outside of Alaska, except in cases where federal minerals are being obtained by operations on property adjacent to a refuge. Nevertheless, the activities of private mineral owners on refuges area subject to a variety of legal restrictions, including Service regulations, Federal laws affect how private mineral rights owners conduct their activities. Also, Service regulations require that oil and gas activities be performed in a way that minimizes the risk of damage to the land and wildlife and the disturbance to the operation of the refuge. The regulations also require that land affected by reclaimed after

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge

Matagorda County, Texas

Map 3-4. Natural Resource Conservation Service - Soils



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MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
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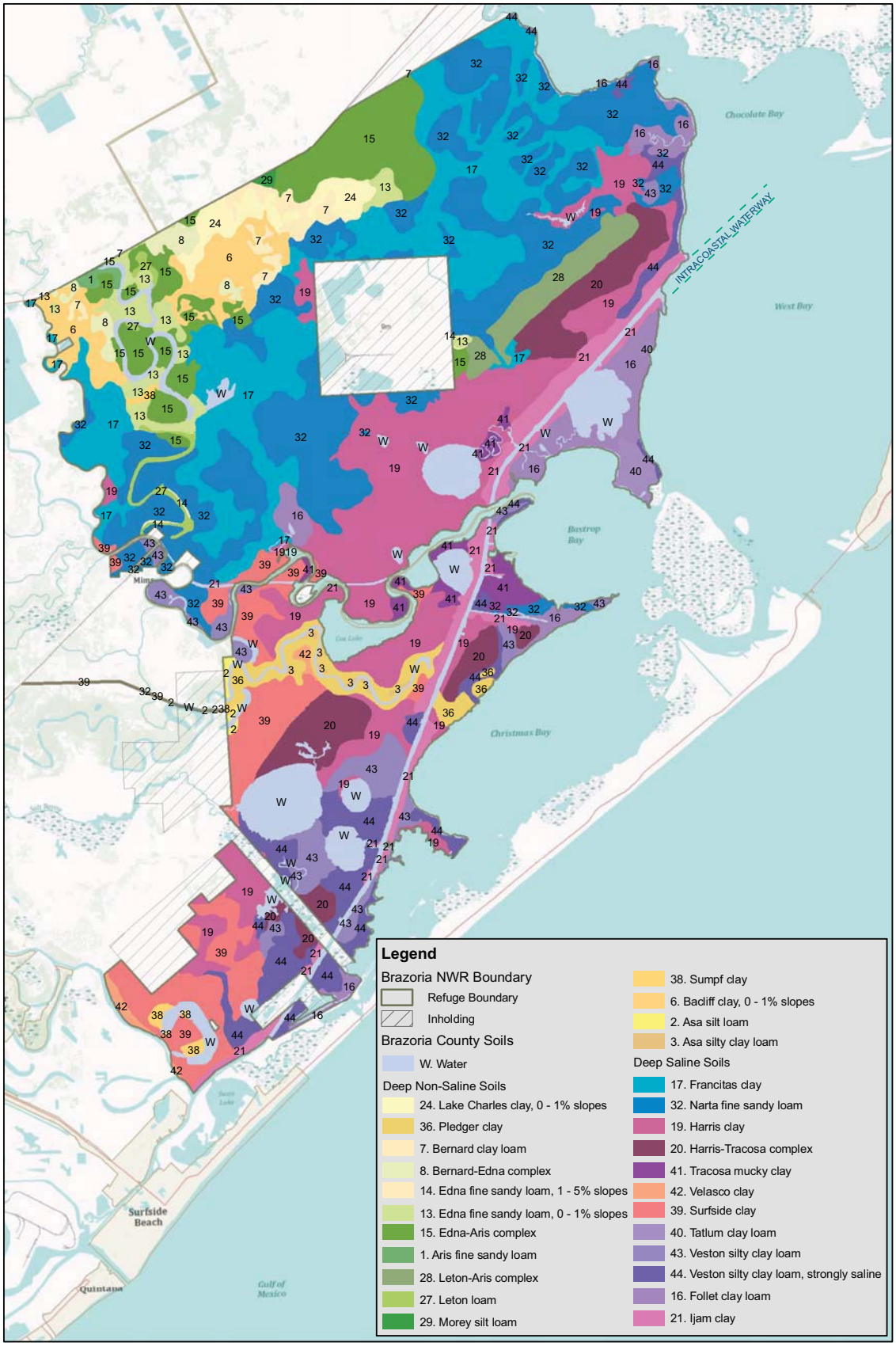
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge
Brazoria County, Texas

Map 3-5. Natural Resource Conservation Service - Soils



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MAP DATE: May 2011
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MERIDIAN: N/A
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0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

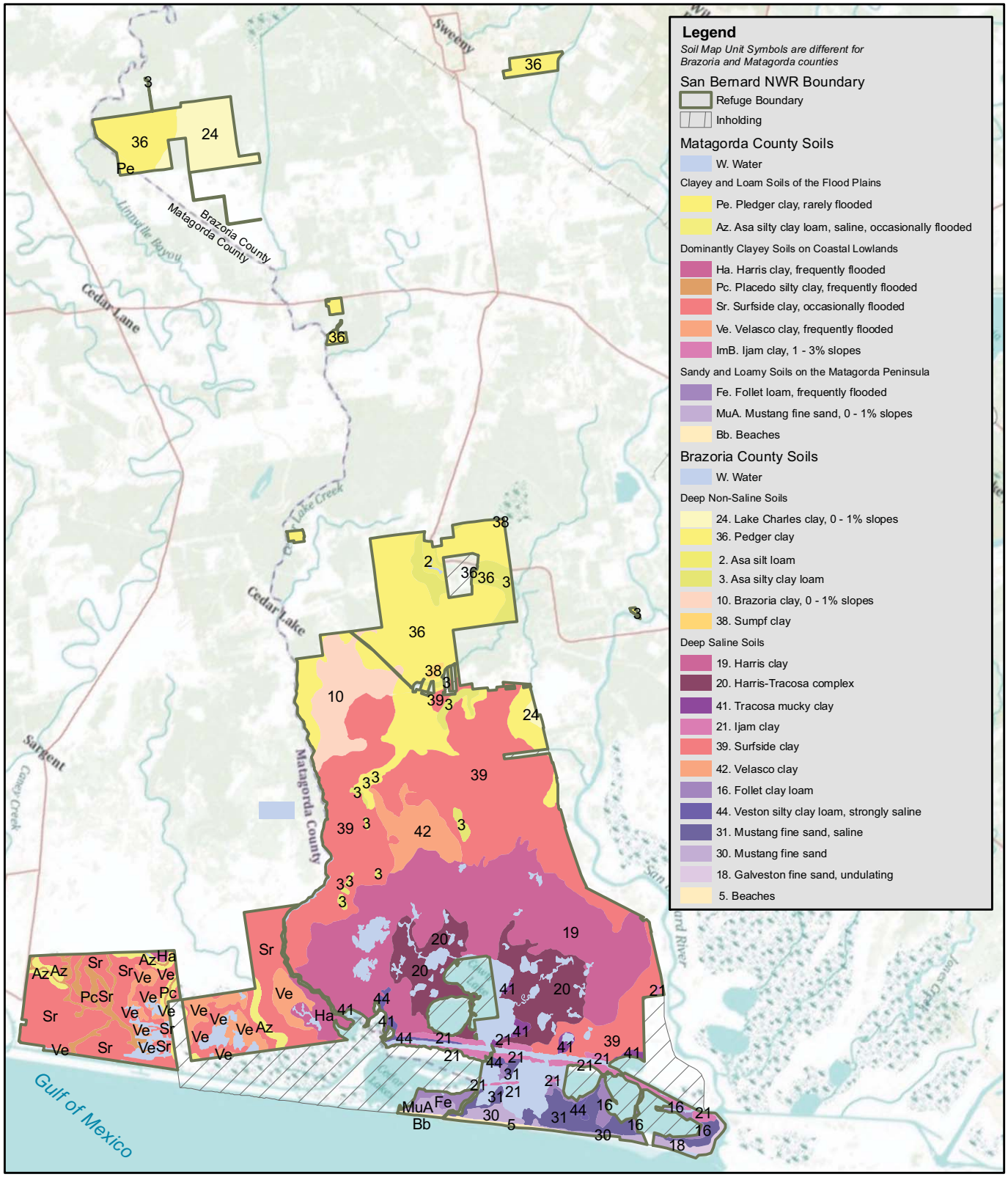
U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-6. Natural Resource Conservation Service - Soils

Area A



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LAND STATUS CUR RENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N /A
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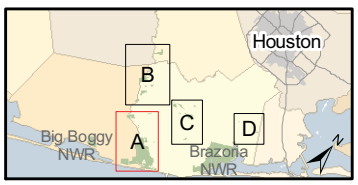
0 0.5 1 2 Miles

0 0.5 1 2 Kilometers



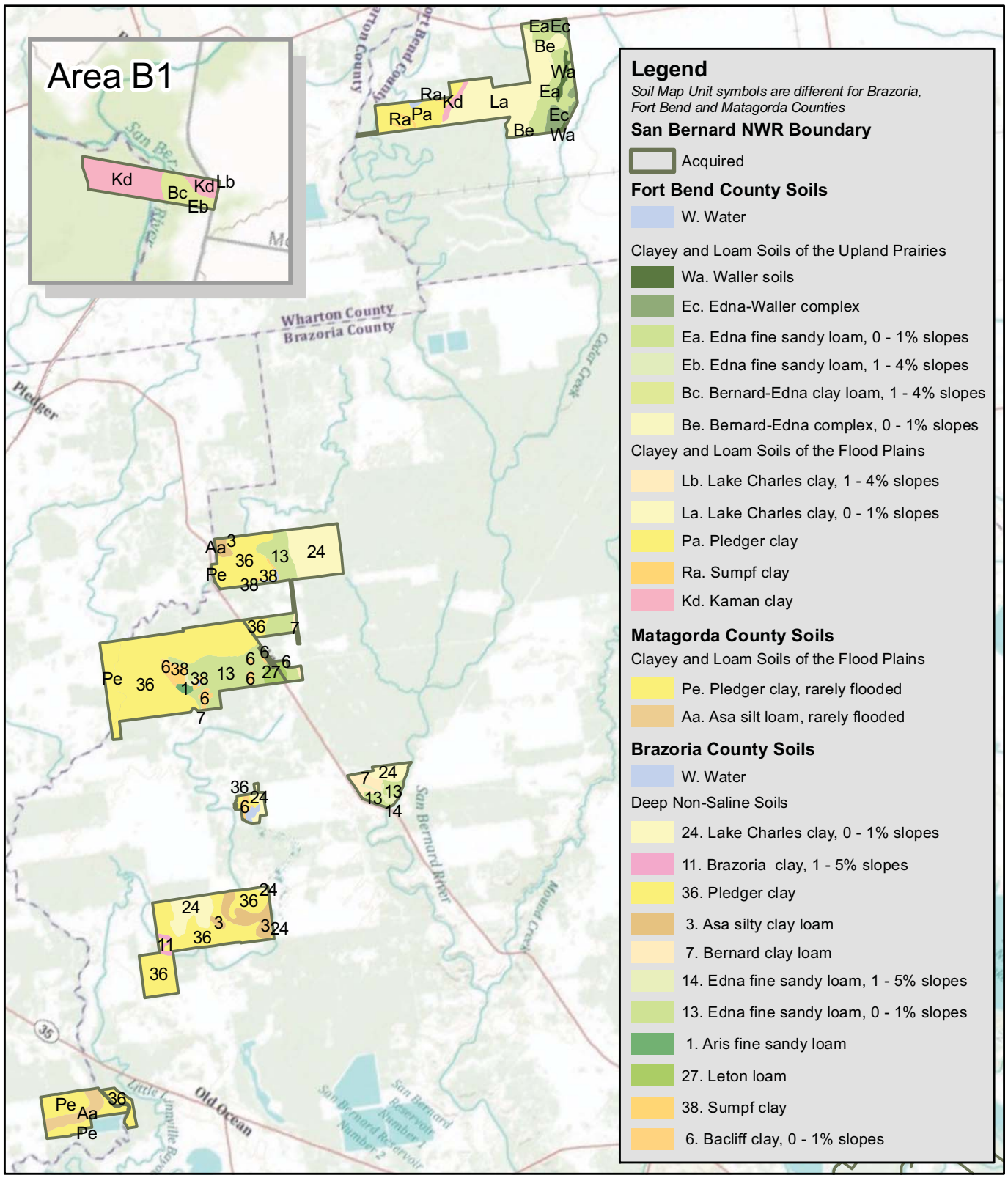
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-7. Natural Resource Conservation Service - Soils
Area B



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ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_soils_B_8.5by11_5.18.11_shl

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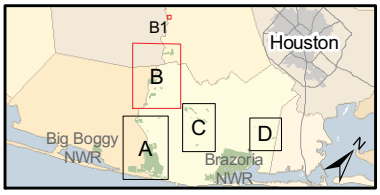
0 0.5 1 2 Kilometers



UTM ZONE 15
NAD 83

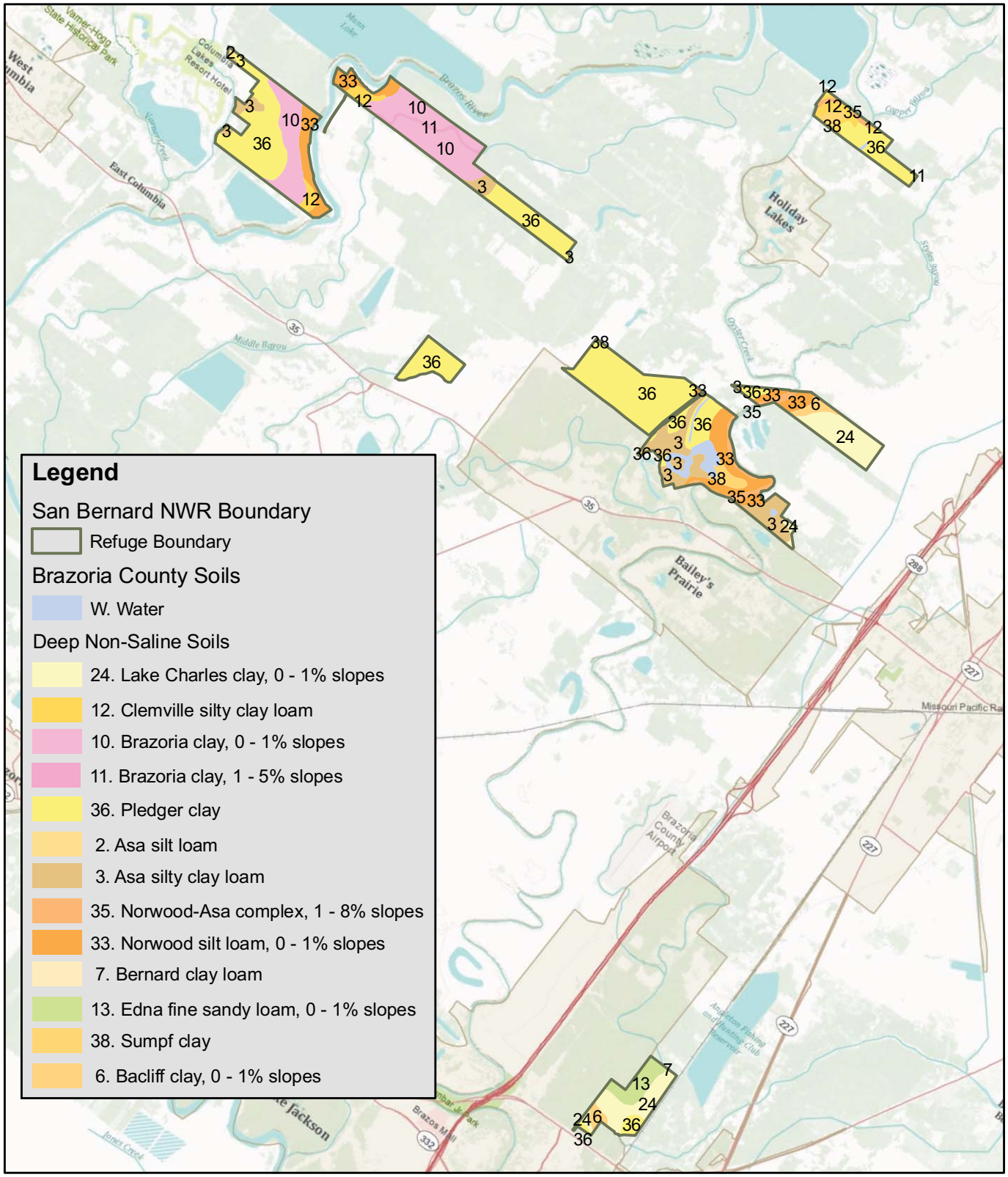
U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-8. Natural Resource Conservation Service - Soils

Area C



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LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_soils_C_8.5by11_5.18.11_shl

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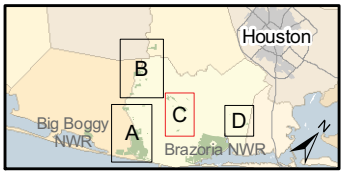
0 0.5 1 2 Kilometers



UTM ZONE 15
NAD 83

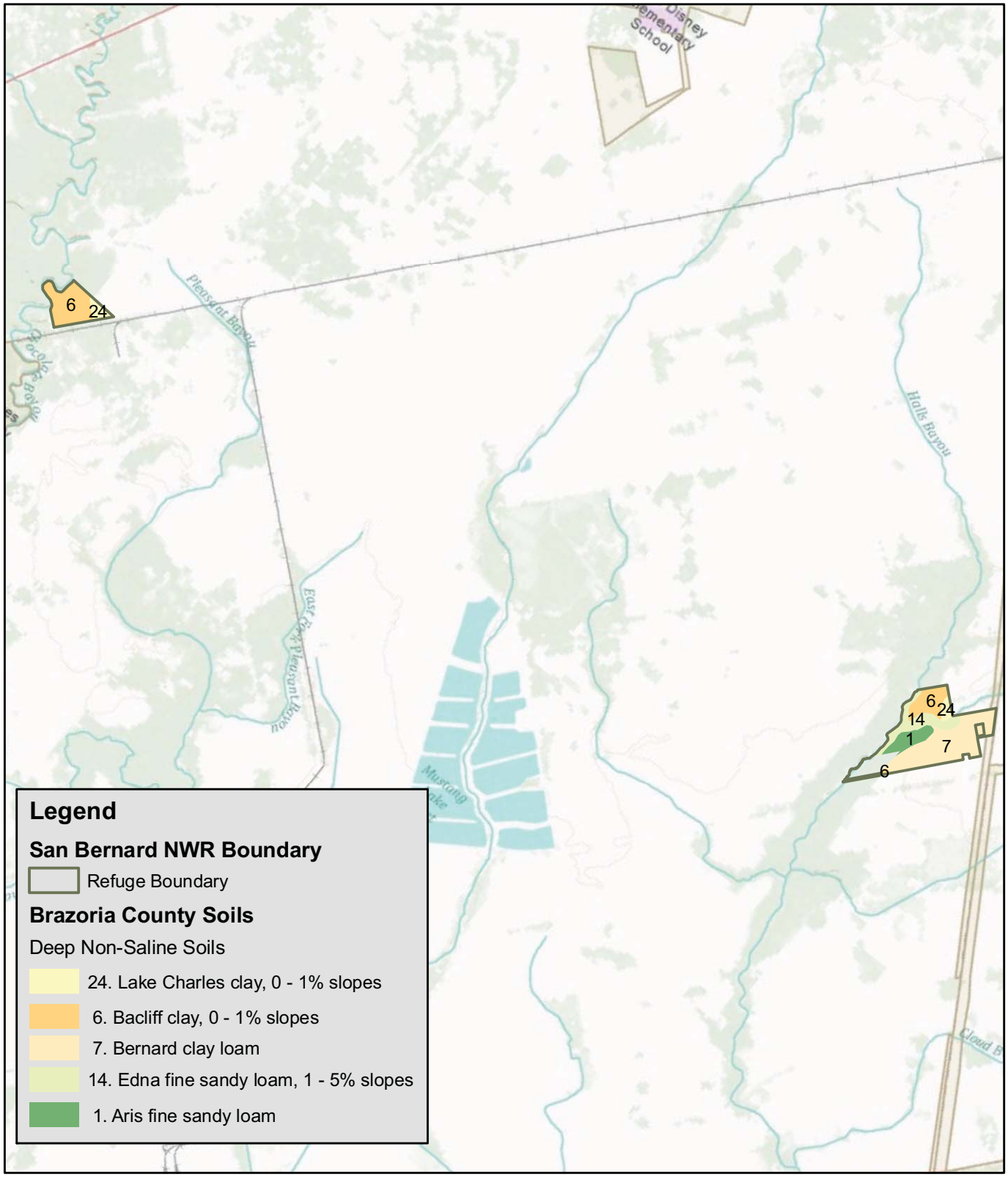
U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-9. Natural Resource Conservation Service - Soils

Area D



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
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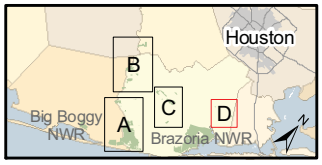
0 0.25 0.5 1 Kilometers



UTM ZONE 15
NAD 83

operations have ceased. Information about oil and gas operations and management on the Complex can be found in Section 3.6.1.3.

3.2.6 Concerns Regarding the Physical Environment

The availability and quality of water resources is critical to maintaining Complex landscapes. As experienced over the past decade, the refuges are generally near the extremes of the rainfall charts, either suffering extreme drought or excess rains. Rarely does annual rainfall occur near the annual average. Managing the refuges at climatic extremes is difficult. Table 3-3 summarizes management concerns due to the physical environment.

Table 3-3. Management Concerns Due to the Physical Environment

Moist-soil management	• Unable to fill ponds in fall for migrating and wintering birds. • Water can be purchased for Big Boggy and Brazoria NWRs to fill limited fields if available from the Gulf Coast Water Authority. However, purchases are often restricted during periods when brood water is needed for target spp.	• Cannot dry ponds out for manipulation resulting in increased vegetation encroachment.
Burning	• Generally beneficial and enables burning; however, under extreme conditions, burning is halted due to the potential damage to native vegetation.	• Reduces burnable acreage, and burn opportunities. • Reduces fire intensity; decreasing control of invasive and aggressive species.
Salt marsh management	• Salt water inundation (storm surge) of upper salt marsh and salty prairie habitats are not diluted and washed out without adequate rainfall. Hyper-saline conditions are created in swales. • Interrupts life cycles of invertebrates in upper salt marsh, and salty prairie, thereby influencing species that feed on those invertebrates.	• Encroachment of freshwater tolerant invasive species (phagmites, Chinese tallow, etc.) into upper salt marsh habitats occurs.
Bottomland forest	• Stresses bottomland trees during extended drought conditions. • Enables fire to ignite and burn through restoration areas.	• Generally beneficial, shallow-rooted trees are susceptible to blow over during storms due to soil saturation.

Environmental Contaminants

The Service assesses existing and potential environmental contaminants found on national wildlife refuges through a Contaminant Assessment Process (CAP) report. A CAP is an information gathering process and initial assessment of a national wildlife refuge in relation to environmental contaminants. Each CAP analyzes particular contaminants of concern to fish, wildlife, and other resources on a refuge. The information summarized through the CAP can provide the basis by which land managers select options to reduce contaminant impacts on the species and lands under their stewardship. The CAP also identifies Service-managed areas located downstream or down-gradient from highways, railways, or navigation channels that may be vulnerable to hazardous substance spills. Such areas may then be targeted for baseline data collection which could support future on-refuge investigations, natural resource damage assessments, or field work. A CAP report for Big Boggy NWR was conducted in 1999. The CAP reports for Brazoria and San Bernard NWRs were updated in 2009.

Management activities for the Complex include monitoring of on/off-land contaminant sites and water sampling of nearby bayous, waterways, and rivers that could carry contaminants onto the refuge. While there are known contaminant sources and suspected contaminant presence within the vicinity of the Complex, to date no contaminant incidents have occurred. On-site sources of contaminants, (pesticides, petroleum products, etc.) are managed and contained according to the Complex's Environmental Management Plan. Absorbant booms and materials are maintained for local spills in accordance with Spill Prevention Plans. In the case of third party spills, the refuge will coordinate with Brazoria County, Texas General Land Office, and the Coast Guard. Approximately 10 staff maintain Hazwopper training for emergency actions.

Brazoria NWR (2009)

Many bays and bayous lie within and around the refuge. West Bay is an impaired body of water that borders the east portion of the refuge, along with Chocolate Bay and the bayous that drain into it. The Christmas Bay, Bastrop Bay, and other small bays border the southern portion of the refuge, where bayous and lakes drain into them. These waters could potentially carry contaminants onto the refuge. North and south winds can carry air pollution onto refuge lands. The GIWW runs from the southwestern corner of the refuge and continues in a northeastern direction through the refuge. It connects with Drum Bay (on the right), Nicks Lake and Salt Lake (on the left), and runs through Bastrop Bayou and Oyster Lake, exiting the refuge at West Bay. A significant amount of barge traffic utilizes this waterway carrying a variety of chemicals and materials. Various sites on the refuge could become contaminated should there be a spill or leak of materials. The industrial sites within the Clute and Freeport areas pose a potential for producing contaminants that could impact refuge resources. These sites include chemical plants, oil and gas storage, and major pipelines. Nearby oil fields located at Stratton Ridge and Hoskins Mound, are potential contaminant sources to the Complex. Multiple pipelines are located on the refuge which have the potential for contaminating refuge lands.

San Bernard NWR (2009)

Several sites in the vicinity of the refuge could pose a threat in the event of a contaminant incident. The sites are primarily industrial areas including Dow Chemical Company, the Freeport Complex, and the cities of Freeport and Lake Jackson, all of which are located east of the refuge. The types of contaminants range from air pollutants to toxins to oil and gas spills. Transport pathways include roads, pipelines, rivers, and bayous. A major pathway for contamination is the GIWW which traverses the southern portion of the refuge for approximately 10 miles carrying a variety of chemicals and materials throughout the length of the refuge. Pollution from numerous nonpoint sources could transport contaminants onto the refuge through the GIWW. Additional pathways include multiple rivers and bayous. The lower San Bernard River and Cedar Lakes (near the outfall) in the southern portion of the refuge are considered impaired bodies of water. Predominant winds carry air pollution from the southeast and northwest. While there are known contaminant sources in the vicinity, no documented contaminant problems or habitat degradation has occurred on the refuge as a result of these sources. Multiple pipelines are located on the core refuge and bottomland units. These pipelines have the potential for contaminating the refuge lands.

Big Boggy NWR (2011)

Aerial drift from nearby agricultural applications of herbicides and pesticides are also possible. Portions of the refuge are subject to periodic inundation during extreme tides, heavy rain events, and major storm surges via Big Boggy Creek. Contaminants from various sources can accumulate in sediments and affect waters within the many ponds and impoundments on the refuge, as well as affected marshlands. Significant surface water pathways such as Big Boggy Creek and irrigation canals are avenues for oil and chemical spills and other contaminants from the GIWW, local agriculture, offshore petrochemical production facilities, and pipelines. Although no oil and gas pipeline corridors transverse the refuge, nearby land and upstream crossings occur and could be an exposure pathway in the event of an accidental discharge.

Other sources

Wildlife can disperse contaminants as well. Mammals are affected through the food chain and can transmit contaminants; wading bird, shorebird, and migratory bird species are affected by spills and can carry pesticides from feeding areas, especially geese that often fly out to the farm fields surrounding the refuge; raptors are affected by pesticides in the food chain and bio-accumulate contaminants; invertebrates are important forage and indicator species sensitive to oil and chemical spills; and resident birds such as mottled ducks and various song birds could be subjected to area contaminants.

Recreational uses, including hunting and special organized group activities, makes possible the disposal of urban waste in public areas and site contamination from the use of toxic shot by indiscriminate hunters. Past use as sugarcane and cotton agricultural land and, more recently, grazing of cattle on what eventually became the refuge, are less significant sources of potential contamination. Remnant windmills and natural gas well sites from the past could present an exposure pathway between surface and groundwater media.

3.3 Biological Environment

This section describes the biological environment in which the Complex is found. It includes a description of the historical, present and potential future condition of terrestrial and aquatic habitat types found on the Complex, as well as the natural processes that influence them. It identifies priority wildlife species and focal species used for monitoring purposes, and includes a discussion of various wildlife types found on the Complex. This section also includes a short discussion on concerns pertaining to the biological environment.

3.3.1 Habitat Types

The refuges are a haven to a myriad of plant communities, co-evolving with biotic and abiotic organisms, rich bottomland soil, and flat to low topography (0–50 ft. elevation) that form a mosaic of wetlands, grasslands, and forested bottomland habitats. The Complex currently has over 19,000 acres of bottomland hardwood forest and continues to acquire additional lands on the San Bernard NWR under the auspices of the Austin's Woods Conservation Plan. Salt marsh and salty prairies make up the greatest part of the Complex. The salty prairies give way to coastal prairie and bottomland hardwood forest on higher elevations. Gulf Coast prairies total less than 250,000 acres in the state of Texas, of which approximately 12,000 acres are on the Complex.

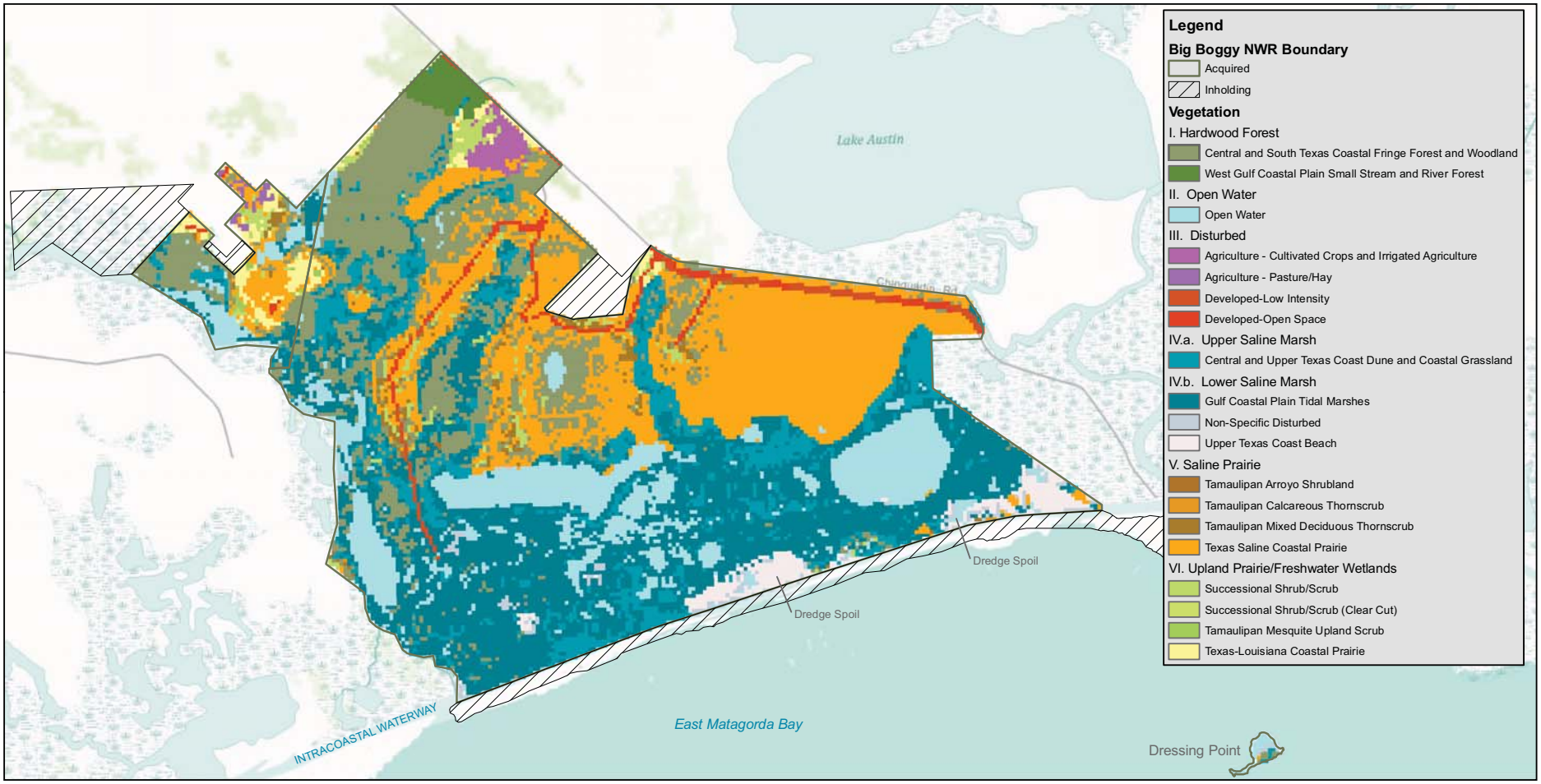
Prairie habitats are managed predominantly with fire. Where fire cannot be used, haying or shredding may be utilized. Where fire has not been implemented on a regular basis, control of invasive species during restoration may require herbicide application or mechanical removal of brush/trees. On Brazoria NWR, approximately 1,000 acres of former prairie are farmed (primarily rice) and also managed as freshwater wastelands. An additional 500 acres are artificially managed as freshwater wetlands through the maintenance of levees and associated water control structures. These structures are meant to replicate acres of freshwater prairie wetlands that have been lost due to past agricultural practices and provide essential freshwater habitats. San Bernard and Big Boggy NWRs have small fields; 10 and 90 acres respectively, that are planted in rye as browse for geese. The forested habitats are managed as old-growth habitats, limiting management to control of invasive species. The marshes are generally left unmanaged however fire (prescribed and wildland) will occasionally run through the marshes. Restoration of degraded and eroded marshes due to saltwater intrusion require a variety of techniques. More details on these and additional management activities can be found in Section 3.6.

The Complex uses the National Vegetation Classification System (NVCS) to describe habitat types at the ecological system level (Map 3-10 Big Boggy, Map 3-11 Brazoria, and Maps 3-12, 3-13, 3-14, and 3-15 for San Bernard Vegetation Maps). *Note: The National Land Cover Data (NLCD) maps for the Complex has been altered substantially to more accurately reflect the actual vegetation communities present. In addition, location-specific vegetation communities that are not part of the NVCS classification system have been represented on the map and roughly described. NVCS tends to focus on climax communities and many managed, previously altered, and invasive communities are not accurately identified.*

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge
Matagorda County, Texas

Map 3-10. National Vegetation Classification System - Vegetation



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: bbg_nvcs_5.19.11_shl

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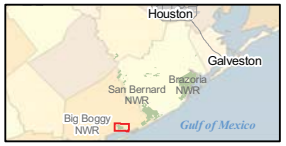
0 0.5 1 2 Kilometers



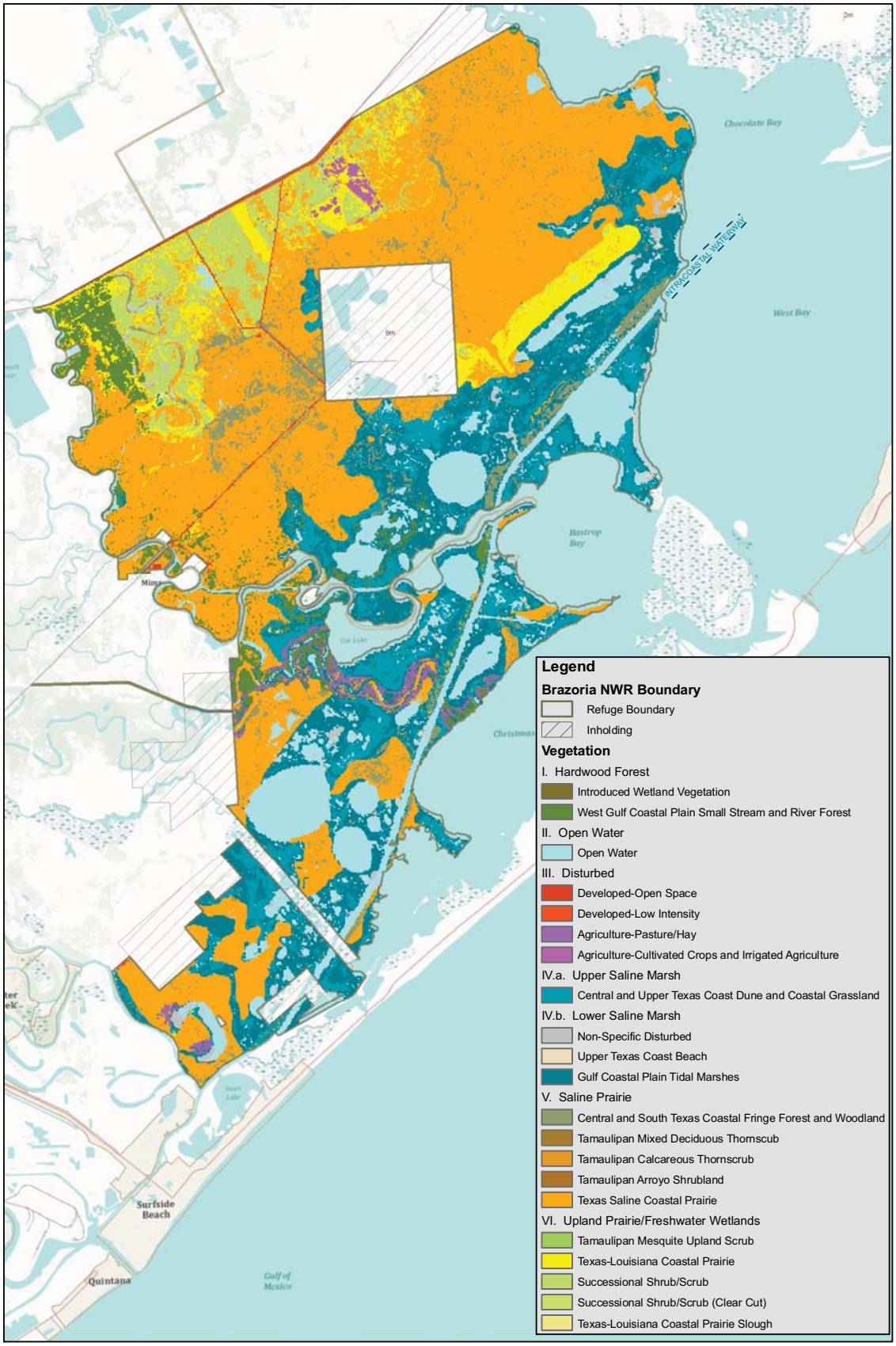
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge

Brazoria County, Texas

Map 3-11. National Vegetation Classification System - Vegetation



PRODUCED IN THE DIVISION OF PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: MAY 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_NVCS_5.19.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

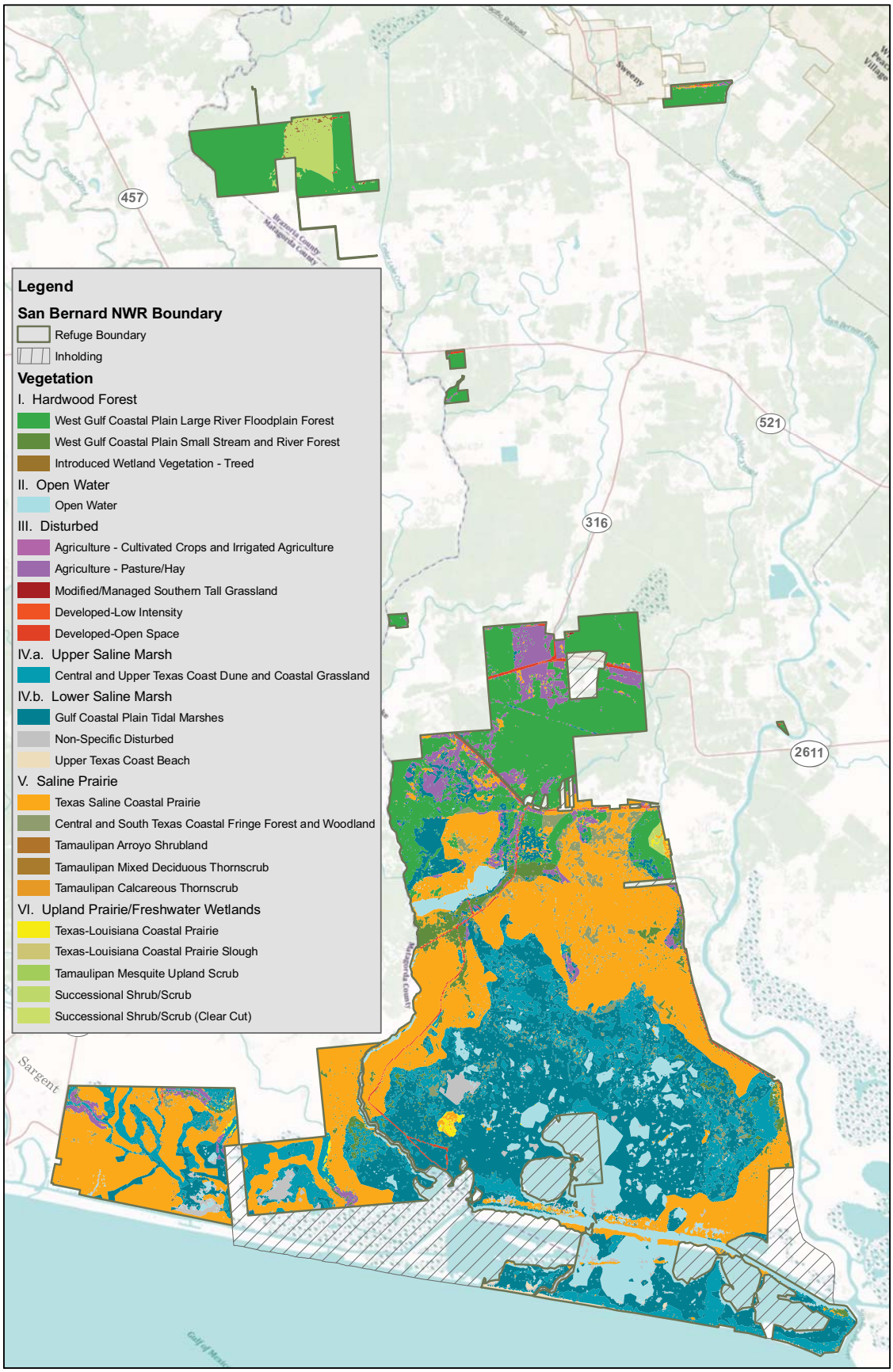
U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda, and Wharton Counties, Texas

Map 3-12. National Vegetation Classification System

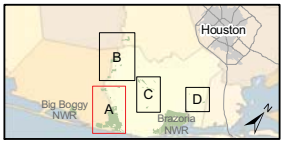
Area A



PRODUCED IN THE DIVISION OF PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 05/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_NVCS_A_5.20.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers



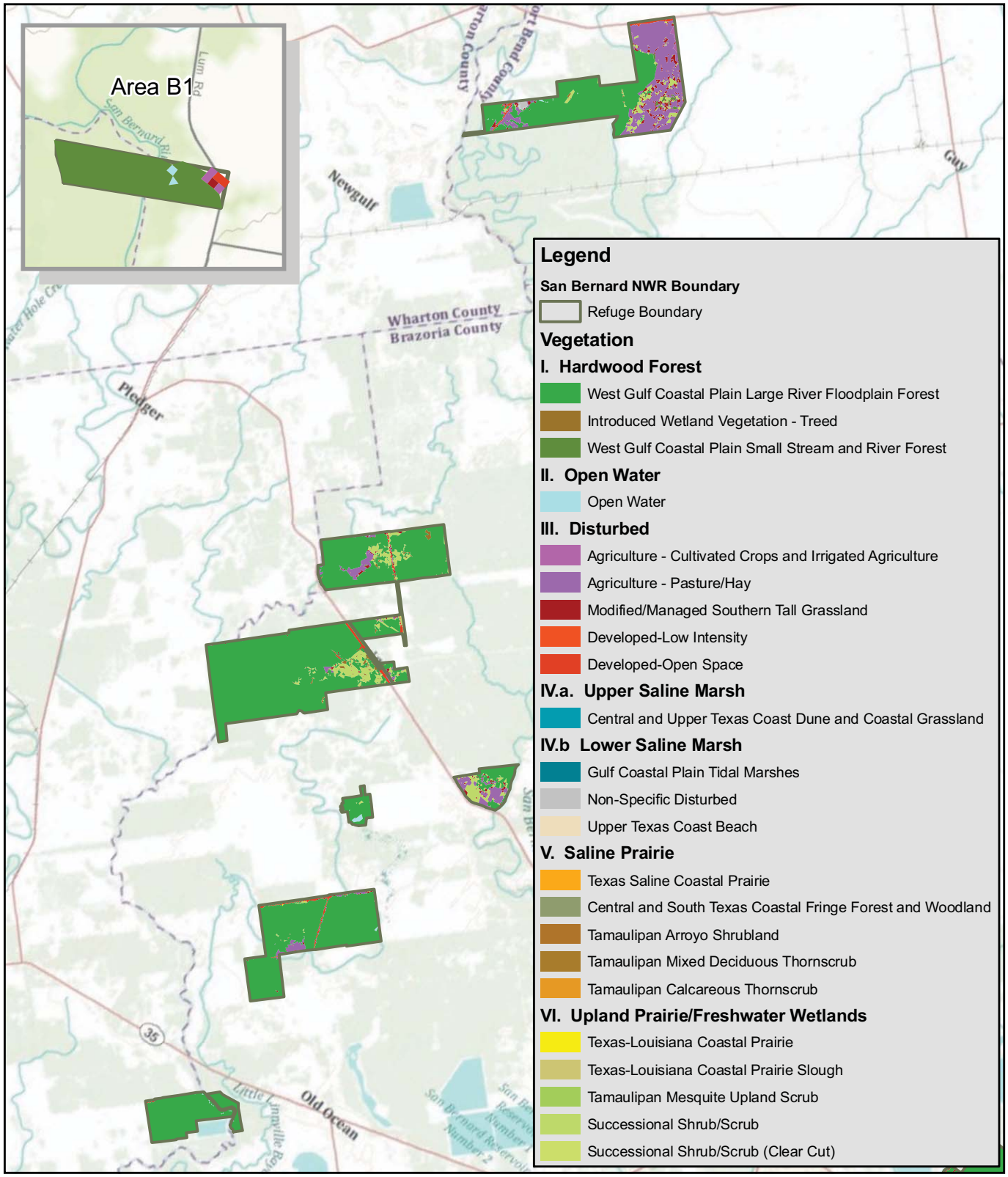
U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-13. National Vegetation Classification System

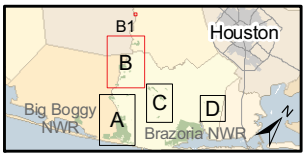
Area B



PRODUCED IN THE DIVISION OF PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_NVCS_B_8.5by11.5.20.11_shl

0 1 2 4 Miles

0 1 2 4 Kilometers



UTM ZONE 15
NAD 83

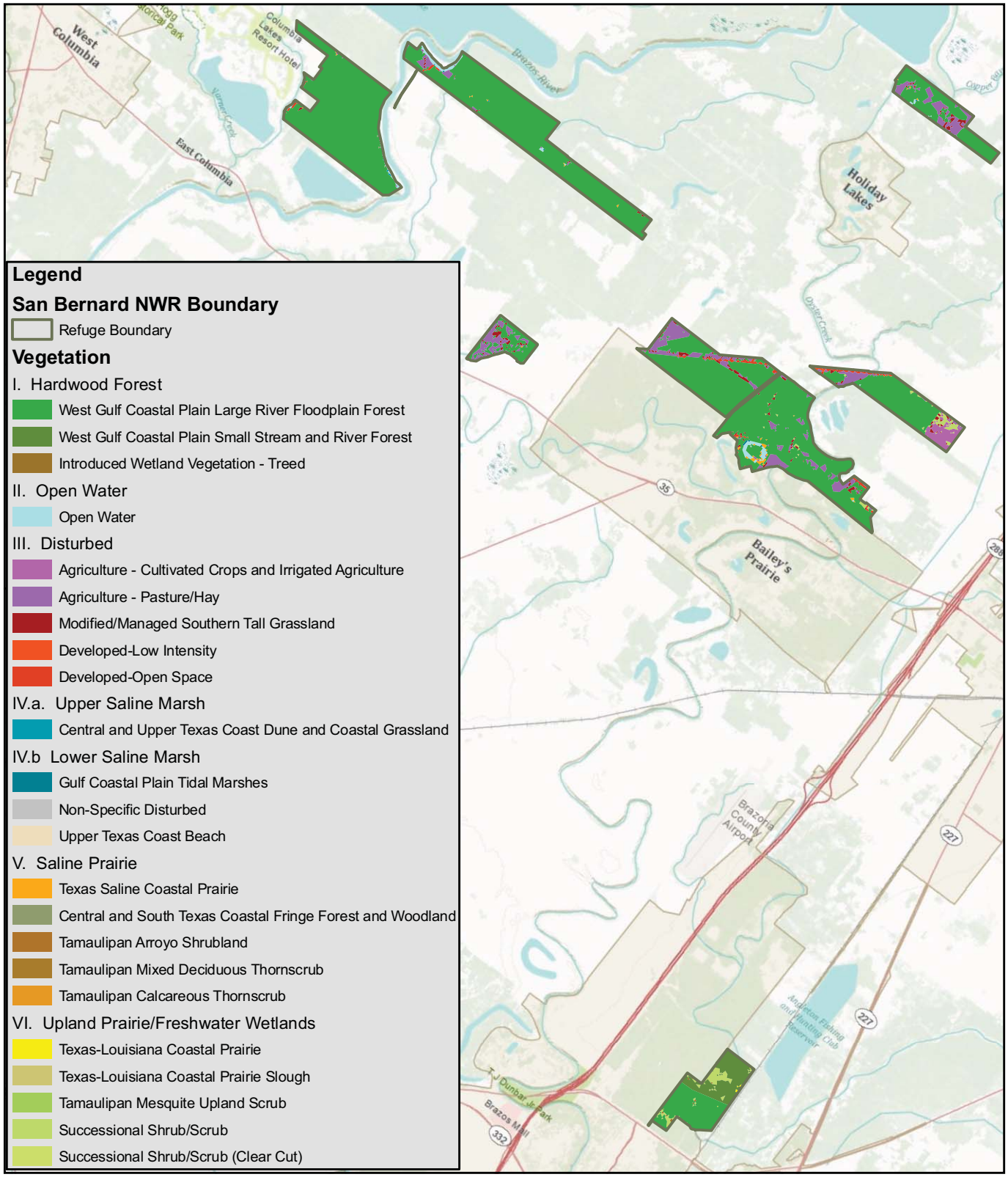
U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-14. National Vegetation Classification System

Area C



PRODUCED IN THE DIVISION OF PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_NVCS_C_8.5by11_5.20.11_shl

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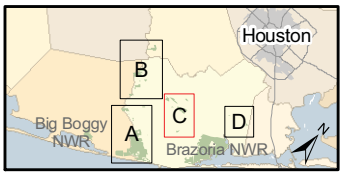
0 0.5 1 2 Kilometers



UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

Map 3-15. National Vegetation Classification System

Area D

Legend

San Bernard NWR Boundary

- Refuge Boundary

Vegetation

I. Hardwood Forest

- West Gulf Coastal Plain Large River Floodplain Forest
- West Gulf Coastal Plain Small Stream and River Forest
- Introduced Wetland Vegetation - Treed

II. Open Water

- Open Water

III. Disturbed

- Agriculture - Cultivated Crops and Irrigated Agriculture
- Agriculture - Pasture/Hay
- Modified/Managed Southern Tall Grassland
- Developed-Low Intensity
- Developed-Open Space

IV.a. Upper Saline Marsh

- Central and Upper Texas Coast Dune and Coastal Grassland

IV.b Lower Saline Marsh

- Gulf Coastal Plain Tidal Marshes
- Non-Specific Disturbed
- Upper Texas Coast Beach

V. Saline Prairie

- Texas Saline Coastal Prairie
- Central and South Texas Coastal Fringe Forest and Woodland
- Tamaulipan Arroyo Shrubland
- Tamaulipan Mixed Deciduous Thornscrub
- Tamaulipan Calcareous Thornscrub

VI. Upland Prairie/Freshwater Wetlands

- Texas-Louisiana Coastal Prairie
- Texas-Louisiana Coastal Prairie Slough
- Tamaulipan Mesquite Upland Scrub
- Successional Shrub/Scrub
- Successional Shrub/Scrub (Clear Cut)

PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
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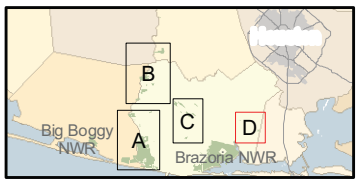


UTM ZONE 15
NAD 83

3.3.1.1 Terrestrial Vegetation Classes

The Complex reviewed previous on-the ground mapping efforts along with TNC's National Vegetation Classification System (NVCS), a hierarchical system of standard vegetation types across the landscape of the Complex to define the broad and alliance level categorization of refuge habitats. This compilation was required because the national vegetation classification system focuses on existing vegetation rather than potential natural vegetation, climax vegetation, or physical habitats. Multiple areas categorized as non-specific disturbed were simply areas impacted by natural processes including drought, fire, or salt-water inundation. Temporal and spatial variation in communities is an intrinsic property of the vegetation itself and, therefore, critical to the protection of biodiversity and landscape dynamics. Not restricting the classification to stable vegetation types ensures the units are appropriate for inventory and site description, and provide the level of detail required to build ecological and landscape models. Appendix F further breaks down vegetative alliances.

<u>Bottomland Hardwood Forest</u>

The Complex classifies these forests as two NVCS divisions; West Gulf Coastal Plain Small Stream and River Forest (CES203, 487) and West Gulf Coastal Plain Large River Floodplain Forest (CES203, 488). These descriptions, recognized by the NVCS, are not accurate for the coastal bottomland hardwood forests adjacent to the Brazos, Colorado, and San Bernard Rivers, known as the Columbia Bottomlands. This unique forest once comprised an estimated 700,000 acres at the beginning of the last century. This forested area has been reduced to about 150,000 acres. Bottomland hardwood species and other trees tolerant of flooding dominate vegetation. The Complex defines an array of alliances within the floodplain, generally associated with geomorphic features; including swales, sloughs, oxbows, and meander scrolls.

West Gulf Coastal Plain Small Stream and River Forest

This is a predominantly forested system of the West Gulf Coastal Plain associated with small rivers and creeks. In contrast to west Gulf Coastal Plain Large River Floodplain Forest, examples of this system have fewer major geomorphic floodplain features. Those features that are present tend to be smaller and more closely intermixed with one another, resulting in less obvious vegetational zonation. Bottomland hardwood tree species are typically important and diagnostic, although mesic hardwood species are also present in areas with less inundation, such as upper terraces and possibly second bottoms. As a whole, flooding occurs annually, but the water table usually is well below the soil surface throughout most of the growing season. Some canopy trees in stands of this system include river birch, sugarberry, common persimmon, green ash, honey locust, sweetgum, loblolly pine, American sycamore, and numerous oak species. Shrubs and understory trees may include American hornbeam, common buttonbush, silky dogweed, hophornbeam, parsley hawthorn, American holly, black willow, and black highbush blueberry.

West Gulf Coastal Plain Large River Floodplain Forest

This system represents a geographic subset of Kuchler's (1964) Southern Floodplain forest found west of the Mississippi River. Examples of this habitat type may be found along the Trinity, Neches, and Sabine Rivers. Several distinct plant communities can be recognized within this system that may be related to the array of different geomorphic features present

within the floodplain. Some of the major geomorphic features associated with different community types include natural levees, point bars, meander scrolls, oxbows, and sloughs (Sharitz and Mitsch 1993). Vegetation generally includes forests dominated by bottomland hardwood species and other trees tolerant of flooding, including bald-cypress and water tupelo. However, herbaceous and shrub vegetation may be present in certain areas as well. Vegetation generally includes forests dominated by bottomland hardwood species and other trees tolerant of flooding, including bald cypress and water tupelo. Other trees associated with examples of this system include Drummond's maple, river birch, water hickory sugarberry, green ash, sweetgum, American sycamore, swamp tupelo, loblolly pine, cedar elm, and various species of oak. Smaller areas of herbaceous- and shrub-dominated vegetation may also be present in certain areas. Shrubs and small trees include hazel alder, giant cane, American hornbeam, common buttonbush, coastal sweetpepper bush, stiff dogwood, Virginia sweetpepper, wax myrtle, dwarf palmetto, and Gulf Sebastian-bush.

Open Water

Within the boundaries of the Complex, this classification generally refers to open water associated with marsh ponds, open saltwater lakes like Cowtrap or Salt Lake, the GIWW, and freshwater ponds that management practices do not drain and otherwise disturb. In the salt marsh, widgeon grass and shoal grass with possibly small populations of turtle grass and manatee grass dominate vegetation known as seagrasses. Widgeon grass is by far the most important and will exist further inland in brackish and fresher waters. Seagrasses provide food and shelter to thousands of invertebrate species, including the economically important shrimp, crab, and juvenile game fishes. Freshwater ponds are solely dependent on rainfall and depths will fluctuate.

Disturbed

The Complex categorizes disturbed areas as: 1) continuously disturbed (e.g., roads, spoil sites, moist soil units, etc.); 2) static successional disturbed (e.g., unclassified static successional communities, mud flats, salt pans, etc.); and 3) successional disturbed (e.g., old fields).

Disturbed areas undergo environmental stresses either naturally or culturally and result in a static vegetation or landscape succession. Therefore, they have vegetative or non-vegetative characteristics. If naturally disturbed, as in the case of old fields, the shift in succession to another population may take several years to a decade or more. Salt pannes or mud flats for example are frequently disturbed by tidal action to the point where the soil is hypersaline and pioneering seeds are washed away before they germinate. Mechanical manipulation of moist soil units disrupts invasion by plants such as cattails to keep the area open for waterfowl activity. Other natural conditions may for a time inhibit or promote the occurrence of one dominant species year after year, such as those found occupied by wolfweed.

Saline Marsh

Saline marsh generally includes two NVCS classifications: the Central and Upper Texas Coast Dune and Coastal Grassland (CES203.465) and the Central and Upper Texas Coast Salt and Brackish Tidal Marsh (CES203.473).

Central and Upper Texas Coast Dune and Coastal Grassland

This system consists of wetland and upland herbaceous and shrubland vegetation of barrier islands and nera-coastal areas in the northern Gulf of Mexico along the upper Texas coast, at least to Galveston Bay. Plant communities of primary and secondary dunes, interdunal swales and adjacent mainland are included. Salt spray, saltwater overwash, and sand movement are important ecological forces.

Efforts to utilize photo applications to depict vegetation characteristics along with efforts to ground truth data will provide long-term monitoring capability. Photo Credit: USFWS

Central Upper Texas Coast Salt and Brackish Tidal Marsh

This ecological system encompasses the brackish to salt intertidal marshes of the central and upper coast of Texas. These marshes typically occur on the bay side of barrier islands. It also includes extensive irregularly flooded tidal flats and salt pannes, which may or may not be vegetated. This system ranges from Galveston Bay in Chambers County, south to approximately Corpus Christi Bay. Vegetation occurring in this habitat type include succulent herbs such as swampfires, glassworts and turtleweed. Other plants that may be found in this system include sand bluestem sand sagebrush, black mangrove, eastern baccharis, bushy seaside tansy, saltgrass, Jesuit's bark, needlegrass rush, shoregrass, Pacific swampfire, various cordgrasses, seashore dropseed and exotic species of tamarix.

Plants of the saline marsh are adapted to clay soils, salinity, and desiccating winds as well as frequent inundation from the Gulf Coast waters through tidal action and storm surges. These plants have adaptive structures to take in oxygen while their roots are under water. The primary dominant species are smooth cordgrass, saltwort, saltgrass, and saltmarsh bulrush. Two recognizable sub-classifications are Upper Saline Marsh and Lower Saline Marsh. Where lower saline marshes transition toward less saline conditions, there can be an annual shift in species populations depending on the inundation of saltwater. For example, seashore paspalum and olney bulrush populations can dominate acres of freshwater until a storm surge shifts the species composition toward salt tolerant saltgrasses.

Saline Prairie

Saline Prairie is denoted as Texas Saline Coastal Prairie (CES203.543) in the NVCS. This system includes grassland vegetation occuring on saline soils that are often saturated with

rainfall and periodically flooded by saline waters during major storm events. The saline prairie is a transition from the upland prairie toward plants adapted to persistent desiccating winds and saline clay soils due to their near proximity to coastal waters. Plants have fleshy leaves that retain water and have waxy surfaces to delay desiccation. The dominate flora of the saline prairie are gulf cordgrass, sea ox-eye daisy, and shoregrass with scattered populations of glasswort. Fire is an important ecological process needed to maintain this system, though periodic submersion by saltwater during storm events also helps to control the invasion of woody species. The woody eastern bacharris shrub will co-dominate with gulf cordrass and become a nuisance that requires periodic burning to eradicate or suppress.

Upland Prairie/Freshwater Wetlands

Upland Prairie/Freshwater Wetlands are generally described in the NVCS's Texas-Louisiana Coastal Prairie (CES203.550) and Texas-Louisiana Coastal Prairie Pond Edges (Slough) (CES203.541).

Texas-Louisiana Coastal Prairie

This system is often characterized by a ridge-and-swale or mound-and-intermound microtopography and encompasses both upland and wetland plant communities. Little bluestem, brown-seed paspalum, and switchgrass dominate the upland prairies, in addition to dozens of rush and sedge species. Common wildflowers found here are the prairie coneflower, Texas coneflower, white heath aster, and yellow-puff. Factors that contribute to the establishment and maintenance of prairie are soil type, fire, rainfall, and grazing. Some estimates state that 99 percent of coastal prairie has been lost through conversion to other uses and environmental degradation due to the interruption of important ecological processes, such as fire, needed to maintain this system. In the absence of regular fire, woody shrubs and trees will invade this system. Examples of invading woody species include eastern baccharis, Chinese tallow tree and yaupon as well as native trees. Many prairie species depend on fire for seed production because it removes accumulated plant litter and satisfies seed dormancy needs.

Drought occurs in areas of low rainfall and heavy clay soils hold water making it unavailable to plants. Plants can also experience drought-like stress as a result of root restriction caused by a 8–12 inch deep hard pan layer in some soils that roots cannot penetrate. Water is retained in scattered ponds and ditches throughout the upland prairie. Here the plant species are adapted to having their roots submerged under water for months. Dominant wetland species are *Sagittaria* sp., cattails, rice cutgrass, bulrushes, and floating forbs. Phragmites, although native to the region, are a persistent invader of freshwater wetlands and must be controlled by mechanical, chemical, and prescribed burn treatments.

Texas-Louisiana Coastal Prairie Pond Edges (Slough)

This system includes small to moderately large ponds and wwales in the coastal prairie of southeastern Texas and Louisiana. These wetlands contain surface water during much of the year, desiccateing only in the driest summer months. They are often fed by water runoff but result from percolation from adjacent sandy areas. Soils in the basins are finer-textured than surrounding areas and may be underlain by pans that enhance perched water tables in the winter. These wetlands occur within the coastal prairie matirx of southeastern Texas and Louisiana and are wetter than wet prairie dominated by eastern gamagrass and switchgrass.

These wetlands may be dominated by squarestem spikerush. Other species that may be present include nipplebract arrowhead, longbarb arrowhead, gaping grass, haspan flatsedge, green flatsedge, cylindricfruit primrose-willow, narrowleaf primrose-willow, hairy umbrella-sedge, Richard's yellow-eyed grass, southern cutgrass, erect centella, and eastern annual saltmarsh aster. Open areas in the ponds may contain floating and submersed aquatic vegetation, includiing sago pondweed, coon's tail, watershield, big floatingheart, yellow pond-lilly, and American lotus.

3.3.1.2 Aquatic Classes

The Complex has a diversity of salt, brackish, and fresh wetlands, including wet prairies, forested wetlands, tidal flats, estuarine bays, bayous, and rivers. The existence and extent of specific plant species within these different wetland types depends on their tolerances to fluctuating salt concentrations and variability in water depth. There is some overlap of species within the different wetland types on the Gulf Coast.

Tidal flats are located in the intertidal zone and are consistently exposed and flooded by tides. Tidal flats, characterized by sand, silt, and clay, have minimal vegetation but are important feeding grounds for coastal shorebirds, fish, and many invertebrates including crabs, oysters, clams, shrimp, and mussels.

Salt marsh, with an average salinity of 18 ppt, it has the greatest tidal fluctuation of all marsh types. Salt marshes contain relatively few plant species and are characterized by smooth cordgrass, a species that depends on water fluctuations. Soils have a lower organic content than fresher inland wetlands.

Brackish marsh communities are transitional between saline and intermediate marshes with an average salinity of 8.2 ppt. They are still subject to daily tidal influence. Marsh soils have a higher organic content than salt marshes, and higher water levels. Brackish marshes contain numerous small bayous and lakes.

Intermediate marshes are somewhat tidally influenced and have greater plant diversity than saline or brackish marshes. The average salinity is 3.3 ppt.

Fresh marshes support the greatest diversity in plant species of all marsh types. They are normally free from tidal influence, exhibit slow drainage, and have the highest soil organic content of coastal wetlands.

Coastal prairie generally extend from the coastal marshes to as much as 75 miles inland. Much of the former tall grass prairies dotted with shallow, ephemeral prairie wetlands (called potholes) and agricultural fields and human development drain and replace meandering bayous, creeks, and rivers.

Forested wetlands consist of bottomland hardwood trees that grow in creek and river floodplains. These wetlands are open productive systems that receive supplement from soil and organic matter upstream. The ebb and flow of floodwater has shaped and reshaped the

forest floor into ridges, swales, and flats. These in turn affect soil saturation and the type and abundance of plants that can grow. Numerous lesser creeks, bayous, and sloughs lie between the major rivers, carrying local rainfall to the coastal marshes, bays, and the Gulf. The waterways are generally forested along their banks and provide riparian habitat for native wildlife and migratory birds.

The Brazos and Colorado Rivers are the primary river basins. The headwaters extend into west Texas and provide water to numerous large and small communities including Austin and the Dallas/Fort Worth Metro Area along the way. Both rivers have numerous dams upstream from the Complex. Several of the bottomland units are adjacent to the Brazos. The San Bernard River follows a former channel of the Brazos and lies between these two major rivers. Its drainage basin extends approximately 100 miles inland. Lesser waterways, including Oyster Creek, Halls Bayou, Chocolate Bayou, and Caney Creek have drainages, which extend beyond 50 miles from the coast. The smallest drainages including Bastrop Bayou, Austin Bayou, Live Oak Bayou, Cedar Lake Creek, Dance Bayou, and Linnville Bayou are slow moving waterways that have drainages within 50 miles of the Gulf Coast. These all carry local rainfall to the coastal marshes, bays, and the gulf.

An extensive amount of rainfall during particularly wet periods drains to the marshes via surface or sheet runoff across the wet prairies; Cocklebur Slough and Rail Pond drainages on San Bernard NWR are good examples. This drainage is particularly important for intermediate and brackish marshes and creates a flushing mechanism. Where the drainage districts have created drainage ditches—particularly at Brazoria NWR, south of FM 2004—this flushing mechanism does not occur to the extent it did historically. The Complex established managed ponds along ditches and natural drainages to capture local rainwater, creating freshwater habits.

Shoreline habitats across the Complex vary from beach habitat at San Bernard NWR to natural marsh edges in the Cedar Lakes and Cow Trap Lakes at San Bernard NWR and Christmas Bay and Bastrop Bayou edges at Brazoria NWR. Shoreline habitat also occurs as both armored and unarmored shorelines along the GIWW. Erosion along the edges of the GIWW has been significant since it was first dredged. In some areas, particularly along spoil sites, the Army Corp of Engineers have armored banks with concrete block. However, acres of marsh are lost annually as vessel wakes, tides, and wind driven wave-action erode fine marsh sediments along exposed shorelines.

Texas coastal wetlands are an important wintering and migration area for North American waterfowl. Numerous birds of special concern, such as the bald eagle, piping plover, and reddish egret all depend on Texas marshes and estuaries, as do otters, alligators, swamp rabbits, furbearers, and amphibians. Texas coastal marshes and estuaries provide productive nursery and spawning areas and habitat for marine species and other marine organisms.

3.3.1.3 Natural Disturbance Processes

The habitats of the Complex have evolved with natural disturbances that continuously shape plant communities, their composition, and structure. In addition, these disturbances, mostly weather generated, maintain an early seral stage, cycle nutrients, and can have dramatic effects on productivity. The primary natural disturbance drivers in these habitats are wildland fire, shifting salinity concentrations (from inflows of freshwater from rainfall, seasonal tidal activity, the passage of frontal boundaries, droughts, and tropical storms), and hurricanes having effects other than changes in salinity.

With the nature of coastal weather in the Gulf of Mexico, wildland fires have generally started from lightning strikes in favorable fuels. A dominant fuel, gulf cordgrass, readily ignites under damp and wet conditions. Showers and thunderstorms generate as seasonal winds (south and southeast) bring gulf moisture over land. They typically form along the coast and move inland. Lightning is a large component of these storms, and is responsible for the majority of wildland fires started on the Complex. In 2010, only three wildland fires were started on San Bernard NWR, but 2009 saw the start of several fires on both San Bernard and Brazoria NWRs due to drier conditions. In 2008, a wildland fire starting from at least three separate lightning strikes and consumed more than 5,000 acres on San Bernard before it was contained. These fires, although in most cases beneficial to the habitat, are controlled or contained to protect life and property both on and off the refuges.

The salinity gradient literally draws the line in the mud for many organisms. There are plants and animals that tolerate a wide range of salinities and there are those with more narrow tolerances of either fresh or saline water, and the Complex distributes both accordingly. The movement of water, both fresh and saline, impacts the salinity gradient. Fresh water enters the Complex via rainfall, run-off, inland waterways, and transport through permeable soils. Saline water comes from the Gulf of Mexico, and seasonal tidal limits impact it daily. The passage of frontal boundaries and winds that can push water inland or out to sea can impact both fresh and saline water, as well as the gradient between them.

Tropical storms and hurricanes impact the refuges. Depending on the severity of the storm (wind classification), size of the storm, and associated factors (storm surge, rainfall, etc.); storms will have varying impacts on the landscape. Storm surges push salt water up onto the marsh, salty prairie, and even into the coastal prairie or forest woodlands. This in itself may or may not be devastating; depending on rainfall and the length of time salt stays inland. Sufficient rainfall will dilute the saltwater, flushing the salts back into the gulf. Without sufficient rainfall, the salt water will pool in shallow wetlands throughout the upper salt marsh, salty prairie, and even coastal prairie, killing vegetation and invertebrate populations that are not capable of sustained high salt conditions. Hurricane Ike was a good example of this drastic condition when the lack of rainfall immediately following the storm, and for months afterward, left rock salt-size crystals lying in dry pond bottoms. The Complex may try to capture and store storm surge water temporarily in freshwater wetlands to control cattail, phragmites, and California bulrush. The primary impact of wind to the natural habitat is to woodlands and bottomland hardwood forests. Even Category 1 force winds like those

of Hurricane Ike can break and blow down smaller trees and may up root larger trees if the soil is saturated.

3.3.1.4 Historical Habitat Description

Bottomlands in the early 1800s were typically composed of mature hardwoods. References also include the description of the forest as the "cane-break forest," describing the immense stands of native cane growing under the canopy. Many bottomlands have now been cut over and cleared and others have thick under stories resulting from timber cutting or various soil disturbances, or are relatively open due to continuous grazing. According to written accounts from early explorers and settlers in the 1800s, white-tailed deer, wild turkey, bison, black bear, squirrel, mountain lion, and red wolf were once common.

The Coastal Prairie of Texas is a tall-grass prairie similar in many ways to the tall-grass prairie of the Great Plains. The Service estimates that, in pre-settlement times, there were 9 million acres of Coastal Prairie, of which 6.5 million acres were in Texas. Today, less than one percent of the Coastal Prairie remains. Nearly 1,000 plant species were known to once occur in the vast Coastal Prairie, but no one knows how many species have followed the prairie vole and the Louisiana Indian paintbrush to extinction. The Coastal Prairie, historically, was home to herds of bison and pronghorn antelope, and red wolves roamed among the riverine forests that crisscrossed the area. The Coastal Prairie and its adjacent marsh habitat provide immense space for waterfowl and other forms of wildlife. Even in its altered state, Coastal Prairies routinely host more red-tailed hawks, northern harriers, white ibises, and white-faced ibises than any other region in the country.

Factors such as soil type and rainfall contribute to the formation of a prairie but fire is the natural mechanism by which prairie reverts to an early successional stage. Fire prevents woody plants from establishing, stimulates seed germination, replenishes nutrients, and allows light to mar young leaves. Historically, lightning strikes caused prairie fires to occur in the summer, and the fires, along with drought and competition from herbaceous plants, prevented the establishment of woody plants and remained a grass-dominated ecosystem. Across the landscape, much of the historic prairie has been converted to improved pasture for cattle grazing, the farming of rice, sugarcane, forage, and grain crops. Much of the Coastal Prairie that remains in Texas exists because it was used as pastureland for cattle production and never plowed. Overgrazing caused the loss of many herbaceous species. Continued threats to what remains of the Coastal Prairie include conversion to agriculture and development, paving, and now face overgrazing or becoming overgrown with shrubs due to fire suppression. Private ownership accounts for most Coastal Prairie remnants, with only a small percentage preserved by agencies or organizations.

3.3.1.5 Estimated Future Habitat Conditions due to Climate Change

The Service assessed future wetland conditions spatially by modeling sea level inundation rates resulting from predicted SLR from 2010 to 2100. They derived low and high estimates of SLR used in the inundation model by combining two SLR prediction models for the region. Results of the sea level inundation model were stored in a GIS and used to quantify

potential impacts to existing wetlands at decadal intervals from 2010 to 2100. Results of the 1938/44–2008 trends analysis showed a significant increase of inflow through (tidally influenced) wetland acres across the Complex. Results of the future conditions analysis predict that SLR will significantly alter or displace the majority of wetlands across the Complex between 2020 (71.03 percent of current wetland acres) and 2050 (87.10 percent of current wetland acres).

Results of the 1938/44–2008 wetlands trends analysis tend to indicate subsidence and/or SLR had been occurring across the Complex prior to the significant impacts of climate change scientists predict today. The increase in the area of flow through wetland basins from 2872.79 (1938/44) acres to 4593.34 (2008) acres is an indication that the coastal wetlands of the Complex have already been impacted by SLR to some degree. In addition to SLR, many climate change studies predict changes to tropical storm events, precipitation rates, and temperature levels at rates that can impact habitat conditions and distributions along the Gulf Coast. Combined with SLR, it is likely that tropical storm events will accelerate wetland impacts across the Complex by increasing wave action and erosion rates that will compound the conversion of coastal salt marsh to open bays. Changes in precipitation amounts and runoff may also impact wetlands. A decrease in freshwater inputs to coastal wetland systems resulting from reduced rainfall and increased upstream water usage from agriculture, urban, and industrial use may increase salinity rates and reduce sediment inputs to coastal wetland systems. Compounding this likelihood is a predicted temperature increase of >3º F (HadCM2) to >7º F (CGCM2), which could increase the annual surface water evaporation rates by more than a foot (Fang and Stefan, 1999), further decreasing freshwater inputs and increasing salinity rates.

In response to past episodes in SLR, coastal wetlands have responded by migrating to adjacent uplands or building additional substrate to account for changes in water depth. Following this scenario, it is unlikely that impacts to coastal wetland systems would be significant in a period of accelerated climate change. However, where development of new wetlands does not coincide with current land use practices or urban extent, wetlands development is likely to be impacted (Cahoon et al., 1999). Using the results of the high inundation model, the Complex is predicted to lose 37,926 acres (35.93 percent of total area) to open bay (seawater) conversion by 2100. This will eliminate 89.68 percent of the current wetlands on the Complex. While San Bernard and Brazoria NWRs will still contain a substantial portion of the upland land mass, it is not known if these areas are suitable for future wetland development or if the wetlands developed there would function at a level where productivity would offset predicted losses. The Complex may need to purchase additional lands suitable for inland wetland development to offset predicted wetland loss.

The Complex will use the results of this report and accompanying data as a refuge-scale decision support tool and incorporate them into existing land management actions, habitat protection, and land acquisition planning efforts. The Complex will also apply data to existing ancillary datasets to address additional management questions.

3.3.1.6 Concerns Regarding Refuge Habitat

Invasive Plant Species

Dozens of non-native invasive plant species occur on the Complex, including Chinese tallow tree, macartney rose, water hyacinth, privet (*Ligustrum spp.*), salt cedar, trifoliate orange, and deep-rooted sedge. Many are very aggressive and have habitat changing characteristics. The Complex's efforts to control these species are discussed in section 3.6.2. Chinese tallow is prevalent in forest, woodland, prairie and freshwater wetlands. This quick growing tree can quickly establish monoculture stands when left unchecked. It quickly establishes itself in disturbed areas, along right-of-ways and fence lines. Much of the restoration activities on the refuge include removal of Chinese tallow. Treatments include aerial spraying on open prairies or monoculture stands, foliar and basal bark spraying in bottomlands. Macartney rose is more isolated to just several problem areas including parts of the Brazoria prairie, Eagle Nest Lake pastures and farm fields, and the Janks tract of Hudson Woods. Treatments include aerial spraying on prairies in association with tallow or individual foliar application. Water hyacinth is can be found in several freshwater wetlands in the bottomlands; including Scobey Lake, Big Pond, and Bird Pond. Irregular (2 to 3 years intervals) herbicide applications seem to keep it in check. Privet is generally scattered in many of the bottomland units, but prevalent population are found on Dance Bayou and Halls Bayou Units and Carolyn Davies Easement. Deep-rooted sedge is a problem on pipeline right of ways in the bottomlands; particularly on Big Pond and Bird Pond and in the Buffalo Creek Unit prairie. Treatments are generally foliar application with a boom or wand sprayer. Salt cedar which had only slowly invaded from the core sites for more than 100 years has become a larger problem in the past five years. It aggressively invades dried ponds such as Wolfweed and Moccasin Pond at San Bernard NWR and Teal Pond at Brazoria NWR. Herbicide and mechanical removal are generally utilized for control salt cedar. Trifoliate orange can be found in isolated locations on many bottomland units but the largest densities occur on the McNeal, Bludworth and Stringfellow Units.

Loss of Salt Marsh Habitat

The loss of salt marsh habitat on the Complex is occurring due to both natural and man-made causes. Wind driven erosion along shorelines, including Salt Lake, Cow Trap Lake, Dressing Point Island, and Cox Lake are occurring at increasing rates. The GIWW has created the greatest change in coastal habitats over the past 75 years. The GIWW is now three to four times wider than when originally dredged. This equates to a direct loss of marsh habitat as well as opening up channels into once isolated wetlands. Vessel traffic along the GIWW creates wave action that continues to erode marsh habitat along the Texas Gulf Coast.

Native Invasives

Native plant communities have existed in concert with each other on the Complex for thousands of years. Each community benefits by a stable interaction with natural changes that allow them to occupy certain niches. European settlers disrupted this balance by manipulating plant communities through farming and grazing. Two primary disruptions by modern day settlement was the suppression of natural wildfires on the prairies and over-grazing by domestic ungulates. Both actions favored the encroachment of shrubs and trees

Chinese tallow is the most wide-spread invasive species across the refuges. It is a problem in and around all freshwater wetlands including ditches, wet prairie and bottomlands. Photo Credit: USFWS

Macartney rose is primarily associated with old field habitats that are being restored to native hardwood or prairie habitats. Photo Credit: USFWS

Salt cedar is becoming increasingly a problem to manage in freshwater wetlands, where it had not been seen previously, possibly due to extensive droughts lengthening periods when the wetland is dry. Photo Credit: USFWS

into the prairies. For example, periodic wildfires prevented woody species from expanding into open prairies. Prairie forbs have adapted by hastening their maturation within a growing season, thereby allowing them to disperse their seeds beyond the perimeters of a wildfire or by introduction into a prairie community after a fire has passed through. Historically, a grassland community would not have a large buildup of "fuels" because of periodic fires.

Therefore, the fires would not burn as hot and the grass would survive. The suppression of wildfires allows more buildup of dead grasses, producing more fuels for a hotter burn and increasing the chances that a grass species will not survive, therefore; allowing opportunities for woody species to establish. Similarly, the repeated overgrazing by domestic ungulates removes grass species and allows less palatable woody species to invade and thrive in an overgrazed community.

Presently, woody native species such as eastern baccharis and trees have occupied many niches on the coastal prairie where grasses and forbs once dominated. Reversing their dominance on the prairie requires extensive labor and costs by the Complex. With a consistent and determined plan of control or eradication, the Complex is succeeding in this endeavor through prescribed burning and mechanical and chemical treatments of woody plant species. The result is the reclamation of thousands of acres of coastal prairie.

Prescribed fire can effectively be utilized to control baccharus, but buring in September/early October provides the best opportunity for complete kill. Photo Credit: USFWS

Accelerated Climate Change

The majority of the coastal wetlands on the Complex are at very low elevations adjacent to or in proximity to the Gulf of Mexico and are susceptible to impacts by major storm events and long-term anthropogenic landscape alterations that can alter wetland function and development. Compounding these impacts is an anticipation of SLR resulting from global warming and accelerated climate change. Current estimates of SLR along the mid-Gulf Coast of Texas range between 8.4 inches to 19.2 inches by 2100 with an additional average subsidence rate of 4 inches over that period (Twilley et al., 2001). At present, it is unclear how such events will fully impact future management decisions and wildlife habitat conditions over time.

Anticipated habitat changes due to accelerated climate change include loss of marshes to open water, loss of prairie to marsh habitat, and even a loss of forest to prairie habitats. The same climate stressors that are impacting native habitat will also increase vulnerability to invasive species. Invasive species in general more easily adapt to changing conditions than native species.

Habitat Fragmentation
Habitat fragmentation occurs both on and off the refuges. Roads, utility corridors, development, pipelines, and the GIWW fragment natural habitats. In addition to significantly altering the landscape, these rights-of-way (ROW) enable the transport and introduction of invasive species, direct take of wildlife, and alteration of adjacent habitats increase light reaching the canopy floor and alters species composition. Oil and Gas operations have the potential of adding roads, pipelines and development into pristine areas. The Complex works with companies to reduce this fragmentation while preparing the Environmental Assessment and Operational Plan. Other ROW requests (common carrier pipelines, roads, utility lines) require Appropriate Use and Compatibility Determinations. Due to these policies no new pipeline right-of-ways have been constructed through bottomland habitats that have been acquired by the Service. Other sources of fragmentation include opening new public use areas (trails, roads, and infrastructure). These too, are addressed during planning with NEPA compliance.

Bottomland Conservation
The Service is nearing the 28,000-acre cap originally set in the deciding documents included in the Austin's Woods Conservation Plan. For 15 years, the Service has been working with partners to conserve bottomland forest working toward the 10 percent of historic forest conservation goal. Due to financial constraints, partner agencies and organizations have not been able to conserve as much lands as may have been originally hoped but rather have been able to support Service's acquisition program through donations. At the same time, remaining forests have been opened up and converted to residential development, open right-of-ways, and agriculture. In order to reach the conservation goal for this ecosystem to support migratory birds and resident wildlife, the Service is proposing an increase in the cap through preparation of a new LPP (see Appendix I).

3.3.2 Wildlife
The Complex supports a great diversity of wildlife, which is one of the most noticeable and outstanding features. The Complex is home to large populations of both resident and migratory wildlife, including more than 400 different wildlife species.

The Complex provides habitat for at least 305 breeding bird species, 52 species of mammals, 67 reptilian species, 24 amphibian species, 128 fish species, and countless invertebrates. These bottomland hardwood forests and prairies also support a large number of neotropical migrants during fall and spring migration. Appendix E provides a complete list of species.

3.3.2.1 Priority Species

The Complex provides habitat for a variety of rare and declining species, including listed (endangered or threatened), proposed, and candidate species, and other species of concern (SOC). Declines are often related to loss and fragmentation of suitable habitat, loss of food sources, increased disturbance, increased pollution, or increased predation.

Table 3-4 includes the listed species (state and federal endangered or threatened species) and refuge SOC that are known to occur or have potential habitat on the Complex. Species accounts for Federal and State listed species and Refuge Species of Concern (SOC) are provided below.

Table 3-4. Listed Endangered and Threatened Species with potential to occur on or adjacent to the Complex and Refuge Species of Concern.

American peregrine falcon	*Falco peregrinus anatum*	DL	T	
Northern aplomado falcon	*Falco femoralis septentrionalis*	E	E	
Attwater's prairie-chicken	*Tympanuchus cupido attwateri*	E	E	
Bald eagle	*Haliaeetus leucocephalus*	DL	T	SOC
Brown pelican	*Pelecanus occidentalis*	DL	E	SOC
Interior least tern	*Sterna antillarum athalassos*	E		
Piping plover	*Charadrius melodus*	E	E	SOC
Reddish egret	*Egretta rufescens*		T	SOC
White-faced ibis	*Plegadis chihi*		T	SOC
White-tailed hawk	*Buteo albicaudatus*		T	SOC
Whooping crane	*Grus americana*	E	E	
Wood stork	*Mycteria americana*		T	
Sprague's pipit	*Anthus spragueii*	C		
Black rail	*Rallus jamaicensis*			SOC
Yellow rail	*Coturnicops noveboracensis*			SOC
Henslow's sparrow	*Ammodramus henslowii*			SOC
Leconte's sparrow	*Ammodramus leconteii*			SOC
Mottled duck	*Anas fulvigula*			SOC
Painted bunting	*Passerina ciris*			SOC
Dickcissel	*Spiza americana*			SOC
Seaside sparrow	*Ammodramus maritimus*			SOC
Swainson's warbler	*Limnothlypis swainsonii*			SOC
Red knot	*Calidris canutus*	C		SOC
Wilson's plover	*Charadrius wilsonia*			SOC

Species				
Snowy plover	*Charadrius nivosus*			SOC
Black skimmer	*Rynchops niger*			SOC
Loggerhead shrike	*Lanius ludovicianus*			SOC
Northern bobwhite	*Colinus virginianus*			SOC
Swallow-tailed kite	*Elanoides forficatus*			SOC
Sharpnose shiner	*Notropis oxyrhynchus*			
Blue sucker	*Cycleptus elongatus*		T	
Smalltooth sawfish	*Pristis pectinata*	E	E	
False spike mussel	*Quadrula mitchelli*		T	
Smooth pimpleback	*Quadrula houstonensis*		T	
Texas fawnsfoot	*Truncilla macrodon*		T	
Texas pimpleback	*Quadrula petrina*		T	
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	E	E	
Green sea turtle	*Chelonia mydas*	T	T	
Kemp's ridley sea turtle	*Lepidochelys kempii*	E	E	
Leatherback sea turtle	*Dermochelys coriacea*	E	E	
Loggerhead sea turtle	*Caretta caretta*	T	T	
Texas scarlet snake	*Cemophora coccinea lineri*		T	
Diamond-backed terrapin	*Malaclemys terrapin littoralis*			SOC
Timber/Canebrake rattlesnake	*Crotalus horridus*		T	SOC
Salt marsh snake	*Nerodia clarkia*			SOC

"DL"=de-listed, "E"=endangered, "T"=threatened, "SOC"=species of concern.

Threatened and Endangered Species

The purpose of the Endangered Species Act is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species.

Under the law, species may be listed as either "endangered" or "threatened." Endangered means a species is in danger of extinction throughout all or a significant portion of its range. Threatened means a species is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened.

The Complex knows the following federally-listed, endangered/threatened species occur or have potential habitat on the refuge:

Attwater's Prairie Chicken
Historically, Attwater's prairie-chickens are found throughout the coastal prairies of Texas; however, only three isolated populations remain. Although not currently occurring on the Complex, several areas have been identified as potential future reintroduction sites. Uniquely situated southwest of the Texas City Prairie population and southeast of the Attwater Prairie Chicken NWR, the Complex may provide an essential link between the populations south of the Houston Metro Area.

Restoration of native prairie is an essential first step in preparing for the reintroduction of Attwater prairie chickens. Although the Attwater Prairie Chicken Recovery Team previously identified Brazoria NWR as a potential reintroduction site, the Complex needs to evaluate current management practices, including rotational burning, lack of grazing, and haying in terms of providing appropriate prairie chicken habitat. The interior prairies associated with bottomland units may be better potential reintroduction locations than Brazoria NWR. These prairies are not as exposed to tropical events and are more similar to the inland prairie at the Attwater Prairie Chicken NWR.

Northern Aplomado Falcon
The northern aplomado falcon is a subspecies of the aplomado falcon that inhabits lowland neotropical savannas, coastal prairies, and higher-elevation grasslands from the southwestern United States south to Tierra del Fuego. The northern subspecies was originally documented in the United States at six general localities in southeastern Arizona, south-central New Mexico, western Texas, and the lower Texas coast. The northern subspecies prefers coastal prairies and desert grasslands with scattered yuccas and mesquites. They also utilize oak woodlands and riparian gallery forests in midst of desert grassland. Aplomado falcons nest in bromeliads or abandoned stick platforms of corvids and other raptors or artifical structures. From 1996 to 1999, northern aplomodo falcons were hacked on Matagorda Island and are continuing to nest and inhabit the Island's prairie habitat. Since then, two documented sightings of aplomado falcons have occurred on San Bernard NWR; the most recent in December 2011. Both sightings appear to be single transient birds. If the population were to increase the refuges may provide future nesting habitats. No directed management actions for this species are planned at this time.

Whooping Crane
Whooping cranes do not regularly occur on the Complex. However, for the cranes to reach recovery status, the Aransas/Wood Buffalo population will need to expand. The tidal marsh areas of the Complex will be required for the cranes to reach recovery status for delisting. Because plans to expand their territory outside the current migration corridor have not been

well defined, the Complex does not yet have management or monitoring plans specific to providing whooping crane habitat at this time. In the mean time, the Complex will manage the native coastal marshes insuring hydrological integrity, native species diversity and protect existing marshes from degradation due to erosion, subsidence, and rising sea-levels.

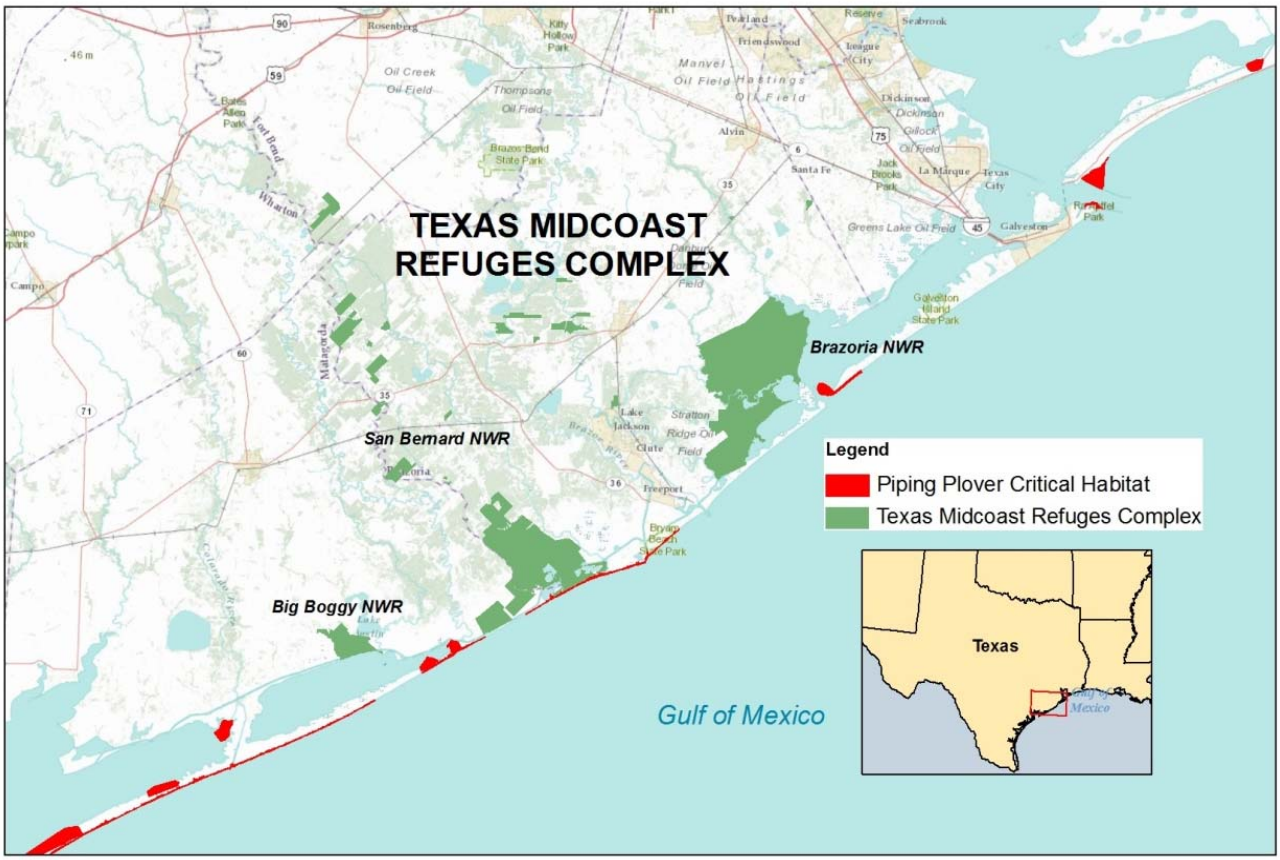
Interior Least Tern

The interior subspecies of least tern is a listed species for Fort Bend and Wharton Counties. This species is distinguished from the coastal subspecies in its location of nesting, along rivers and mudflats on the interior middle North America. For this reason, nesting birds identified more than 50 miles from the coast are considered interior subspecies. These birds cannot be easily distinguished from coastal least terns and overlap migration and wintering areas. No documented nesting occurs in either Fort Bend or Wharton County and birds found are wintering or transient. No directed management actions for this species are planned at this time.

Piping Plover

Breeding piping plovers are not know to occur on the Texas Gulf Coast (Haig and Elliott-Smith 2004); however, our coastal habitat is very valuable as a wintering area. Individuals typically arrive here July through November and most have left for the breeding grounds by mid-May (Haig and Elliott-Smith 2004).

Figure 3-6. Designated Critical Habitat for Wintering Piping



The tidal mudflats on the Complex, especially in the Cedar Lakes area of San Bernard NWR, are extremely valuable to this and other plovers when tides are low. The critical habitat designation does not clearly identify these mudflats, but they are at times more valuable to this species than the nearby beaches. Research shows that they prefer the bayside mudflats to the beaches periodically (Haig and Elliott-Smith 2004). The map below shows critical habitat areas near or adjacent to the Complex. For each area, the Complex considers the beach and adjacent "wind tidal flats" critical habitat.

Smalltooth Sawfish

The U.S. population of smalltooth sawfish is found only in the Atlantic Ocean and Gulf of Mexico. Historically, the U.S. population was common throughout the Gulf of Mexico from Texas to Florida, and along the east coast from Florida to Cape Hatteras. The current range of this species has contracted to peninsular Florida, and smalltooth sawfish are relatively common only in the Everglades region at the southern tip of the state. The loss of juvenile habitat, namely mangroves and other shallow water habitats, is thought to be a primary reason for the species' decline. Because the species generally requires marine habitats, which are outside of the Complex boundaries, the refuges cannot play a direct role in the species recovery. However, the Complex can assist with outreach and partnering with state and federal entities to encourage habitat protection.

Sea Turtle Species

Five sea turtles—Kemp's ridley, loggerhead, green, leatherback, and hawksbill—occur in the gulf and bay waters near the Complex. San Bernard NWR, which has a small segment of gulf beach, had one documented Kemp's ridley nest in 2009. The Complex continues to restrict refuge beaches from vehicular traffic to protect this and other turtle species. The Complex supports all sea turtle recovery efforts by patrolling area beaches for stranding and nests. The Complex excavates and transfers all nests to the incubation site at Padre Island National Seashore, and transfers live turtles to the NOAA recovery facility in Galveston.

Candidate Species

Candidate species are those species for which the Service has enough information to warrant proposing them for listing as threatened or endangered, but these species have not yet been proposed for listing due to other higher priority listing activities. The Service works with States and private partners to carryout conservation actions for candidate species to prevent their further decline and possibly eliminate the need to list them as endangered or threatened.

Sprague's Pipit

Sprague's pipet is known to occur in Brazoria, Fort Bend, Matagorda, and Wharton counties. It is associated with native coastal prairie and salty prairie habitats on the Complex similar to the American pipit. It prefers shorter prairie or prairie patches among denser or more mature prairie stands. It does not tolerate brush encroachment in prairie habitats (Robbins et.al. 1999). It can be found in post-burn areas. The species is a wintering migrant, feeding on insects spiders and some seeds, and may be found on the refuges October through March. Prescribed burning to reduce shrub encroachment as well as residual grass cover and reduce or restrict invasion of exotic plants is the preferred method of prairie management. Grazing to reduce residual grass cover, stimulate growth of native plants and prevent or slow invasion

of exotic plants may be employed as well but can be detrimental if not appropriately managed.

Red Knot

The red knot occurs in Brazoria and Matagorda counties mainly September through April. Small numbers oversummer (Eubanks et al. 2006). It mainly rests and forages along beaches, where it is seen eating *Donax* during both spring and fall migration. However, on one occasion during fall migration a small group was observed on tidal mud flats at Cedar Lakes, on the bay side of the dune lines. San Bernard and Sargent Beaches and Cedar Lakes Pass ("the cut") harbor knots during migration and for the winter. Significant numbers of first-year birds were noted on San Bernard and Sargent Beaches in June 2012 (J Wilson personal observation). It is possible that these non-breeding individuals summered at this location (D. Newstead, personal communication). The habitat types in which this species occurs receive little management. It would benefit from policies that limit vehicle disturbance on beaches and intertidal locations in Cedar Lakes. When its potential habitat is included, it should be considered in reviews of any activities that could impact potential habitat, such as oil and gas operations.

During the summer of 2011, large **numbers of red knots were found feeding on the San Bernard beach. Photo Credit: USFWS**

Other Species of Concern

The Complex's SOC list was established based on the TPWD's Comprehensive Wildlife Conservation Strategy, the state and federal endangered/threatened species list, and consideration of how Complex management activities, or the activities of others, may impact potentially sensitive species that have no state or federal status.

Bald Eagle

There are at least six active bald eagle nests in Brazoria County. These are primarily located on private land, however one historic nest is located on the Eagle Easement. This pair of birds have recently abandoned this historic nest tree and moved to a nearby tree along the forest edge on private land. Nests are generally located in mature trees however, they are often at forest edges or in pastures where canopy and mid-story underbrush have been removed.

It should be noted that over half of nest departures result in the young being tended on the ground until they can fly. This puts them at a disadvantage regarding predators. Thick vegetation on the ground beneath the nest can result in the adults not tending the young. When fledglings are flight-capable, they can remain with the adults for 1–2.5 months. At this time, they begin a roaming period that will last 4 years. These birds normally breed at age 5 years, but can start sooner or later depending on how much competition is present. Lifespan is roughly 30 years (Buehler 2000). At the Eagle Easement, fledglings normally leave the nest site by the end of May.

White-tailed Hawk

White-tailed hawks are year-round residents. Successful nesting territories have 40 percent or less shrub cover (sometimes up to 75 percent) and are interspersed with potential nesting sites, trees, or shrubs that offer nesting substrates approximately 9 feet from the ground (Farquhar 1992).

This raptor is associated with open grasslands with little woody cover, but needs shrubs for nesting substrates. Nesting territories become established in December, and take at least a month to build a nest; the Complex expects nesting activities to continue until at least mid-May. They will not re-nest following nest failures later than the incubation stage and will abandon due to human disturbance. They commonly leave the nest when people come within 547 yards or less. Pesticide applications may be particularly detrimental to this species.

This raptor's status and its narrow nesting range, coupled with the tendency for suitable nesting habitat off the Complex to be overgrazed, are justifications for considering nest sites in land management planning. Pairs are present typically near Mottled Duck Marsh at Brazoria NWR and in the interior of San Bernard NWR off Rail Pond Road.

Gulf Coast Salt Marsh Snake

Gulf coast salt marsh snakes have a very narrow range along the Texas Gulf Coast, extending from the Sabine River to Corpus Christi (Werler and Dixon 2000). Populations are supported at all three refuges in coastal prairie, salty prairie, and lower salt marsh, as well as in moist soil units and freshwater marsh habitats. This snake has sharply declined in association with habitat loss and degradation, making refuges and other conservation areas its last stronghold.

Gulf Coast salt marsh snakes have been seen near water in upland prairie and salt marsh habitats. Photo Credit: Charlie Brower

Seaside Sparrow
Oberholser (1974) describes a steady loss of habitat for this species on the Texas Gulf Coast beginning with WWII; in 1974 he listed only Chenier Plains, Texas Mid-coast, and Aransas NWRs as offering a stronghold for this species. Nesting occurs on the Texas Gulf Coast any time between early April and late July (Oberholser 1974), so this species benefits from the Complex's current policy of not burning grasslands in this timeframe. At least one full season is needed for this sparrow to return and use burned habitat following prescription. Seaside sparrows exhibit strong nest site fidelity (Post, 1974), have a social monogamous reproductive strategy, and both male and female share parental care. They have a restricted range inhabiting marshes only along the Atlantic and Gulf coasts. Seaside sparrows are habitat specialists, spending their entire life cycle in tidal marshes (Robins 1983). They forage in shallow muddy areas of the marsh along the banks of ponds, and by gleaning prey off of tidal marsh vegetation. Their main prey consists of adult and larval insects, spiders and their egg cases, and amphipods (Post and Greenlaw 2009).

LeConte's Sparrow
Grassland birds are in decline over much of their range in North America. LeConte's sparrow is one of the most secretive grassland birds. Given their secretive behavior, historic changes in their status and distribution are poorly understood. Wetland drainage probably caused declines in some populations, but since this species also breeds in upland grasslands, their overall populations may not have been reduced to the same extent as species restricted wetlands. Additionally, populations are known to experience considerable annual fluctuations in abundance in portions of their range, becoming most numerous during wet years (Stewart 1975). These fluctuations tend to obscure long-term population trends.

LeConte's sparrows are generally recorded in small numbers from Texas and Oklahoma across the southeastern U.S. and northward along the middle Mississippi Valley to southern Illinois. This species has a very narrow wintering and breeding range (Lowther 2005), occurring on the Complex as a wintering migrant; it may appear during early fall migration and be noted as late as March or April. Baldwin (2005) expressed management concerns due to this species' tendency toward within-season site fidelity. Prescribed burns on the Complex are necessary to remove brush cover, thatch, and maintain grassland prairies. However, applying these burns during the dormant season to large blocks of habitat without leaving behind adjacent, similar habitat will leave these birds with no options for the rest of the season (Baldwin 2005). The Complex implements a burn-rotation strategy that produces a mosaic of different-aged grasslands and provide adjacent habitat next to areas burned in late fall and winter. Growing season burns conducted in August and September will eliminate the possibility of evicting winter grassland birds from their home ranges, which is believed to increase mortality (Thatcher et al. 2006). Baldwin (2005) also determined a greater density of this sparrow at Brazoria NWR two years post burn. This age post burn correlates with "relatively medium non-woody vegetation density."

Henslow's Sparrow
The Henslow's sparrow has a very narrow wintering and breeding range. On the Complex this species is a wintering migrant; it may appear during early fall migration (October) and may remain as late as March or April. Interestingly, in 1973, this sparrow was well

documented in Harris County, Texas, as a nesting species, with fledged juveniles resulting (Oberholser 1974). This is the only known account of nesting by this species in the southern United States.

The Henslow's sparrow is considered to be the sparrow most in peril. Like LeConte's sparrow, this species shows within-season site fidelity. Local birders that have followed this species in our vicinity comment that they most frequently observe it wintering in tall grass prairie infiltrated by saplings and baccharis, and it is on the heavy side regarding leaf litter (Ron Weeks, personal communication, December 2010).

Black Rail

The smallest of North America's rail species, it measures six inches in length. Population declines are likely attributable to increasing development in coastal areas that has resulted in habitat loss and degradation of breeding areas. The biggest threat may be yet to come if sea levels rise as a result of climate change. Climate change model predictions suggest that the low-lying habitat of this species will likely be among the first areas inundated (http://www.dec.ny.gov/animals/).

The black rail has a very narrow wintering and breeding range. They are present on the Complex year round. Oberholser (1974) relays former Brazoria NWR manager Fleetwood's 1969 and 1970 documentation of nests with eggs for this species at Brazoria NWR. Some of the birds present on the Complex during the wintering months likely leave to breed in more northerly locations (Eddleman et. al. 1994). Black rails nest on the higher ground portions of coastal salt and brackish marshes dominated by rushes, grasses, and sedges. A clutch of 6 to 10 buffy white eggs with brown spots is incubated for 16 to 20 days. Both sexes share incubation and brood rearing duties suggesting a monogamous relationship, but it is unknown whether the pair bond lasts longer than one breeding season.

Little is known about black rails, due to their secretive nature and rareness. Night surveys on the Complex have demonstrated their potential use of any salty prairie unit two years or more after the habitat has been burned. They also occur in coastal prairie habitats. As these birds are cover-dependent, managing in a mosaic of different-aged units will be highly beneficial ensuring that suitable, dense habitat is always available on the Complex. Leaving nearby, similar habitat is also appropriate for this species, as cover is needed for survival and long treks in the open, leaves them vulnerable to predation. Their reluctance to flush from cover and their lack of vertical lift leaves them highly vulnerable to disturbance, including refuge management activities such as burning or mowing. To minimize potential impacts the Complex assumes suitable habitat is occupied and implements management activities accordingly (see section 3.6.2).

Yellow Rail

Yellow rails occur on the Complex as a migratory stopover and wintering species only. Wintering yellos rails have be recorded to arrive as early ast September 12 (2006 observation) and stay as late as early May (Given 2005).

These birds are very secretive in nature and will not flush unless forced to do so. Often they escape disturbances by running on the ground. However, they will sometimes "hunker down" in an attempt to let a disturbance event pass them by. Oberholser (1974) reports the death of many yellow rails by hay mowers due to the birds' hesitance to flush from cover. Similar to black rails, these birds are cover-dependent and are vulnerable to disturbance. Managing the Complex in a mosaic of different-aged units is highly beneficial, ensuring that suitable, dense habitat is always available. Leaving nearby, similar habitat is also appropriate for this species, as cover is needed for survival and long treks in the open, leaves them vulnerable to predation.

Wintering yellow rails along with mottled ducks and black rails are priority species that benefit from managed salty prairie which provides hiding ground cover, invertebrates for food and minimal brush cover. Photo Credit: USFWS

Mottled Duck

The mottled duck is one of only four nesting duck species found on the Texas Gulf Coast. This species does not regularly migrate between a wintering and breeding range; it spends its entire life cycle in the wetlands of the Gulf Coast from Mexico to Florida with the ducks of the western Gulf Coast not documented as breeding with those of the Florida coast (Haukos et. al. 2004). Waterfowl management professionals are concerned over the status of the mottled duck as available long-term data suggest a declining trend in Texas and a stable population trend in Louisiana.

Stutzenbaker (1988) documented a 36 percent decline for this species in Texas and Louisiana from 1971–1983. Between 1986 and 2004, Haukos et. al. (2004) report a decrease in numbers on Texas national wildlife refuges of 88.6 percent. He also reports decreasing female survivorship from 1997–2004 for ducks banded on Texas coastal refuges.

Texas refuges designated this species a priority for CCPs and the GCJV Mottled Duck Conservation Plan calls for conservation planning efforts on public and private lands. Mottled ducks are likely constrained by habitat availability; thus it is vital that we consider the habitat needs of this species in our management planning. Although placed in a variety of salt marsh vegetation (gulf cordgrass, marshhay, *Scirpus*, and mixes of these plants), gulf cordgrass is the most common (Merrit, K., 1981, and FWS 1982). Mottled ducks also use upland bluestem prairie sites. In nesting areas with both heavy and thin vegetation densities, ducks choose the heaviest, highest clumps of vegetation available for situating their nests.

Ideal nest sites are thus in heavy, tall cover within, but not limited to, a little over a mile from water (Stutzenbaker 1988).

As this species is dependent upon relative cover for nesting, managing in a mosaic of different-aged units across the landscape, the Complex ensures that this species has available nesting habitat. In years with heavy rainfall, these ducks can initiate nests as early as late January.

Painted Bunting

The painted bunting is a breeding species found on the Atlantic and western Gulf Coast and the central U.S. This bunting is a nesting species on our Complex, present from March–September.

Habitat loss has thrown populations into sharp decline, prompting the inclusion of this species on the Partners in Flight Watchlist (Lowther et. al. 1999). This bird uses grasslands with light shrub or tree components, including the upper reaches of the Complex's salt marshes and coastal prairies. It is sensitive to management actions during the nesting season, March–July. Management activities such as prescribed burning and mowing are timed to minimize disturbance during the breeding season. Management actions are also implemented in a manner that produces a mosaic of habitat, which is beneficial to this species.

Dickcissel

The dickcissel is a breeding species found chiefly in the central United States. This bird is a nesting species on our Complex, present from March–September. Habitat loss has thrown populations into sharp decline in the periphery of the dickcissel's range, including Texas. This bird uses salty prairie or coastal prairie grasslands with light shrub or tree components, a high density of forbs, grass heights of 4.9 feet or more and relatively thick thatch (1.9–5.9 in. deep). This species is sensitive to activities during the nesting season, March–July. Timing burns and mowing activities to maximize reproductive opportunities and distributing these activities in a mosaic fashion will benefit this species.

Diamondback Terrapin

Seven subspecies of diamondback terrapins are known to occur in the U.S. Our diamondback terrapin subspecies is found in coastal brackish waters from Mexico to Louisiana (Hogan 2003). In recent years, visitors observed this terrapin on our Complex at Cedar Lakes (San Bernard NWR) and Wolf Lake (Brazoria NWR). It is likely to occur in other areas. Recently, this species was well documented in Galveston Bay, a short distance from likely terrapin habitat along the east shoreline of Brazoria NWR (Hogan 2003).

The diamondback terrapin is a state species of concern and TPWD proposes it for species of concern status at the federal level (TPWD 2005). Brazoria NWR's current ban on crabbing in the Salt Lake, Wolf Lake, and Nicks Lake areas is beneficial to this species, as is annual participation in the state's crab trap removal program. Terrapins would benefit from having additional areas closed to crabbing. Some consider terrapins a delicacy. Presently, there is no harvest limit at all on this species and fishermen can remove all captured in crab traps from refuges if we do not regulate these activities that lead to their capture.

Reddish Egret
Reddish egrets are strictly coastal in habitat choice and have the narrowest distribution of any of the herons found in Texas. The Gulf Coast hosts some individuals for the wintering months, but most migrate to Central America and Mexico (Dyes 1993).

Two thousand pairs nest in the U.S.; 1,500 of those are on the Texas coastline (Lowther and Paul 2002). Dressing Point Island (Big Boggy NWR) is a Gulf Coast Joint Venture priority island for its high concentration of nesting reddish egret (average 19 pairs). Erosion of nesting islands used for rookeries threatens the local population. Several attempts to slow the erosion on Dressing Point Island have occurred over the past 20 years with limited success. The Cedar Lakes rookeries, which were man-made islands, continued to erode as well. Treatment of fire ants as needed and work to reduce acreage loss on these islands will benefit reddish egrets. Also of concern in refuge management activities are West Bay Bird Island and the Drum Bay colonies. Although these colonies are not under refuge ownership, these islands hold noteworthy numbers of reddish egrets which justify efforts for continuing to work toward their protection from human disturbance.

Swainson's Warbler
Swainson's warbler breeds in the coastal plains, alluvial floodplains, and mountains of the southeastern United States (Peters et. al. 2005). Belize, the Caribbean, and the Yucatan Peninsula are its wintering grounds (Brown and Dickson 1994). It's narrow distribution is part of the reason for conservation concerns for this species.

Current management of the bottomland hardwood forests to allow small, naturally forming, early successional tree gaps created by attrition of canopy trees is beneficial for this species. The current practice of prohibiting grazing is also beneficial, as grazing decimates the thick understory favored by this species. Although research indicates that even-aged stands of trees created by clear-cutting are useful for Swainson's warblers (Peters et. al. 2005), refuge units are so small, with high Chinese tallow invasions, that clear-cutting even small patches does not seem a viable management option for this bird. Swainson's warbler is sensitive to changes in hydrologic regime; therefore the Complex avoids projects with the potential to back up water into their habitat during the nesting season.

White-faced Ibis
White-faced ibis in Texas are found nesting near the Coast, where it selects shrubs, trees, and emergent vegetation in flooded freshwater marshes for constructing its platform nest. It also has been documented nesting on the ground in coastal rookeries of Louisiana and Texas, but its occurrence within colonies of this habitat is not annually consistent.

The white-faced ibis has nested on our coastal rookeries in the past, especially Dressing Point Island. Why they discontinued nesting there and so many other areas along the coast is unknown. It is known these birds suffered diminished reproductive success due to DDT exposure in the U.S., and that they still come into contact with DDT when wintering in Mexico (Ryder and Manry 1994). Maintenance of quality nesting habitat at our colony sites for our assemblage of colonial nesters will ensure available habitat for them when they return again. The refuge needs to look at what is missing from area rookeries to support white-faced ibis

populations. This key may involve restoration of islands, vegetation control, or enhancement of appropriate vegetation as well as control of fire ants.

Wilson's Plover

Locally abundant on and adjacent to the complex, only 6,000 Wilson's Plovers are estimated on our continent (Corbat and Bergstrom 2000). It is present March through September with small numbers overwintering (Eubanks et al. 2006). This plover nests on beaches, bay shorelines and both sides of the GIWW. It is found on all local beaches including San Bernard and Sargent beaches. Its groundnesting habits and restriction to areas easily accessible by humans make disturbance and habitat impacts a concern for this species.

Snowy Plover

This plover frequently uses loose sand, sand dunes, and exposed substrates on tidal flats in the beach and bay habitats where it is encountered. It is present July through May, and small numbers may linger through the summer. It is a rare nester on our section of coastline (Eubanks et al. 2006), so summering individuals should be scrutinized for nesting activity. Invasive plants, human disturbance, and habitat loss and degradation are threats facing this plover species. Only 18,000 are estimated to breed in North America (Page et al. 2009).

American Oystercatcher

This large shorebird nests on shell or sand on either islands or mainland habitats of our beaches and bays. Nesting occurs in Chocolate, Bastrop, and Drum Bays at Brazoria NWR, in Cowtrap and Cedar Lakes at San Bernard NWR, and on Dressing Point Island and various shell hash islands in East Matagorda Bay. It is present throughout the year. Only 10,000 remained in North America in 2001. Current threats include sea level rise; habitat loss and degradation due to disturbance and development; food resource compromise due to invasives, pollution, and water quality changes; and increased predation due to human induced predator increases (American Oystercatcher Working Group et al. 2012).

The Service has been assisting Gulf Coast Bird Observatory with locating and monitoring American oystercatchers and their nests on and around the refuges. Photo Credit: USFWS

Black Skimmer
This large tern can be found on shell and sand stretches along bay shores or beaches. Just over 2,000 pairs nested on the Texas coast in 2001 (Eubanks 2006). Accurate estimates of the remaining continental population do not exist, but this species is declining in many locations. Disturbance and habitat loss and degradation are concerns (Gochfeld and Burger 1994), as is sea level rise. Colonies exist or have existed at Chocolate Bay, Bastrop Bay, Wolf Lake, San Luis Pass, Dow Chemical Company, Cedar Lakes, and Dressing Point in and near the Refuges.

Loggerhead Shrike
This bird of open grasslands is in sharp decline nationwide. Known threats include loss and degradation of habitat, changes in land utilization, chemical pest control, and nest site disturbance. Trees and shrubs with ample canopy scattered in large expanses of open area and absence of chemical application are correlated with the presence of this species in some portions of its range (Yosef 1996).

Northern Bobwhite
This species is found on the Complex in the salty prairie habitats and higher elevations. It is typically found in grasslands with both early or late successional cover, but needs overhead cover in the form of grass or hedgerows for concealment. Able to produce 25+ offspring in a successful nesting season, this short-lived species is most productive in Texas in successive years of above normal rainfall. Its populations are in decline throughout most of its range (Brennan 1999).

Swallow-tailed Kite
A coastal plain nester in the southeastern United States and increasingly common in east Texas, this kite is found during the nesting months on the Complex during some years. Two years ago Charlie and Olivia Brower documented recent fledglings at a location near Sweeny; the landowners indicated that Swallow-tailed kites had nested in that area previously. No observations have been made since the drought of 2011, but the recent nesting activity of this imperiled species warrants SOC status. The Swallow-tailed kite is area sensitive and affected by logging activity and human disturbance (Meyer 1995). In some parts of its range this kite uses premigration roost sites; these areas are protected in South Carolina. Complex staff should be on the lookout for roost sites and sightings of individual birds in the 4-county Columbia Bottomlands project area. The habitat protection and acquisition components of this project are highly favorable for this species. When reviewing projects that impact bottomland hardwood forests, Complex staff should consider habitat impacts for this species.

Canebrake (Timber) Rattlesnake
Timber rattlesnakes are forest dwellers native to the eastern United States and Canada. Prior to widespread extermination and habitat degradation, this snake's historical range in Texas included the forested eastern third of the state (TPWD 2005).

These snakes hibernate between early November and late March annually. Appropriate hibernation habitat is 10-30 cm beneath the surface of the ground (TPWD 2005), and includes areas like armadillo burrows, rotting logs and stumps, rotting tree roots that have become channelized, or in the case of our snakes at Big Pond, concrete slabs that have burrows beneath them, which all provide warmth.(Werler and Dixon 2000). The need to move to appropriate hibernacula makes fall a time of travel, the period when this snake is most active. Timber rattlers are genetically programmed to move along the same pathways used to reach a hibernaculum as their ancestors. The increase of roads throughout its range and the presence of roads near its denning sites is a cause for concern for this species. These snakes are vulnerable not only to direct extermination by humans but also indirect extermination via increasing forest fragmentation.

Timber rattlesnake observed at winter denning site on Big Pond Unit of San Bernard NWR. Photo Credit: USFWS

It is important that this site be protected and we continue to search for other den sites. The nearest known den site to the Big Pond location is near the town of Damon, Texas. Timber rattlesnakes have also been located on private property near the town of Iago, Texas, and on Stringfellow WMA.

3.3.2.2 Focal/Representative Species

The Migratory Bird Program Strategic Plan 2004-2014 identified 139 focal species or populations to increase the percent of migratory birds that are at healthy and sustainable levels. Focal species are a subset of priority species and represent larger guilds of species that use habitats in a similar fashion. Selecting priority species and from this a subset of focal species for Strategic Habitat Conservation (SHC) is outlined in the Strategic Habitat Conservation Technical Implementation Guide. As discussed in the Implementation Guide, the selection of a subset of species for full SHC adaptive management should strive to optimize landscape-scale conservation to benefit additional priority species and habitats within the landscape. It is important to consider the full species' range in assessing its landscape potential to extend management and conservation benefits to other priority species. Four basic scales of importance are evaluated in determining these species: 1) ecological significance of the species; 2) management significance of the species; 3) legal/policy mandate for the species; and 4) cost effectiveness and feasibility of managing the species. Focal species and their associated habitats will be included in the CCP's objectives and strategies to emphasize specific management efforts used to promote life history requirements of these species.

Table 3-5 Focal Species, Habitats, and Limiting Factors

Timber (Canebrake) rattlesnake	Bottomland Hardwood Forest	Hibernate between early November and late March 10–30 cm (4-12 inches) beneath the surface of the ground, and includes areas like armadillo burrows, rotting logs and stumps, and rotting tree roots.
Swainson's warbler	Bottomland Hardwood Forest	Nest on or near the ground. Favor small, naturally forming tree gaps created by attrition of canopy trees. Require thick herbaceous understory for nesting and cover.
Black rail	Upper Saline Marsh	Cover needs require ungrazed areas with completely closed grass canopy to shield from avian predators.
Seaside sparrow	Upper Saline Marsh	Require a mosaic of grassland for feeding and cover and combination of tall grasses such as cordgrass and low growing shrubs for nesting.
Reddish egret	Lower Saline Marsh	Healthy estuarine systems for foraging; nest sites free of disturbance and with natural or manmade barriers to prevent predation.
Yellow rail	Saline Prairie	Cover needs require closed grass canopy to shield from avian predators. Forage from the ground on invertebrates and seeds.
LeConte's sparrow	Upland Prairie	Cover and nesting needs require mosaic coastal to ensure stands of grass of various ages and size.
Henslow's sparrow	Upland Prairie	Mosaic coastal prairie with grass of various ages and size for cover and nesting. Wet topographic features with brushy component desirable
Dickcissel	Upland Prairie	Uses grasslands with light shrub or tree components, a high density of forbs, grass heights of 1.5 m (1.6 yards)(or more with thick thatch (5–15cm (2-6 inches)deep) for feeding and nesting. Ground nester.
Loggerhead shrike	Upland Prairie	Uses grassland with light shrub or tree components from which it scans for food from perches.
White-tailed hawk	Upland Prairie	Associated with open grasslands with little woody cover to feed, but needs shrubs for nesting substrates. Avoid grazed areas.
Northern bobwhite	Upland Prairie	Requires early successional habitats that can exist across wide variety of vegetation types. Will use moderately grazed prairie and prairie 1 year post burn.
Mottled duck	Freshwater Wetlands	Low saline marshes (<8 ppt) with <50 percent emergent vegetation to allow nesting, brood rearing and adult flight feather molt. Wetlands with emergent islands preferred for roosting.

3.3.2.3 Birds

Texas Gulf Coast is the primary wintering area for most of the Central Flyway waterfowl; utilizing both freshwater and saline habitats for feeding and shelter. Breeding waterbirds including mottled ducks, secretive marsh birds, and waders utilize coastal wetland and upland habitats as well. In addition, islands and islets provide nesting habitat for a large population of colonial water birds, while thousands of shorebirds use the beach and tidal mud flats. Inland, coastal prairie supports large populations of wintering songbirds and other grassland dependent resident species. Bottomland forests support large numbers of migrating nearctic-neotropical and wintering songbirds. The Complex lists 320 bird species which regularly utilize habitats during parts of their life cycles.

Grassland Dependent Species

Native coastal prairie grasslands on the Complex include a mosaic of upland bluestem dominated prairie, fresh water wet prairie, and coastal marsh (salty prairie). Noteworthy grassland bird species include the northern bobwhite quail, LeConte's sparrow, Henslow's sparrow, seaside sparrow, Sprague's pipit, dickcissel, eastern meadowlark, yellow rail, black rail, clapper rail, king rail, sora, and Virginia rail. Unfortunately, the loss of prairie habitat has affected many of these grassland bird species, making them a guild of birds with one of the fastest rates of decline. About 48 percent of these species are of conservation concern and 55 percent are showing significant declines (NABCI, 2009).

Waterfowl

Waterfowl use on the Complex during the winter months occurs in salt marsh areas, bays adjacent to the Complex, and in actively managed moist-soil units. The Complex provides habitat for approximately 31 species of waterfowl. Brazoria NWR has a rice farming program that results in second-harvest rice fields being re-flooded to provide wintering habitat for waterfowl; mottled ducks, fulvous ducks and black-bellied whistling ducks use these fields heavily for several weeks after the first harvest. Habitat quality varies in the unmanaged natural habitats in accordance with annual rainfall; drought years produce poor habitat across a large-scale for waterfowl. Peak numbers of waterfowl occur in December and January. Some of the more common duck species that use the Complex include green-winged teal, blue-winged teal, gadwall, American widgeon, northern shoveler, ruddy duck, and northern pintail. Fulvous and black-bellied whistling ducks continue to use the Complex during the spring and summer months.

Shorebirds and Waterbirds

The Complex provides habitat for approximately 90 species of shorebirds and waterbirds. The rice farming program and moist-soil units aid shorebird and waterbird use during drier months. These species are also commonly seen using the salt marshes with their regularly exposed muddy substrates, and beaches. Some of the more common shorebirds and waterbirds seen on the Complex include great blue herons, great egrets, snowy egrets, black-necked stilts, greater yellowlegs, lesser yellowlegs, and short-billed dowitchers. Black-necked stilts nest in moist soil units and the salt marsh, and the Complex includes a number of colonial waterbird nesting sites within or adjacent to its boundary. Reddish egret, white

ibis, roseate spoonbill, black skimmer, and brown pelicans can be found throughout the Complex's wetlands.

Raptors
The Complex is also home to 12 species of raptors and owls; including white-tailed hawks, crested caracara, turkey, and black vultures, red-shouldered hawks, red-tailed hawks, and Mississippi kites, and barn, great horned and barred owls. In recent years, visitors commonly observed swallow-tailed kites near the Complex during the nesting months and credible reports exist of swallow-tailed kite fledglings, implying that they are becoming established as a nesting species. Wintering raptors include the northern harrier, American kestrel, peregrine falcon, short-eared owl, and sharp-shinned hawk.

Perching Birds
The Complex provides habitat for approximately 90 species of perching birds. Perching birds are primarily grouped in terms of management into the grassland, bottomland, and marsh bird/perching bird species that use the Complex. They include loggerhead shrikes, yellow-billed cuckoos, common nighthawks, red-bellied woodpeckers, northern mockingbirds, scissor-tailed flycatchers, painted buntings, and numerous warbler and sparrow species.

3.3.2.4 Mammals

The Complex includes habitat suitable for approximately 52 species of mammals (Appendix E). Visitors frequently observe white-tailed deer, bobcat, coyote, raccoon, armadillo, skunk, and opossum. A greater abundance of wildlife may be observed near the heavily wooded areas of the Columbia Bottomlands. Of medium conservation concern status on the state's Comprehensive Action Plan that may be observed on the Complex are the river otter, long-tailed weasel, cougar, and Eastern spotted skunk. Rafinesque's big-eared bat is of high conservation status and is a state-threatened species that occur on the Complex.

Other not-so-welcomed species, like feral hogs, often represent a problem or challenge for the management of the refuge, particularly because uncontrolled rooting behavior destroys important habitat for other species of wildlife are readily observed throughout the Complex.

3.3.2.5 Reptiles

The Complex falls within the ranges of 67 reptilian species associated with coastal tallgrass prairie, marsh, and riparian habitats of the Texas Gulf Coast (Appendix E). Characteristic species of the Texas Gulf Coast include the American alligator, common snapping turtle, box turtle, red-eared slider, soft-shell turtle, water snake, western mud snake, rat snake, cottonmouth, and canebrake rattlesnake. Of high conservation status concern on the state's Conservation Action Plan are both the ornate box turtle and the three-toed box turtle that may be observed on the Complex. Of medium status are the map turtles, Kemp's ridley sea turtle, canebrake rattlesnake, and diamondback terrapin that also occur on the Complex.

3.3.2.6 Amphibians

The Complex lies within the ranges of 24 amphibian species associated with coastal tallgrass prairie, marsh, and riparian habitats of the Texas Gulf Coast (Appendix E). Characteristic species of the Texas Gulf Coast include the Gulf Coast toad, bullfrog, southern leopard frog, and green tree frog. Of medium conservation status on the state's Conservation Action Plan is the Southern crawfish frog that also occurs on the Complex.

3.3.2.7 Fish and Marine Life

The Complex lies within the ranges of 128 fish species associated with wetland areas of the Texas Gulf Coast (Appendix E). Tidal-inlet dependent fish species, including 20 species with commercial and recreational value, use refuge wetland and marshes for spawning, nursery, and rearing habitat. Generally, two categories of fish associated with the coastal marshes of this region include: (1) species directly dependent on coastal marshes and (2) species making opportunistic use of coastal marshes. The first category includes species such as shrimp, oyster, crabs, tidewater silversides, southern flounder, killifish (four species), striped mullet, white mullet, inland silverside, spot, pinfish and redfish, who have a well-established dependence on marsh vegetation. The second category includes near-shore and bay species such as gizzard shad, black drum, spotted seatrout, bay anchovy, silver perch, pigfish, Atlantic croaker, Atlantic and cownose rays, sea catfish, and sheepshead; shown to be seasonally common in coastal marshes as young or adults.

3.3.2.8 Invertebrates

There are a myriad of terrestrial and aquatic invertebrate species that occur throughout the uplands, rivers, creeks, and floodplains within the Complex; however, they are not well documented. Invertebrates serve as food for numerous other invertebrate and vertebrate species already discussed above. Dragonfly and butterfly species lists are included in Appendix E.

Invertebrates, like this Queen on a salt marsh aster, are an integral part of maintaining healthy ecosystems. Photo Credit: USFWS

3.3.2.9 Concerns Regarding Wildlife Populations

Species of Concern
Documented population declines for Complex species of concern, coupled with expected loss of coastal habitats due to climate change necessitates the need for management actions throughout the Complex. Moist-soil units and prescribed fires are managed to provide habitat for many species of concern throughout the Complex.

The Complex's acquisition program is targeted to conserve bottomland hardwood forests, fresh and salt marsh habitats, and coastal prairie to offset population declines, habitat loss and the anticipated effects of climate change.

Invasive, Exotic, and Native Nuisance Species
Feral Hogs – Feral hogs are present in all habitats on the refuge. Dense stands of baccharis and groves of salt cedar or other trees in the main refuges are prime denning sites. An elevated feral hog population can adversely affect habitats and native animal populations by competing for food, transmitting disease, direct mortality, and damaging habitat through rooting. Their rooting of habitat opens the door for invasive plants, negatively impacting the surrounding environment.

Nutria - Nutria are present on the Complex, but not in large numbers. Sudden loss of nutria often correlates with increased use of the area by alligators.

Ants - Originally from South America, red imported fire ants (RIFAs) began to appear on the Texas coastal prairie landscape during the mid-1970s. Research documented the disruptive impacts of RIFA on native insect communities. It is hypothesized that invasive red imported fire ants have negatively impacted native prairie invertebrates, especially leaf hoppers. Studies have also documented negative impacts on a diverse group of bird species including loggerhead shrikes, northern bobwhites, and colonial waterbirds. However, it is also known that woodland habitats (such as the Columbia Bottomlands), typically hold few RIFA, and grasslands with good grass canopy (i.e., ungrazed ones) have fewer ant mounds than those that are managed for short grass height. Scientists will conduct further research to determine the significance of RIFA to the Complex.

Unfortunately, another invasive ant species found east of Houston, could potentially pose a major threat to local wildlife. Some ant experts consider Rasberry crazy ants to be worse than RIFA and have the potential to destroy biodiversity further. Unfortunately, the Complex knows little about their biology. Masses of Rasberry crazy ants affect ground and tree nesting birds and have the potential to cause birds to die of asphyxia by obstructing their nasal passages. Texas A&M University ant experts have documented Rasberry crazy ants consuming carcasses of slow-moving animals such as snakes, but the exact cause of death was not established. The Gulf Coast Bird Observatory recently surveyed the Brazos River Unit of San Bernard NWR. Located within a mile of Brazoria County's largest and highly studied Rasberry crazy ant colony, the Gulf Coast Bird Observatory believes it lies in the path of dispersal and colony expansion. Surveys completed in summer 2010, revealed no evidence of their presence on the Complex.

3.4 Socioeconomic Environment

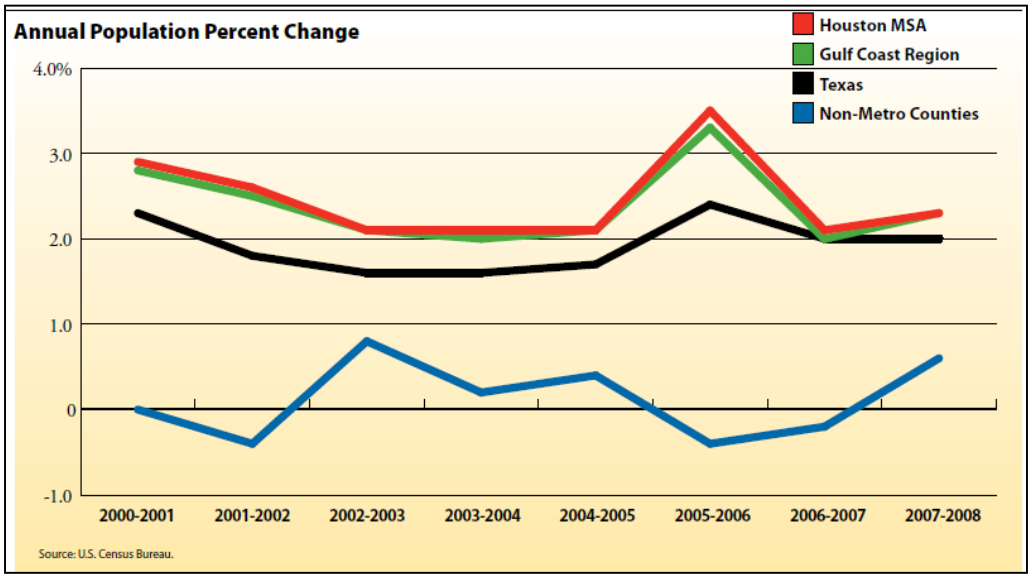
This section describes the socioeconomic environment of the communities surrounding the Complex. It includes a discussion of nearby human populations and economies; the archeological, cultural, and historical resources associated with the Complex; public use opportunities and access; and public use and the Service administrative facilities. It concludes with a short discussion about the Service's concerns pertaining to the socioeconomic environment.

3.4.1 Population

The Complex is located in the Texas Gulf Coast region, which consists of 13 counties. The counties include Austin, Brazoria, Chambers, Colorado, Fort Bend, Galveston, Harris, Liberty, Matagorda, Montgomery, Walker, Waller, and Wharton. Only four of these counties (Colorado, Matagorda, Walker, and Wharton) are not in the metropolitan statistical area (MSA) of Houston-Sugar Land-Baytown. The Houston-Sugar Land-Baytown MSA is the nation's fouth-largest metro area and the second largest in Texas with an estimated population of 6.3 million people in 2010. Figure 3-7 indicates the region's population rose by an estimated 20.8 percent between 2000 and 2008, led by strong growth in Fort Bend, Montgomery, and Brazoria counties (Susan Combs Texas Comptroller of Public Accounts, 2010).

Population change can be an indicator of economic vitality, the types of economic sectors that are likely to be strong, probable development and disturbance impacts on wildlife habitat, and trends in real estate markets. Table 3-6 shows population changes for all four counties between 2000 and 2010. Find additional U.S. Census data at http://www.census.gov/.

Figure 3-7. Annual Population Percent Change from 2000–2008



Source: Texas Comptroller of Public Accounts

Table 3-6 Focal Four County Population Changes 2000 to 2010

Brazoria	241,767	313,166	71,399	29.5%
Matagorda	37,957	36,702	-1,255	-3.3%
Fort Bend	354,452	585,375	230,923	65.1%
Wharton	41,188	41,280	92	.2%

Source: Bureau of the Census (2012)

3.4.2 Economy

3.4.2.1 Regional Economic Profile

The median income for all Texas households was $50,049 in 2008. The ten counties of the Houston-Sugar Land-Baytown MSA have the highest median household incomes in the region, ranging from $48,374 to $83,968 (Texas Comptroller of Public Accounts, 2009).

Table 3-7. Median Household Income by County

Brazoria	$65,607
Matagorda	$43,205
Fort Bend	$79,845
Wharton	$41,148

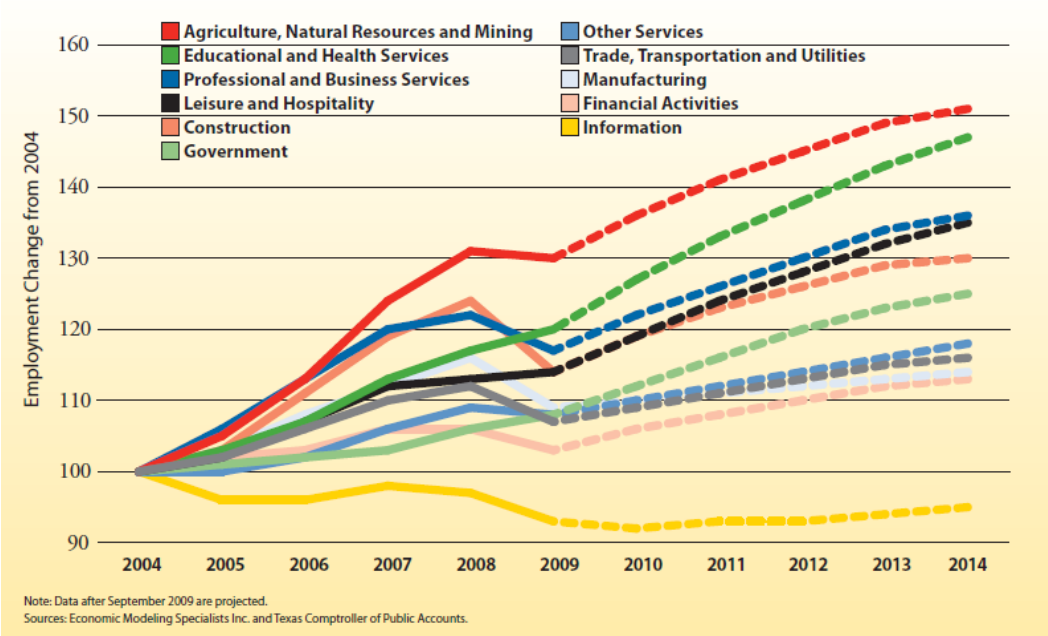
Source:US Census, 2010

The region's proximity to the Texas Coast makes the area a center for commerce, industry, and recreation. Ship and rail transport facilities support such industries as petroleum refineries, metals fabrication, plastics, and chemical plants. Available natural gas supplies, freshwater, distance from heavily populated areas, and the GIWW originally attracted these industries to the area. In 2009, the Gulf Coast region employers provided a total of 2.6 million jobs, representing nearly a quarter of the jobs in Texas (Texas Comptroller of Public Accounts, 2010). Figure 3-8 provides a picture of projected employment trends in the region. A vast majority of growth is due to new jobs in oil and gas well drilling, oil and gas extraction, and support activities.

Agriculture is a popular industry in this region because of its proximity to the coast. In 2008, the Gulf Coast Region produced crops, livestock, and other agricultural goods worth $1.69 billion (Texas Comptroller of Public Accounts, 2010). Rice crops in this in this region account for 79 percent of the total rice acreage in Texas. Matagorda County is one of the state's top three rice-producing counties. Also, Matagorda County produced 45 percent of the state's catfish sales and 40 percent of the state's total aquaculture sales (USDA Census of Agriculture, 2007).

Nature tourism rapidly developed as another industry particularly important to the refuge and the region's economy. Nature tourism is defined as "discretionary travel to natural areas that conserve the environmental, social, and cultural values while generating an economic benefit to the local community". Nature tourism includes such things as wildlife or bird watching, photography, nature study, hiking, boating, camping, biking, and visiting parks. Nature tourism also provides opportunities for communities to promote their cultural and ethnic diversity.

Figure 3-8. Gulf Coast Region Industrial Employment from 2004–2014.



Source: Texas State Comptroller of Public Accounts

3.4.2.2 Economic Significance of the Refuge

The socioeconomic impact of the Complex consists primarily of the contributions it makes to local retail trade in the form of equipment rental and purchases as well as in the purchase of services. The Complex also contributes to the area's socioeconomic well being through the salaries of its staff. Annual salaries totaling more than $2 million are currently paid to refuge employees, many of whom own homes and pay taxes in Matagorda and Brazoria Counties. In addition operational and project funds exceeding $600,000 also feed into the local economies.

Land acquired by the Service in fee title is removed from the county tax rolls. To help pay for lost tax revenues, the county receives an annual payment in lieu of taxes, as provided by the Refuge Revenue Sharing Act of 1935 (16 U.S.C. 7145:49 Stat. 383, as amended). Revenue funds are generated from all refuge fees and include grazing, haying, farming, special use permits, etc. If not enough generated revenues are available in the fund to make full payments; the Service distributes the funds proportionately nationwide. Congress is authorized to make up the difference. This has been the case since 1975. The 2010 Refuge Revenue Sharing payments were delivered to Brazoria and Matagorda and Fort Bend Counties. A total $70,683 was delivered to Brazoria County for Brazoria (44,245 acres) and San Bernard (36,844 acres) NWRs. A total of $5,659 was delivered to Matagorda County for San Bernard (6,566 acres) and Big Boggy (4,216 acres). A total $3,866 was delivered to Fort Bend County for San Bernard (1,828 acres). These payments were approximately 12 percent lower than the previous year's due to Federal Budget cuts. For 2009, the Complex's payments to Matagorda County was $8,032 for San Bernard (6,566 acres) and Big Boggy (4,216 acres) NWRs; Brazoria County's payment was $80,810 for Brazoria (44,245 acres) and San Bernard (36,199 acres) NWRs, and Fort Bend County's payment was $5,515 for San Bernard NWR (1,828 acres).

In addition, the Complex hosts a Migration Celebration in April every spring to provide an opportunity for visitors to become familiar with management actions and available resources to the general public. Visitors also come from all parts of the world to bird watch and recreate on the Complex, thus providing an economic stimulus to local towns through the use of hotels, gas stations, and restaurants.

3.4.2.3 Other Economic Uses

Cooperative Farming Program

The Cooperative Farming Program is not only an economic use of the Complex, but is also an important habitat management tool. Many cooperative farming programs on refuges grow crops as supplemental food sources for wildlife, such as migratory waterfowl. On Brazoria NWR, the program focuses on providing feeding and resting areas for migratory birds along with moist soil habitat improvements.

Haying

Where and when fire cannot be implemented haying becomes an option for removing fuel loads and promoting forb growth among. Although it does not recycle the nutrients the way fire does, haying can be an effective alternative management tool. Haying rights are provided at market value unimproved or native pasture rates.

3.5 Archeological, Cultural, and Historical Resources

Cultural Resources

Three basic prehistoric periods comprise southeast Texas prehistory: Paleo-Indian, Archaic, and Late Prehistoric. The Paleo-Indian period follows the last ice age in North America during the Pleistocene. The nomadic people who followed the migrations of mega-fauna, such as mammoth and mastodon, characterize this period. Small bands of hunters and gatherers who roamed in search of plants and animals characterize the Archaic period, which follows the extinction of the Pleistocene mega-fauna. During this time, the overall population increased as evident by a greater number of known archaeological sites.

The Texas Gulf Coast was historically home to several Native American nations and early European settlers. This region is also significant for its history in the spread and development of early American ranchers, pioneers, and especially oil prospectors. When Alvar Nunez Cabeza de Vaca shipwrecked along the Texas coast in 1528, he and three surviving shipmates became the first Spaniards to explore the territory that would become Texas (Chipman, 2007). Cabeza de Vaca and his companions lived among the Native Americans for eight years before returning home to what is now Mexico. They took with them tales of cities of gold that caused great excitement. In 1540, Francisco Vasquez de Coronado set off with an army to find the fabled cities of gold. Coronado searched all the way to present day Kansas without ever finding the wealth described by Cabeza de Vaca. Numerous historic sites dot the region such as homes, buildings, cemeteries, farmsteads, and settlements. Researchers consider the banks of many local rivers and bays to have good potential for archaeological sites, as indigenous cultures preferred to locate near sources of water and the Tonkawan, Coushatta, and Karankawa tribes were known to inhabit this area before European settlement.

Historical Resources

There are currently no sites listed on the National Register of Historic Places (NRHP); however, numerous identified archaeological or cultural sites are located within the boundaries of the Complex. The majority of the sites are prehistoric, generally shell middens and campsites located along the banks of bayous, lakes, and oxbow lakes or meander scars. The remaining sites are historic in nature and include cemeteries, shipwrecks, a plantation, canal, cattle dipping vat, and foundations for structures.

Prehistoric Sites

The Texas Archeological Survey recorded prehistoric sites during the Seadock project in 1973. The predominant diagnostic artifacts found at these sites are pottery fragments, which date them to the Late Prehistoric period, probably the Galveston Bay Focus. These sites are composed mainly of oyster and rangia shells and vary in depth from a single shell lens two inches in size, to over a yard in thickness. Some of the shell middens are located beneath spoil piles, while others remain visible on the surface. Brazoria Girl, which dates back to the middle Holocene (5600 B.P.), was located in 1999 by refuge staff constructing reservoir levees for the Wolfweed Wetland Complex at San Bernard NWR. Texas A&M University excavated the skeletal remains in 2003.

In 2003, Brazoria girl, a 5,000 to 6,000 year old skeleton was excavated at San Bernard NWR by researchers at Texas A&M University. Photo Credit: USFWS

Historic Sites

The following historical information was provided by the Texas State Historical Association's website:

Brazoria County

The Brazoria and San Bernard NWRs are located in the center of colonial movement into Mexican Territory. In the early 1820s, Stephen F. Austin brought the first of his colonists to the area where they landed at the mouth of the Brazos River. Known as the "Old Three Hundred," they settled along the alluvial bottomlands of the San Bernard River and Brazos River and along Jones Creek and Oyster Creek. Most of the early settlers relied on cotton and sugarcane to make a living and founded large plantations that relied on slave labor. In the 1840s, there were 29 sugar mills in Brazoria County.

In 1832, the Mexican government organized a separate municipal district, called Brazoria. As a result, Brazoria county became one of the original counties following Texas independence in 1836. The town of West Columbia in west-central Brazoria County is the site of the first capital of Texas and dates to pre-revolutionary days. Prior to Anglo-American settlement, transportation routes were Indian trails and navigable streams and rivers such as the Brazos River, San Bernard River, and Oyster Creek. Early settlers later traveled some of these trails and eventually they became roads. Prior to the Civil War, sugar plantations used Oyster Creek as a transportation route along its banks. Brazoria NWR developed the Maddox home site into a historical interpretive trail. Adjacent to the

Stringfellow unit of San Bernard NWR is the oldest known Anglo-structure in Brazoria County. A small trail across from the office takes visitors up to the cedar cabin where the refuge will display an interpretive sign. When the Service acquired the DuCroz Unit, they agreed to erect a sign identifying the historical use of the property by the DuCroz Family during the mid-1800s.

Wharton County

The land was inhabited as early as the Paleo-Indian period, and a stable occupation pattern lasted through the Late Prehistoric period for as long as 10,000 years. The Karankawa Indians, a Coco band, occupied the area that became Wharton County until the late eighteenth century, using the region for hunting and settlement along the Bernard, Caney, Peach, Mustang, and Colorado waterways as late as 1823. The Tonkawas came into the area on occasions, as their lower range overlapped the upper range of the Karankawas. Skirmishes with white settlers continued as late as 1840, but by 1850 most of the Indians had retreated out of this area into Mexico.

Wharton County is in the section of Texas first explored by Europeans. In 1687 René Robert Cavelier, Sieur de la Salle, traversed the area on the last exploration he made before his death. Alonso De León passed through on his third and fourth trips in search of the La Salle colony in 1688 and 1689, and in 1718 Martín de Alarcón came to inspect East Texasqv missions after exploring Espiritu Santo Bay. Pedro de Rivera y Villalón crossed the area in 1727, and between 1745 and 1746 Prudencio Orobio y Basterraqv explored the coastal area. Spain controlled the territory until Mexico achieved independence in 1821, and Anglo-American colonization began under a program sponsored by the Mexican government in 1823, when thirty-one of Stephen F. Austin's Old Three Hundred received titles to land in the area of present Wharton County. The main transportation trails across the county originally passed along the Colorado River and Caney and Peach creeks from Matagorda to San Felipe, bisected by a trail across the Colorado near Egypt that connected Richmond with Texanna; the Old Spanish Trail crossed the San Bernard River to East Bernard connecting Richmond with Columbus.

Fort Bend County

The settlement of Fort Bend County began in the early 1820s as part of the Anglo-American colonization of Texas under the auspices of the Spanish government. Authorization to settle 300 families in the valleys of the Brazos and Colorado rivers was initially granted to Moses Austin, but plans were delayed by his death in June 1821 and Mexican independence from Spain. Stephen F. Austin assumed the responsibility of leadership from his father and gained confirmation of the original Spanish grants from the newly established Mexican government in 1823. Following arrangements with Austin, a group of colonists sailed from New Orleans in November 1821 on the schooner *Lively* and anchored near the mouth of the Brazos River on the Texas coast.

In 1822 a small party of men from this group left the ship and traveled inland some ninety miles and, on a bluff near a deep bend in the river, built a two-room cabin. As the settlement grew, the cabin became known as both Fort Settlement and Fort Bend; the latter name, in time, prevailed. In 1824 the Mexican government issued documents officially granting to the colonists their leagues of land. Of the 297 grants, fifty-three were issued to Fort Bend

settlers. The presence of the Karankawa Indians near the new colonial settlements proved to be a comparatively minor problem. The first settlers had a few skirmishes, but as the colonies increased, the Karankawas began moving out of the area and by the 1850s had migrated as far south as Mexico.

Matagorda County

Archeological research has revealed a pattern of relatively dense occupation near inland water sources in the upper Texas coastal region, and projectile points from the early Paleo-Indian period (10,000–6,000 B.C.) have been found thinly scattered along the Texas coastal plain. By the time of European exploration in the early 1500s, the central section of the Texas coast, including Matagorda County, was home to several linguistically related subgroups of the hunter-gatherer Karankawa Indians. By the eighteenth and nineteenth centuries the shifting of tribal territories further north forced other tribes, notably the Tonkawa Indians of Central Texas, toward the coast and into Karankawa territory. Alonso Álvarez de Pineda mapped the Texas coastline in 1519, but the first recorded European expedition into the Texas interior was conducted by Álvar Núñez Cabeza de Vaca, who sometime after 1528 probably passed through what later became Matagorda County. Guido de Lavazares landed at Matagorda Bay in 1558, surveyed the northern Gulf Coast, and claimed the area for King Charles V. In 1690 Manuel José de Cárdenas y Magaña mapped Matagorda Bay as part of the Llanos-Cárdenas expedition, and the Alarcón expedition passed through what is now Matagorda County between 1718 and 1719.

As early as 1820 plans were made to establish a port at the site of the future town of Matagorda, but none developed, since silt deposited in the bay by the Colorado River made a port impractical at that time. Settlement by Anglo-Americans began in 1822, when the schooner *Only Son* landed immigrants for Stephen F. Austin's colony at the mouth of the Colorado. Some of the first white residents of what is now Matagorda County were soldiers sent to protect the new settlers from the Karankawa Indians. Austin gave grants in the area to fifty-two families, principally from New York, and in 1827 received permission to settle 300 more within thirty leagues of the coast in areas where settlement had previously been forbidden by the Mexican government.

The town of Matagorda, at the mouth of the Colorado River, was founded in 1829 after Austin had convinced the Mexican government that a military post was needed to protect incoming settlers. The town quickly flourished, and settlement proceeded inward from the coast, initially along Caney Creek. A custom house established at Matagorda in 1831 was maintained until the Texas Revolution. Steamers and sailing vessels approached within six miles of the town on Matagorda Bay; other county transportation was also largely by water. The municipality of Matagorda, which comprised the southeast corner of the original Austin grants, was established in 1834 while the area remained under Mexican control.

Cemeteries

DuCroz Cemetery is located within the San Bernard NWR near the community of Cedar Lakes. The cemetery was founded in 1907 (Leezer, 2006), and Laurentz and Mary DuCroz were buried there in 1910 and 1911 respectively. There are reports of other family members interred there as well.

3.6 Current Management

3.6.1 Administration

3.6.1.1 Staffing

In fiscal year 2011, the Complex had a staff consisting of 27 permanent full-time employees. They also hired 5 interns, and more than 120 individuals volunteer their time to conduct work each year (Chapter 5, Table 5-1 identifies existing Complex staff). The annual operations and maintenance budget was 3.05 million in 2011.

Volunteer Program
Volunteers play a vital role in daily refuge operations. Volunteers accomplish numerous work projects within all aspects of refuge management, including biological, maintenance, and administrative tasks. The amount of time volunteered varies from full-time to a few hours a week or month, or during a particular season. During 2011, the Complex recorded more than 13,000 volunteer hours.

Volunteers perform a wide variety of tasks. These could include assisting in habitat modification projects such as developing freshwater impoundments, maintenance projects, construction of additional public use facilities, leading tours, providing information and interpretation to the public, helping with environmental education for school groups, performing clerical and administrative duties, and taking part in special projects such as bird banding and sea turtle beach patrol.

The Friends group provides local volunteers to help with biological surveys, construction of public facilities, maintenance, fundraising, and the annual Migration Celebration. The DEEP docents teach students during field trips and are mostly Texas Master Naturalists. Additional parent volunteers help to manage small groups of children during the field trips. San Bernard NWR supports the Kemp's ridley sea turtle recovery plan by monitoring beaches from the mouth of the Colorado River to the mouth of the Brazos River for nests and nesting turtles. Volunteers are an essential part of this program to monitor beaches. A citizen scientist organization called the Forest Bird Study Group has been conducting winter bird banding for the past eleven San Bernard NWR.

Both San Bernard and Brazoria NWRs host RV volunteers, typically during the winter months. Brazoria has an eight-pad volunteer village. San Bernard NWR has two RV sites. The refuges provide the sites to volunteers who donate a minimum of 24 hours per week of work. Many volunteers provide considerably more hours.

Seasonal and local volunteers have assisted with the construction of many public use facilities. Photo Credit: USFWS

The DEEP program relies on local volunteers, many of which are Texas Master Naturalists, to provide the hands-on education opportunities. Photo Credit: USFWS

Specialty projects like tree planting will bring in community support volunteers including honor society students and boy scouts. Photo Credit: USFWS

Youth Conservation Corps Program

The Complex continues to use the Youth Conservation Corps (YCC) Program as a part of operations. Typically, the Complex hires four enrollees and a group leader for the summer months. The group works on habitat and maintenance projects including fence construction, rip-rap of water control structures, clean-up of brush, weeds, and litter at fishing areas, and assists with environmental education programs.

Friends Group

National wildlife refuges have many needs beyond those that can be provided by their traditional funding sources and limited staff. Refuge Friends groups are private, non-profit organizations that partner with their respective refuge to advocate for refuge program needs. The Friends of Brazoria Wildlife Refuges (FBWR) was established in 1994 by local volunteers, is a non-profit organization dedicated to supporting the Brazoria, San Bernard, and Big Boggy NWRs. They provide volunteers for many important refuge activities and raise funds for a variety of refuge projects. Funds are raised through donations, grants, and gifts to help fund refuge projects, educational programs, and other activities. Members of this group are dedicated volunteers who work tirelessly for the benefit of the refuges and the community. Activities provided by the Friends include: construction of public use facilities; environmental education through DEEP and summer programs; clean-up efforts at the refuges; hosting the annual spring Migration Celebration; promoting public awareness of our refuges' habitat and wildlife; fundraising for refuge projects and programs; and participating in data gathering and bird counts.

A Harris hawk flies over the heads of spectators during Earthquest® presentation at Migration Celebration. Photo Credit: Dave Sanders

Youth enjoy numerous hands-on educational activities during Migration Celegration including crabbing.
Photo Credit: USFWS

3.6.1.2 Administrative Facilities

Infrastructure

Brazoria NWR
The Otter Slough field headquarters is located off FM 2004. The office has eight individual offices and supports field operations including management, maintenance, fire, and law enforcement. Adjacent to the office is a 20-foot-by-50-foot metal building, a 40-foot-by-60-foot metal storage building, a 40-foot-by-60-foot metal tractor shed, a 14-foot-by-8-foot pesticide storage building, two fuel tanks, and water quick fill. One water well, a septic system, and numerous wooden power poles provide utilities. The Service maintains a remote automated weather system (RAWS) near Otter Slough as well. The refuge maintains 50-plus miles of barbed wire boundary fence, two automatic entry gates, numerous field gates, approximately 100 water control structures, 27.9 miles of limestone gravel roads, 40.8 miles of earthen levees, and three irrigation wells.

Volunteer village, located near Bastrop Bayou, consists of eight recreational vehicle (RV) pads all supplied with electricity, sewer, and water. A mobile home and one travel trailer are set up for temporary quarters in the village as well. A portable building is used for a common area and wash house. A wooden well house sits across the yard alongside a 100-foot radio tower. A wooden fence and information signs front the yard.

San Bernard NWR
The field headquarters of San Bernard NWR is located on CR 306 and includes the refuge's office and fire office, three maintenance buildings, three storage buildings, two storage sheds, one quarters (three-bedroom), two volunteer pads, and a communications tower (repeater). The refuge maintains 17-plus miles of gravel or shell roads, 16-plus miles of earthen levees, many miles of barbed wire boundary fence, 27 water control structures, four automated entry gates, and a RAWS. There are numerous wells and windmills also located near the headquarters and in the bottomlands. A twelve-inch water well is located at the Sargent Unit, and an eight-inch water well is located at the Wolfweed Wetlands for irrigation. Facilities in the bottomland hardwood forest units include a 600-square-foot cabin with a 320-square-foot deck overlooking the pond located on Hudson Woods. The Complex acquired a small cabin (500 square feet) located on the Buchanan Tract and it is being utilized for temporary quarters. The Complex uses a 35-foot-by-70-foot Quonset hut located on the east side of Hudson Woods for hurricane evacuation.

The Complex headquarters is located at the intersection of FM 2611 and CR 316. Construction was completed on the headquarters in 2008 and supports the administrative, management, biological, acquisition, fire, and public use programs across the Complex.

Big Boggy NWR
The refuge has 6.7 miles of gravel and shell roads, 5.23 miles of earthen levees, several miles of boundary fence (barbed wire), seven gates, 1.36 miles of water delivery canals, several

culverts, and 13 water control structures. There are also three known water wells and three deteriorated windmills on the refuge.

Utilities and Rights-of-Way

Brazoria NWR

Centerpoint Electric has a right-of-way (ROW) for the utility pole along FM 2004 and the Otter Slough Entrance Road which supplies electricity to the field headquarters. Multiple pipeline ROWs occur on the refuge; including a large corridor which contains 23 pipelines (See Table 3-8). Brazoria County drainage district maintains fourteen drainage ditches on the north side of the refuge. The CR 208 ROW is on the refuge crosses the refuge. The CR227 ROW adjoins the refuge property line. An undeveloped ROW for an alternate segment of CR 227 crosses the Bluestem Unit. There are several oil and gas wells in the Slop Bowl unit with associated ROW rights on a field road.

San Bernard NWR

Table 3-9 summarizes the ROWs on San Bernard NWR. Prior to each acquisition the Complex Project Leader reviews the existing ROWs, along with outstanding interests, and confirms that these interests would not adversely impact the Service's ability to manage the parcel to meet the mission of the Service.

Big Boggy NWR

County Road and the adjoining service line to Chinquapin are the only current ROW's on Big Boggy.

Table 3-8 Pipelines on Brazoria NWR.

Strategic Petroleum Reserve	Petroleum	AMOCO	LPG
Buckeye Gulf Coast Pipeline	Petroleum	AMOCO	LPG
Exxon	Chem Grade Propylene	AMOCO	LPG
Equistar	Ethylene	AMOCO	LPG
Chevron	Propylene	AMOCO	LPG
Praxair	Hydrogen	Texas Ship Channel LLC	Natural Gas
Dow	Petroleum	Coastal Refining and Marketing	Anhydrous Ammonia
Dow	Petroleum	Air Liquide	Hydrogen Gas
Dow	Petroleum	Air Liquide	Nitrogen Gas
Dow	Petroleum	Air Liquide	Oxygen Gas
Dow	Petroleum	Seminole	LPG

Dow	Petroleum		
Equistar	Ethane Propylene Propylene	Houston Pipeline (2 easements)	Natural Gas

Table 3-9. Rights-of-Way on San Bernard NWR.

San Bernard (core)	Service line along CR 306 Service line to check station	Zinn Petroleum – natural gas Winn Crosby, - Poole gathering line Am. Mid-stream Offshore (2 lines) – both natural gas Brazos Lat. Holding – natural gas Wynn-Crosby - natural gas	CR 306, FM 457, FM 2918
Buchanen	Along CR 321		
Dance Bayou	Service line along FM 524	Exxon Mobil – propylene dilute Kinder Morgan – 2 lines both Nat. Gas Chevron Pipeline -2 lines both ethylene Seadrift Pipeline Co. (3 lines) - (1)propylene, ethane, propane (2)propylene, Ethane, Propane (3) LPG Energy Transfer Co. - natural gas Houston Pipeline - natural gas ConocoPhillips - ethylene	CR 524 CR 781
Big Pond	Service line along FM 1301 Service line along entrance road to	Exxon Mobil – (1) propylene dilute (2) proylene chem. Kinder Morgan – (2	Communications Tower

Bottomland Unit			
	pipeline pump stations and communications tower. CenterPoint Transmission Line	lines) both nat. gas Equi Star – (1)ethylene (2)propylene Panther Gas – nat. gas Houston Pipeline - natural gas (2 lines) Enterprise – crude oil Enterprise - ethane Energy Transfer - natural gas Tx. Petrol. Invest – nat. gas (7 lines) Dow - EP Mix	
Bird Pond		Tx. Petrol. Invest – Nat. Gas (2 lines)	Access Easement along pond levee for adjacent land owners
San Bernard River	Service line along FM 1301		
Buffalo Creek		Energy Transfer - Natural Gas	Drainage Easement across east end
Stringfellow/ McNeal/Ducroz	Transmission Line Service line along FM2611, CR 306 and CR 316 Service line to Poole #4 well and toward San Bernard Oak and water wells.	Equi Star - ethylene Equistar - empty Celanese - propylene	CR 306 CR 316 FM 2611
Brazos River Unit		Kinder Morgan - LPG Seadrift Pipeline Co. - ethylene	Access easement to sand pit inholding
Eagle Nest Easement		Gulfmark – crude Houston Pipeline – natural gas ConocoPhillips – crude Chevron – ethylene ConocoPhillips – natural gas Enterprise – natural gas (2 lines)	

Bottomland Unit			
Eagle Nest Lake	Service line along CR 24 & CR24a	Enterprise Crude – crude Enterprise Prod. - nitrogen ConocoPhillips (4 lines)- (1) EP mix (2) gas/distillates/naptha (3) EP mix/propane (4) gas/distillates/ naptha	CR 24 and CR 24a CR 25
Dow Woods	Service line along CR 288 Center Point transmission line	Equistar - petrol	County Road 288
Hudson Woods	Service line to cabin Center Point – Transmission Line	Noble Energy Inc. – product line ConocoPhillips – (9 lines) – (1)crude (2) crude (3)crude butadiene (4) EP mix/propane (5) ethylene (6) nat. gas (7) propylene (8) propane (9) empty Chevron – (3 lines) (1) Ethylene (2) EP mix/propane (3) ethylene TX Eastern Trans. LP – natural gas Standard Resources – natural gas Gulfmark Ener - crude	Railroad easement on west side of property (inactive) CR 29
Carolyn Davies Easement		ConocoPhillips (4 lines) – (1) EP mix/propane (2) crude butadiene (3) crude (4) natural gas Chevron (2 lines) – (1) EP mix/propane (2) ethylene Houston Pipeline-	

Bottomland Unit			
		natural gas Enterprise Prod. – natural gas	
Sweeny		Conoco Phillips – 4 corridors (a) Hydrogen Nat. Gas (b)Pentane Butane Mix Ethan/Propane Ethylene Propane Nat. Gas Propylene Propylene Butane Isobutane (c) Crude Oil (d) Gas/oil Raffinate/Naphtha Empty	
Halls Bayou		Monument Pipeline – natural gas Seadrift Pipeline (2 lines) – both propylene/ ethane/ propane	Access easement for two adjacent land owners
Media Luna		Oxea – prolyene Equistar - empty	CR 457
Cedar Lake Creek		Oxea - prolyene Equistar - empty	CR 318

3.6.1.3 Oil and Gas Operations and Management

Oil and gas exploration and production is prevalent in the area. Although the Complex does not own mineral rights and cannot deny access for oil and gas development, various laws, regulations, and administrative procedures must be adhered to before access is granted. Therefore, oil and gas companies contact each refuge to prepare an Operational Plan and Environmental Assessment prior to receiving a Special Use Permit for initiating any exploration or production activities. Complex staff works closely with each operator to carefully consider and mitigate any impacts of oil and gas operations on wildlife species or refuge visitors. Although somewhat unsightly on the prairie landscape, these oil and gas operations can be minimally intrusive and consistent with the purposes of the refuges as long as their activities are properly managed. Operations in the bottomlands require extensive planning and negotiation to ensure the removal of trees are minimized in order for these operations to be compatible with the purpose of the bottomlands, namely the provision of old growth habitat for dependent wildlife. The potential for future oil and gas exploration and production activities on the Complex is possible depending on the economic stability of the industry. The following oil and gas activities occur on the Complex:

<u>Brazoria NWR</u>
Current oil and gas operations on Brazoria NWR include natural gas wells in the Slop Bowl Unit, operated by Texas Petroleum Investment Co., and a saltwater disposal well. Exploration drilling for natural gas at several locations around the Hoskins Mound inholding, has been proposed by Suemar Inc. They would like to begin the first of these drilling operations in the spring/summer of 2012. The most recent 3-D seismic survey, completed by Seitel Inc., covered the southern part of the Brazoria NWR from Otter Slough through the Slop Bowl Unit during 2008. (Map 3-16 Brazoria National Wildlife Refuge Oil and Gas Operations)

<u>San Bernard NWR</u>
Oil and gas operations on San Bernard NWR include the following: Wynn Crosby Inc. operates three natural gas wells located near the Wolfweed Wetlands; Wynn Crosby operates five natural gas wells and a saltwater disposal well within the Sargent Unit, which is located near the GIWW; Zinn Petroleum and Endeavor Natural Gas each operate a well in Cedar Lakes; and three oil wells located on the Buffalo Creek Unit near the San Bernard River are operated by ZK Petroleum (Map 3-17 San Bernard National Wildlife Refuge Oil and Gas Operations).

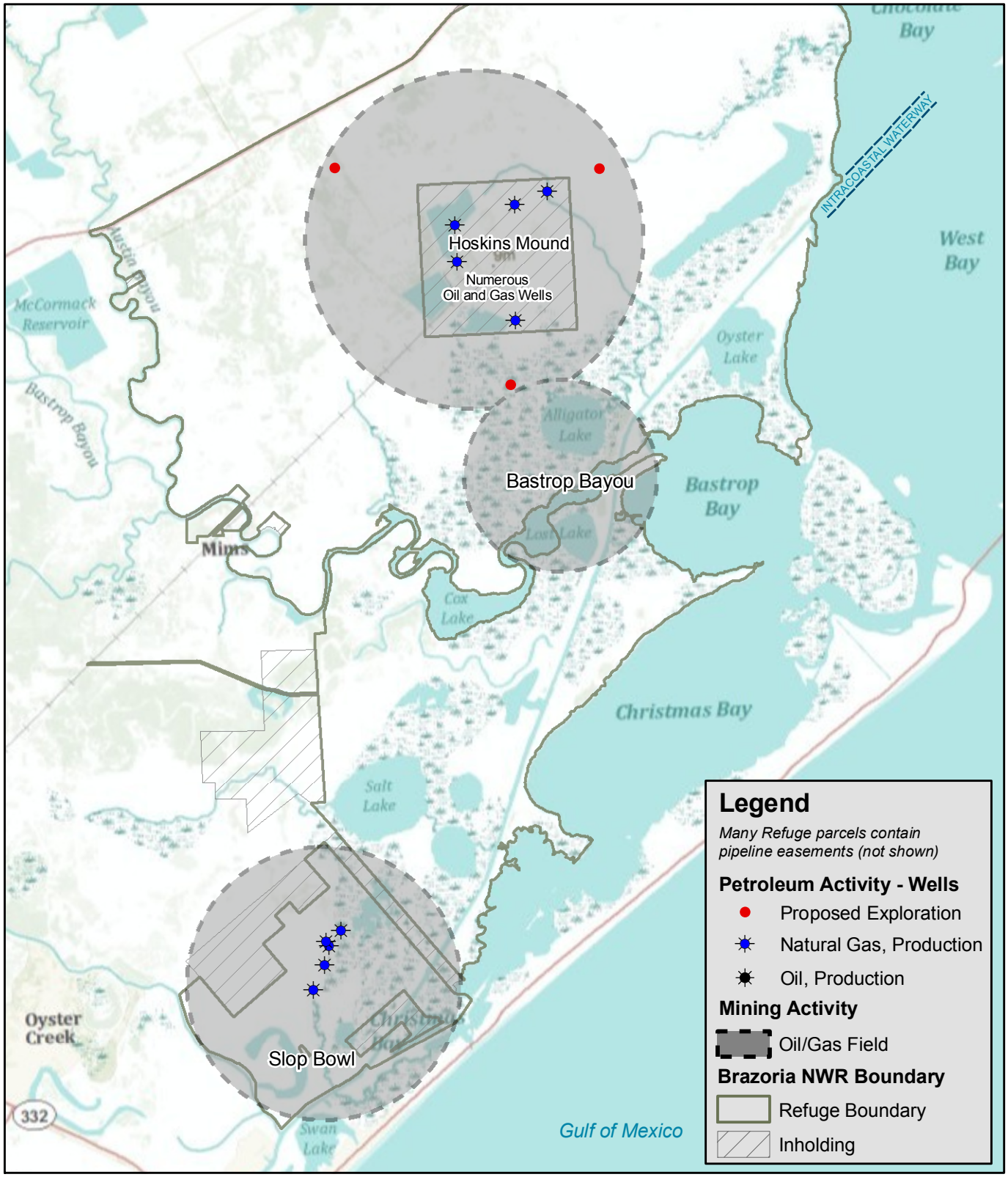
<u>Big Boggy NWR</u>
No oil and gas operations occur on the Big Boggy NWR.

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge

Brazoria County, Texas

Map 3-16. Oil and Gas Exploration



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_oil_gas_8.5by11_5.18.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

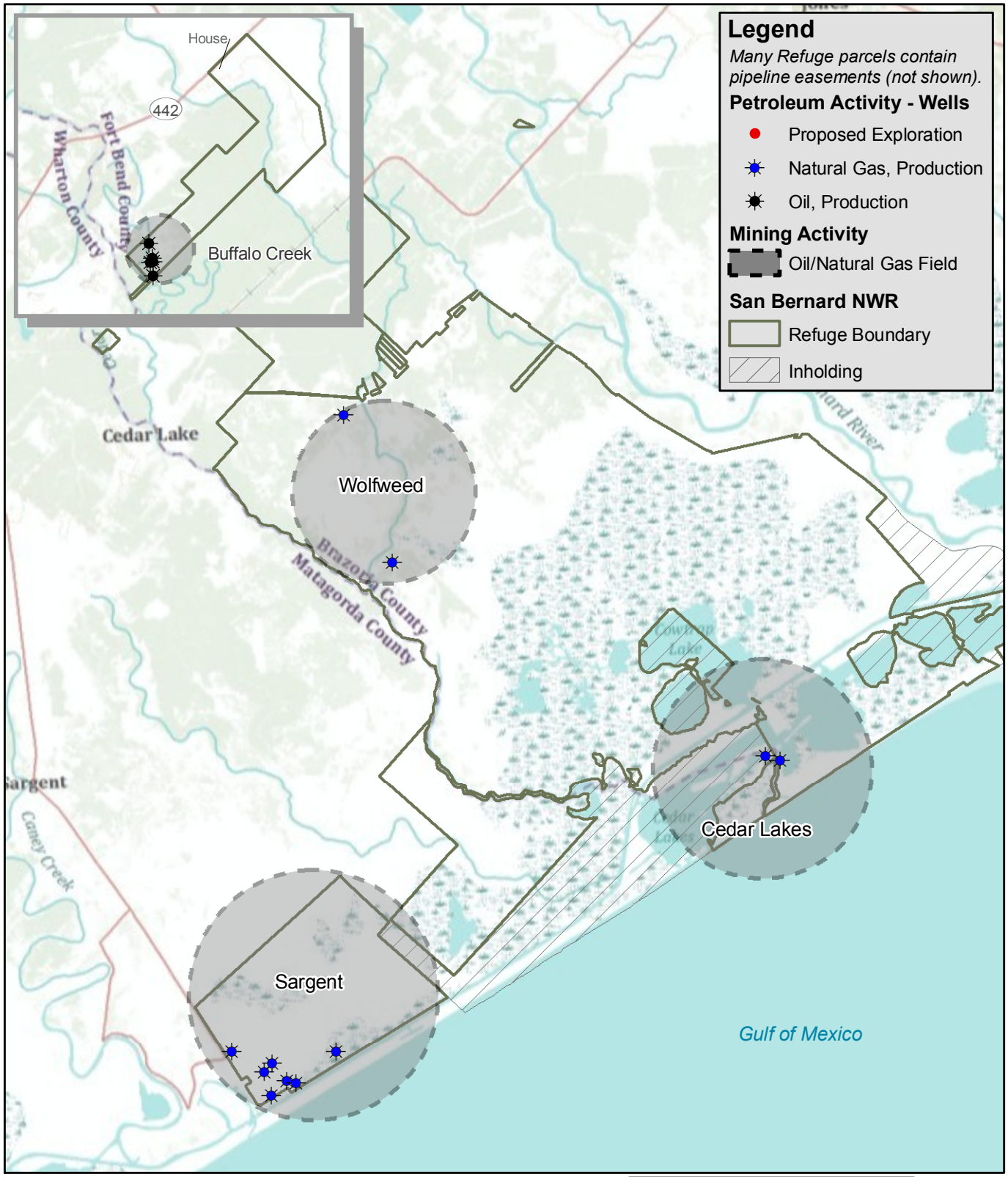
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda and Wharton Counties, Texas

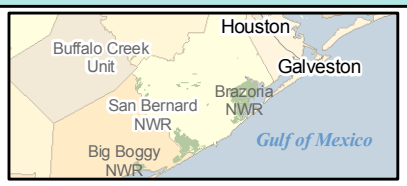
Map 3-17. Oil and Gas Operations



PRODUCED IN THE DIVISION OF PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: MAY 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_oil_gas_8.5by11.5.18.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers



UTM ZONE 15
NAD 83

3.6.1.4 Partnerships

The Complex has a strong history of working with numerous partners to implement Service policy, projects, and Complex goals. These partnerships include biological research, land conservation, community protection, land management, public use opportunities, environmental education, and habitat restoration/improvements. The Complex includes the following organizations and agencies as partners:

- Brazosport Independent School District
- Texas Parks and Wildlife Department
- Texas General Land Office
- U.S. Army Corp of Engineers
- Brazoria County Parks and Recreation
- Natural Resource Conservation Service
- Houston Audubon
- National Fish and Wildlife Foundation
- Gulf Coast Bird Observatory
- Trust for Public Land
- The Conservation Fund
- The Community Foundation
- Brazosport Birders
- The Nature Conservancy
- Galveston Bay Foundation
- Ducks Unlimited
- Bayou Land Conservancy
- Houston Wildlerness
- Cradle of Texas Conservancy
- Texas Master Naturalist
- Friends of Brazoria Wildlife Refuges
- Texas RICE
- Brazoria County
- Matagorda County
- Nat. Oceanic and Atmospheric Administration
- U.S. Geological Service
- Houston Regional Group of the Sierra Club

3.6.1.5 Memorandums of Understanding and Other Agreements

The Complex has a Memorandum of Understanding with Brazoria County's Emergency Management Office. In accordance with the agreement, the Service may assist Brazoria County with Wildland Fire Response and during all-risk (Hurricane) situations. Only the County's Emergency Management Coordinator can make requests for assistance from the refuges.

3.6.1.6 Law Enforcement and Resource Protection

Complex staff recognizes the obligation that has been entrusted to them – the care of valuable natural and cultural resources. Law enforcement on the Complex is used both for protection and for prevention. Used for prevention, law enforcement safeguards the visiting public, staff, facilities, and natural and cultural resources from criminal action, accidents, vandalism, and negligence. Law enforcement inhibits incidents from occurring by providing a law enforcement presence. The Complex has two full-time law enforcement officers and one collateral law enforcement officer.

3.6.1.7 Safety

Safety is important for both staff and visitors. Monthly staff safety meetings are held at the Complex with safety videos and discussions on safety issues. The intent of the safety meetings is to update and train personnel, as well as to resolve any safety concerns that arise. Sample topics include safety awareness, heavy equipment safety, hazardous materials, first aid, and heat stress. Job Hazard Analysis are prepared for all projects and kept on file. Tail gate safety meeting prior to beginning a new or not reoccurring assignment are incorporated in planning.

The Complex has a Safety Plan which is updated annually, that describes the safety program and the responsibilities of the refuge staff and volunteers. All Complex staff are trained annually in CPR and AED operation. All permanent staff maintain current CPR/AED and First Aid Certification.

3.6.2 Habitat Management

Prairie/Grassland Restoration and Management
Active restoration activities occur on Brazoria and San Bernard NWRs. Because much of the prairie habitats were in agriculture prior to establishment, there remains a significant amount of infrastructure in place that interferes with native prairie restoration and management including roads, levees, ditches, and water control structures that all affect the natural hydrology of the prairie.

Many of the species of special management concern have life history requirements (i.e., nesting, wintering habitat, etc.) directly tied to grasslands. The coastal prairies of Texas are important wintering grounds for sparrows and wrens. With nationwide habitat loss of prairies and grasslands, there are fewer places migrating birds can feed, rest, and winter. Direct habitat loss is the biggest concern for prairie-dependent species.

Brazoria and San Bernard NWRs actively restore old fields and coastal prairie through a combination of chemical, mechanical, fire, and planting of native prairie seed. Fire is utilized to maintain the prairie habitat on all three refuges, mimicking historic fire regimes in restored areas.

The Complex collects a small amount of native seed for restoration efforts from native prairie grasslands within its borders. However, this is challenging because production and access to seed harvested is highly dependent on weather conditions. To help overcome this challenge, the Complex has purchased native prairie hay and distributed that hay using a bale spreader to restore native prairie.

Invasive Species Management (Flora)
Of the dozens of non-native invasive plant species on the Complex, management efforts have concentrated on the most aggressive and invasive species with habitat changing characteristics. These are the Chinese tallow tree, Macartney rose, water hyacinth, privet (Ligustrum spp.), trifoliate orange, salt cedar and deep-rooted sedge. The Complex uses

herbicide application, mechanical manipulation, and prescribed fire to control and prevent the spread of invasive species. The Complex anticipates the development and implementation of an integrated pest management plan by 2013. Table 3-10 below describes the applications used and invasive species targeted to manage/restore the Complex to a native plant community.

With disturbances initiated through farming, grazing, and development, prairies and grasslands are easily encroached by invasive species like Chinese tallow and restoration efforts have proved to be a challenge on budget and resources. Exotic and invasive species have complicated restoration efforts in prairie habitats since they can quickly become established prior to implementing restoration plans. The Complex initially treats many Chinese tallow-infested tracts with herbicides as well as mechanical manipulation in an attempt to convert it back to a functional prairie habitat.

Brazoria NWR uses mechanical treatment on up to 100 acres of invasive species, including salt cedar and Chinese tallow. Mechanical treatment is the direct removal of trees using a tub grinder on an excavator or grinding using a gyrotrac. Mechanical removal of Chinese tallow trees along drainage ditches has been done in partnership with the Drainage District. Approximately 1,600- 2,500 acres of Chinese tallow are treated with chemical application as part of an annual on-going prairie restoration initiative. The chemicals generally used are Grazon P+D ® and Grazon Next® through aerial application. This process has been extremely successful in reducing Chinese tallow and Macartney rose. Ground application is used for road maintenance and in small problem areas of deep-rooted sedge using a backpack pump or an ATV. The use of herbicides continues to decline as the refuge transitions from a restoration to a maintenance management approach in prairie habitats. Prescribed fire is used as a management tool on approximately 5,000 – 10,000 acres of prairie annually.

San Bernard NWR treats up to 50 acres annually by the same mechanical means as Brazoria NWR designed to remove Chinese tallow. Chemical application (same chemicals as Brazoria NWR) is applied to approximately 100 acres annually and the refuge burns approximately 2,500 – 6,000 acres of coastal and salty prairie habitats to control invasive species annually. Because of the presence of native hardwood trees in the bottomland forests of San Bernard NWR, mechanical and ground applied chemical treatments are used to control invasive species, including Chinese tallow. On average, the refuge annually treats up to 100 acres of bottomlands for invasive species.

At Big Boggy NWR, the refuge primarily utilizes prescribed fire to control invasive species among the coastal and salty prairie habitats. However, mechanical and herbicide application may be utilized when species and density warrant their use. The refuge generally treats less than 100 acres of invasive species annually.

Table 3-10 Treatment Applications for Target Invasive Species

Rodeo and Habitat	Cattails & Phragmites	Boom sprayer & aerial	Create open water for wildlife
Clearcast	Chinese tallow	Aerial	Eradicate invasive flora in bottomland forest
Glyphosate	Various grasses and Deep-rooted sedge	Hand & Backpack sprayer	Manage various grasses in & around facilities for safety & aesthetics
Garlon 4	Chinese tallow & Macartney rose	Hand & Backpack sprayer	Coastal Prairie restoration
Roundup & Arsenal	Various grasses	Hand & Backpack sprayer	Manage various grasses in & around facilities for safety & aesthetics
Grazon P+D & Remedy	Chinese tallow & Macartney rose	Aerial	Coastal Prairie restoration
Grazon Next	Chinese tallow & Macartney rose	Aerial	Coastal Prairie restoration

Fire Management

The Complex uses prescribed fire as a management tool for restoration and maintenance of fire-adapted ecosystems including upper marsh, and prairie habitats. Restoration of coastal prairie may require treatment with prescribed fire annually or once every two years depending on the response of the vegetation and the ability to carry fire. Maintenance of coastal prairie habitats generally requires the application of fire to the unit on a three to four year cycle. The Complex treats 25 to 35 percent of the coastal prairie and salty prairie habitats annually. The Complex uses a helicopter on prescribed fire ignitions on larger burns as funding permits, and ground ignition when not feasible. The Complex uses backing fires (against the wind) and flanking fires (parallel with the wind) and limited head fires, with flanking fire preferred due to longer combustion rates. Backing fires are used to reinforce the firebreak. Map 3-18 depicts the fire management units on Big Boggy. Map 3-19 depicts the fire management units on Brazoria and Map 3-20 depicts the fire management units on San Bernard.

More than 12,000 acres of coastal and salty prairie are treated with prescribed fire across the complex. Photo Credit: USFWS

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge

Matagorda County, Texas

Map 3-18. Fire Management

PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: bbg_fire_5.24.11_shl

0 0.25 0.5 1 Miles

0 0.25 0.5 1 Kilometers

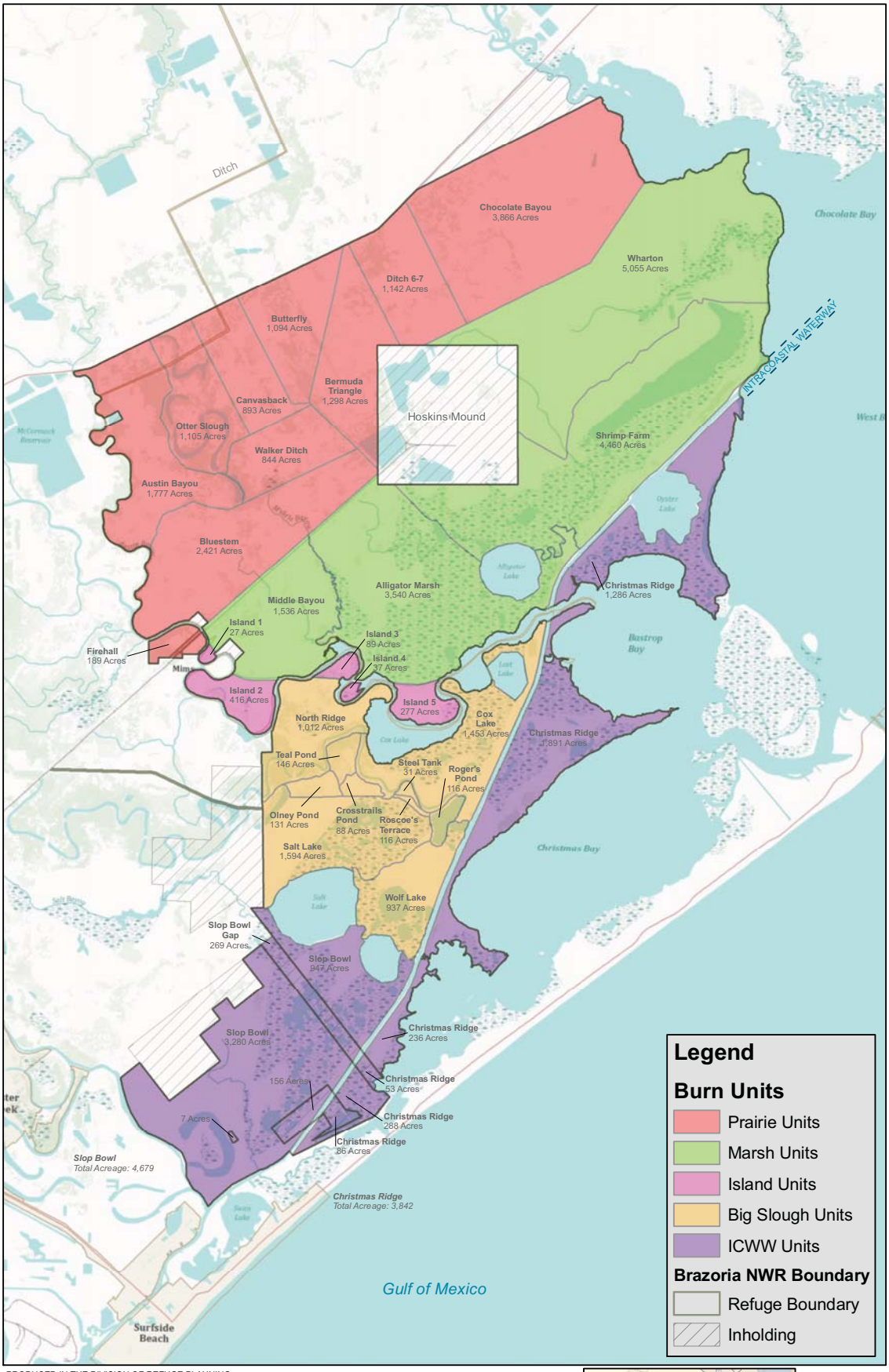
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge

Brazoria County, Texas

Map 3-19. Fire Management



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_fire_5.24.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

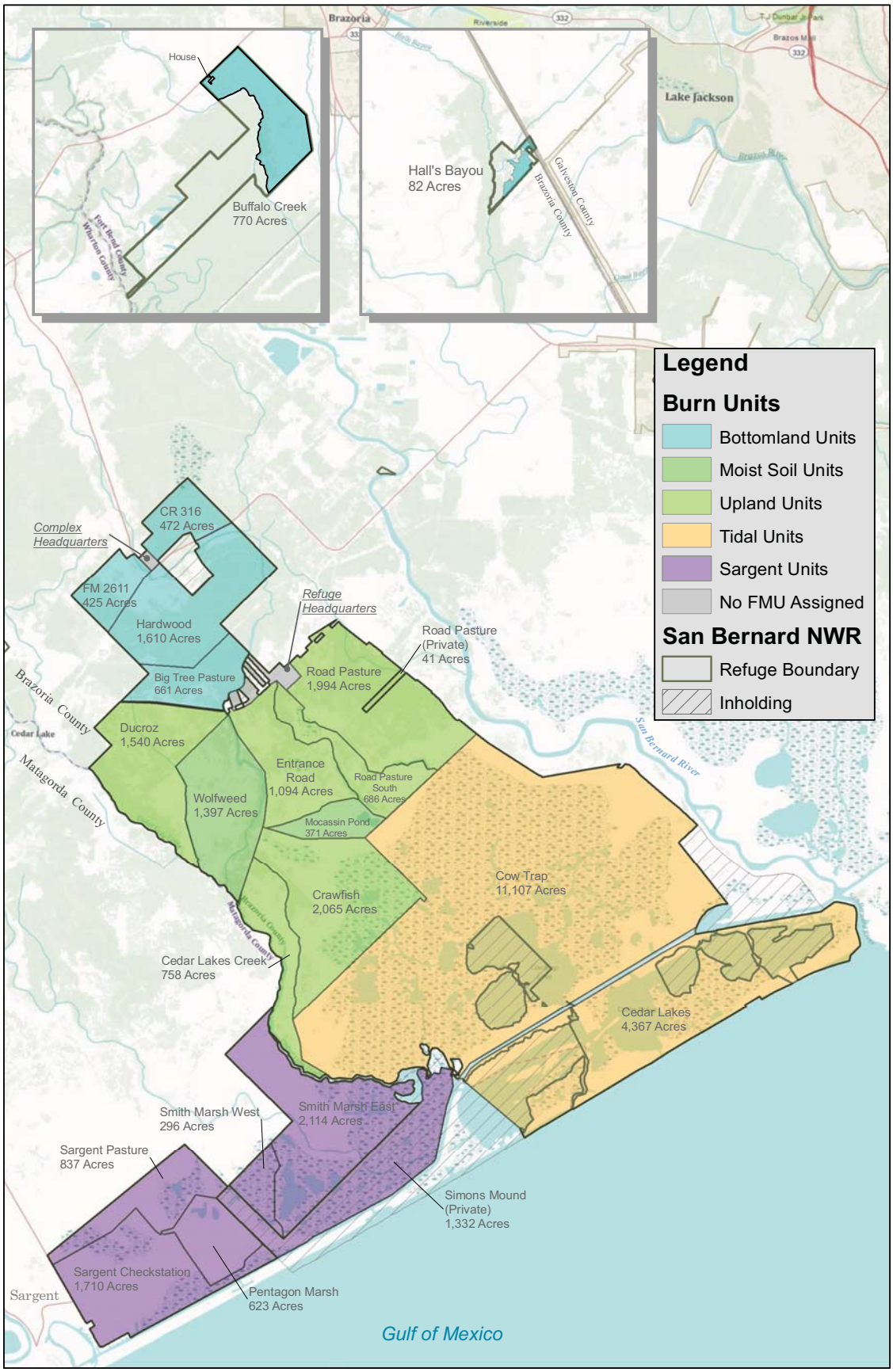
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria, Fort Bend, Matagorda, and Wharton Counties, Texas

Map 3-20. Fire Management



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE:snb_fire_5.24.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

Farming Program

At Big Boggy NWR**,** a total of 90 acres are farmed through force account at Mathis Field (Map 3-21). The entire 90 acres is planted with rye grass to provide winter browse for waterfowl.

Brazoria NWR uses cooperative farming on 10 farm fields that fall in a three-year rotation and range from 50 to 120 acres for a total of 1,000 acres (Map 3-22). Out of these 1,000 acres, approximately 220-350 acres are farmed on a given year. Three out of ten units (approximately 220-350 acres) are put into production each year with the remaining seven left fallow. The fallow fields are generally manipulated through discing and flooding during the off cycles of the rotation. The units essentially become a moist soil unit and may be flooded to provide wildlife habitat during non-production years. Rice is the main crop in production with the occasional grain sorghum. The purpose of the cooperative farming program on Brazoria NWR is for habitat benefits from the farming operations. Rent equivalents from farmers may include discing in non-farmed marshes; purchase of herbicide used to spray invasive trees and brush on irrigation laterals and/or track-hoe or excavator work on irrigation laterals. Rent equivalents have also included maintenance of feeder ditches, pipes, and water control structures and water credits purchased by farmer to be used by the refuge as duck or shorebird water following harvest. The farmer ensures that after final harvest, all cropped fields will be prepared for re-watering. Levees will be made water tight up next to control structures. Discing immediately after harvest will generally not be allowed because of excess rutting of fields and breaching levees. In the event that a second cutting of rice crop occurs, the farmer is required to leave 25 percent of the second harvest uncut to provide forage for waterfowl.

Rice fields are planted on a 3 year rotation . Photo Credit: USFWS

During fallow years, the fields can be flooded and managed as moist soil units. Photo Credit: USFWS

San Bernard NWR farms a 10-acre plot located in the headquarters area (Map 3-23). This minimal field is planted with rye grass during the winter as a source of winter browse and to attract wildlife with emphasis on white-fronted geese to the area for winter wildlife viewing. At other times, the field is basically used for administrative purposes such as testing plastic sphere ignition devices, testing and demonstrating rocket nets or other activities requiring a minimally vegetated area.

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge

Matagorda County, Texas

Map 3-21. Agricultural Units

PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: bbg_farm_5.24.11_shl

0 0.5 1 2 Miles

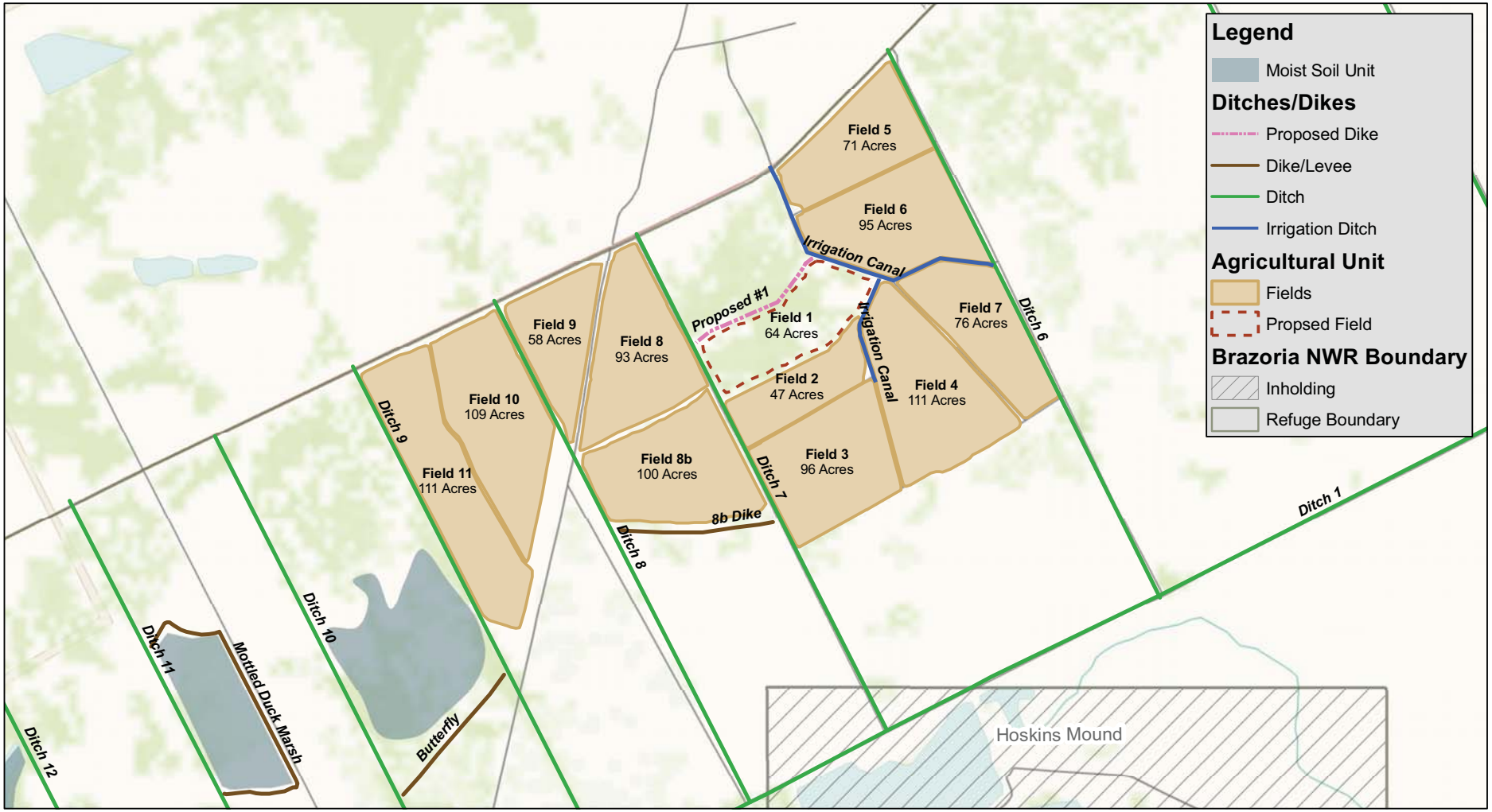
0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge
Brazoria County, Texas

Map 3-22. Agricultural Units



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_farm_5.24.11_shl

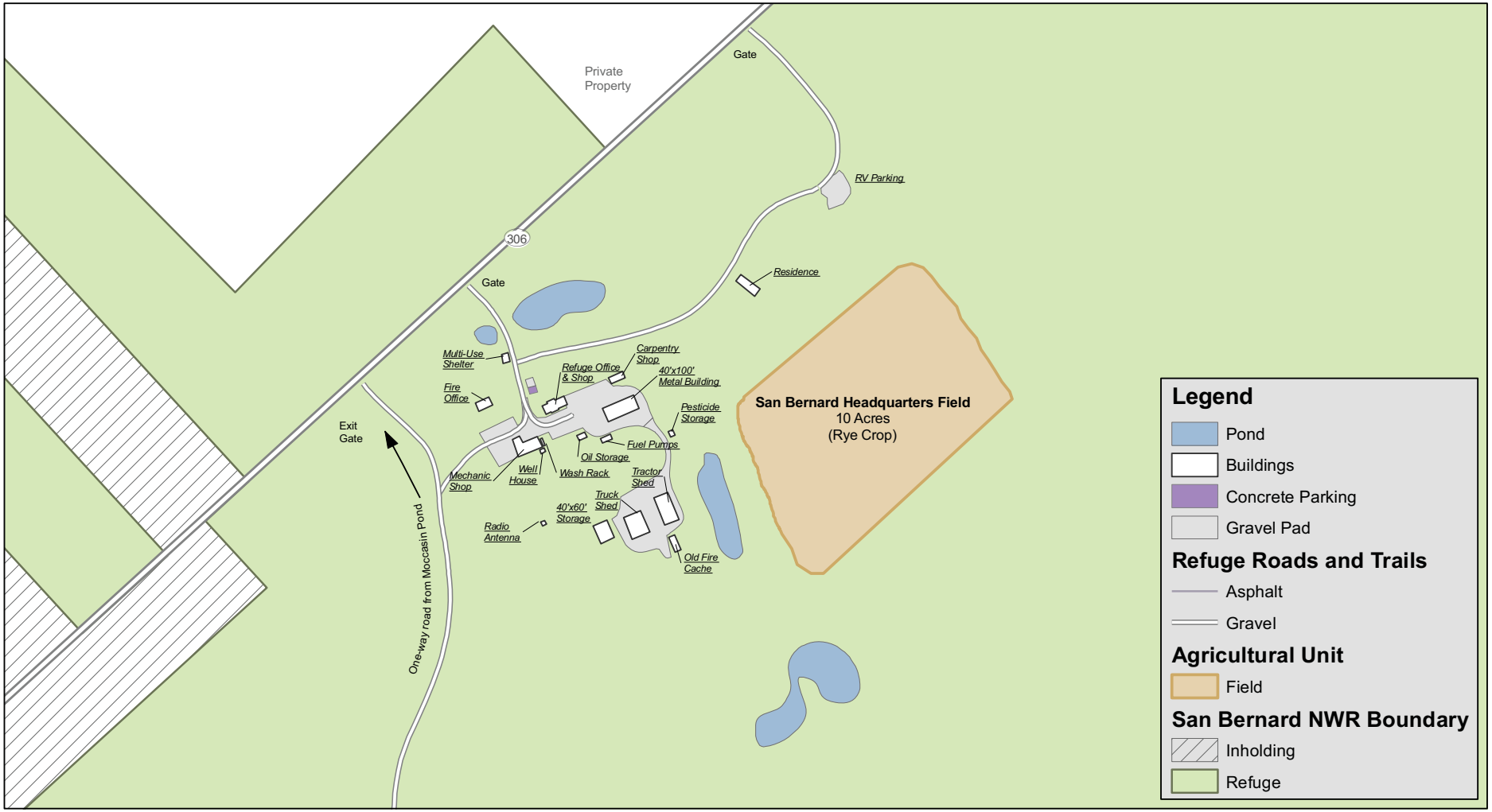
0 0.25 0.5 1 Miles
0 0.25 0.5 1 Kilometers

UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge
Brazoria County, Texas

Map 3-23. Agricultural Units



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_farm_5.24.11_shl

0 0.05 0.1 0.2 Miles

0 0.05 0.1 0.2 Kilometers

UTM ZONE 15
NAD 83

Haying

Brazoria NWR is the only refuge in the Complex that administers a cooperative haying program although haying has been utilized on San Bernard NWR in preparation of bottomland hardwood restoration. Cooperative haying of 35 to 50 acres annually on Brazoria NWR establishes wildfire buffer areas for Wildland Urban Interface (WUI) areas at the refuge. A WUI area is the zone where natural areas and development meet. These areas have gained increasing importance as more Americans build homes in rural settings adjacent to public lands. The cooperative haying program is designed to reduce fuel buildup in salty and coastal prairie habitats where prescribed fire cannot be implemented due to an expansion of WUI areas closing in on the refuge boundary. Two units, Halls Bayou near Santa Fe, Texas and Fire Hall Units near Demi John are currently hayed. Cooperative haying is generally conducted in late summer.

Mowing

Mowing is utilized as an alternative to fire when fire cannot be implemented do to habitat or weather conditions. In 2010, mowing was utilized on the Ducroz Unit during a period of extremely high wildfire potential. The County had been under a 6-month burn ban and north wind, which would enable the smoke to blow off-shore rather than inland toward inhabited areas, failed to develop. The cost of mowing is high but this cost is weighted by the potential of not completing an essential restoration project.

Water Management

Whenever possible, the Complex restores drained wetlands through plugging ditches or installing water control structures. Brazoria NWR restores the wetland component of wet prairie mostly by reshaping and building-up ditch borrows material. Water control structures are installed to manipulate water levels in the prairie, recreating a mosaic of freshwater wetlands and wet prairie. In addition, water delivery canals, and levees around farm field/moist soil units, are rebuilt to improve water management and movement capability across the units. Moist-soil Units are depicted on Maps 3-24 and 3-25 for Brazoria NWR, 3-26 for San Bernard NWR, and 3-27 for Big Boggy NWR.

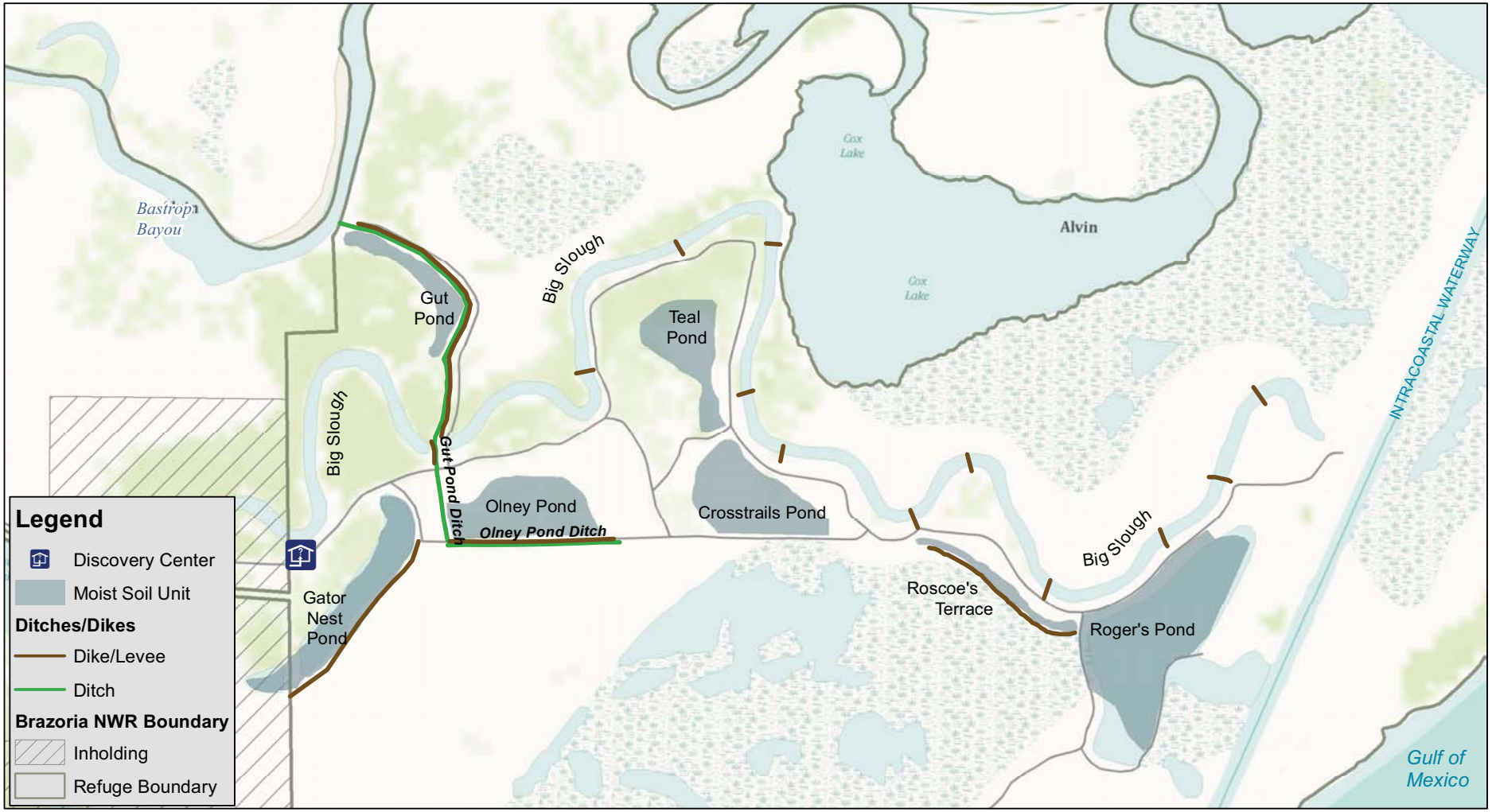
Ponds, Reservoirs, and Moist Soil Units

All refuges on the Complex manage moist soil units and fields with a combination of draining and summer discing, utilizing a stubble roller while flooded, and where opportunity exist, flood units with saltwater to control vegetation. Brazoria NWR manages 23 fields/ponds for moist-soil and freshwater habitats. San Bernard NWR manages two reservoirs along with four moist soil units and two ponds near Cocklebur Slough and five moist-soil units on near Sargent. The 2,000 acre Eagle Nest Lake will be restored to an emergent marsh in partnership with NRCS. Hudson Woods includes two natural oxbow lakes, one of which can be artificially managed with a large flashboard structure. A total of five moist-soil units have been constructed at Big Boggy NWR. Freshwater habitats can be extremely limiting during extended droughts, as seen in 2009 – 2011. The refuges continue to look for opportunities to provide freshwater resources. Potential expansion of the

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge
Brazoria County, Texas

Map 3-24. Moist Soil Units - Big Slough



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_big_slough_MSU_5.25.11_shl

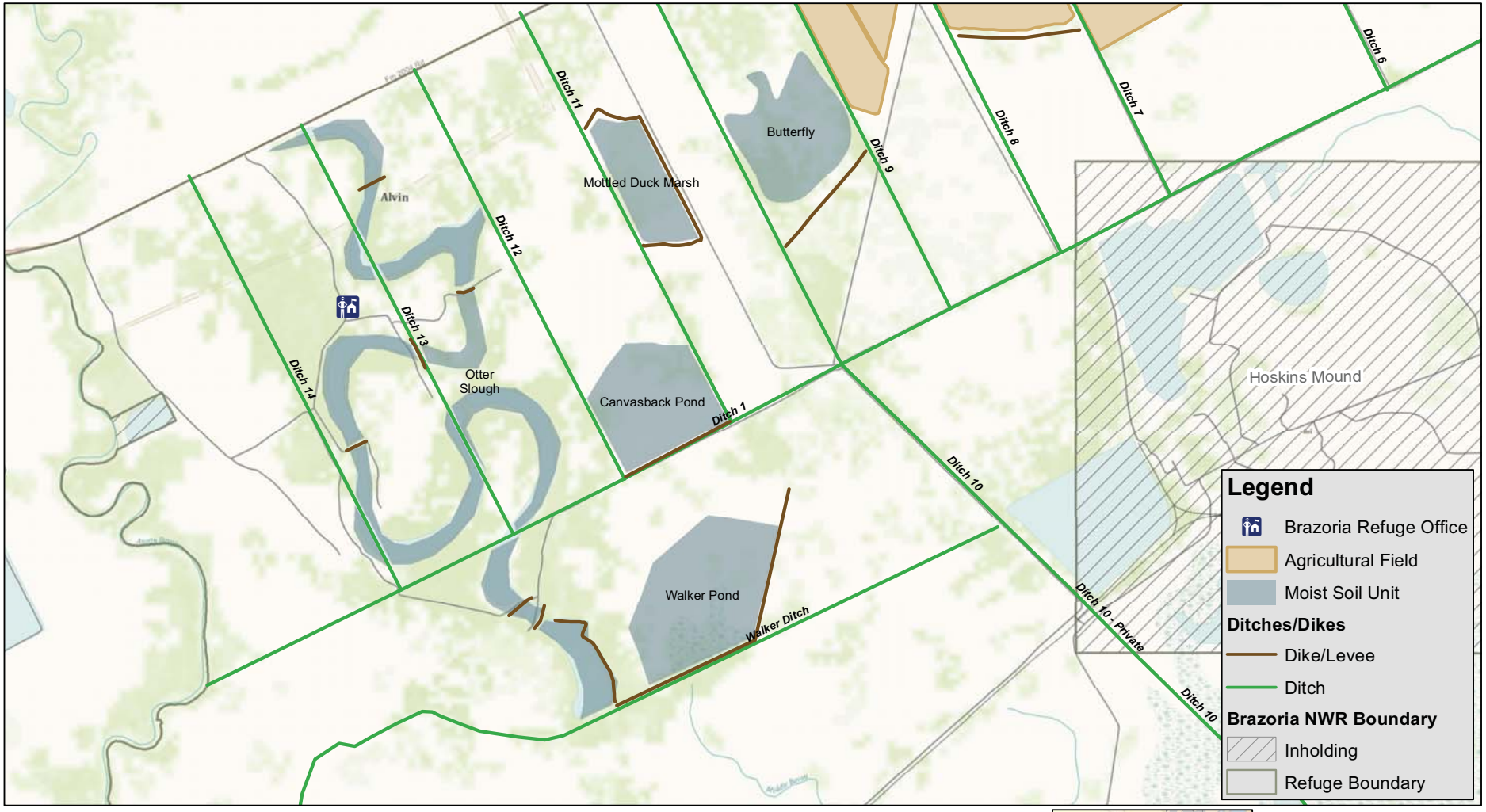
0 0.25 0.5 1 Miles
0 0.25 0.5 1 Kilometers

UTM Zone 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge
Brazoria County, Texas

Map 3-25. Moist Soil Units - North Refuge



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_north_MSU_5.25.11_shl

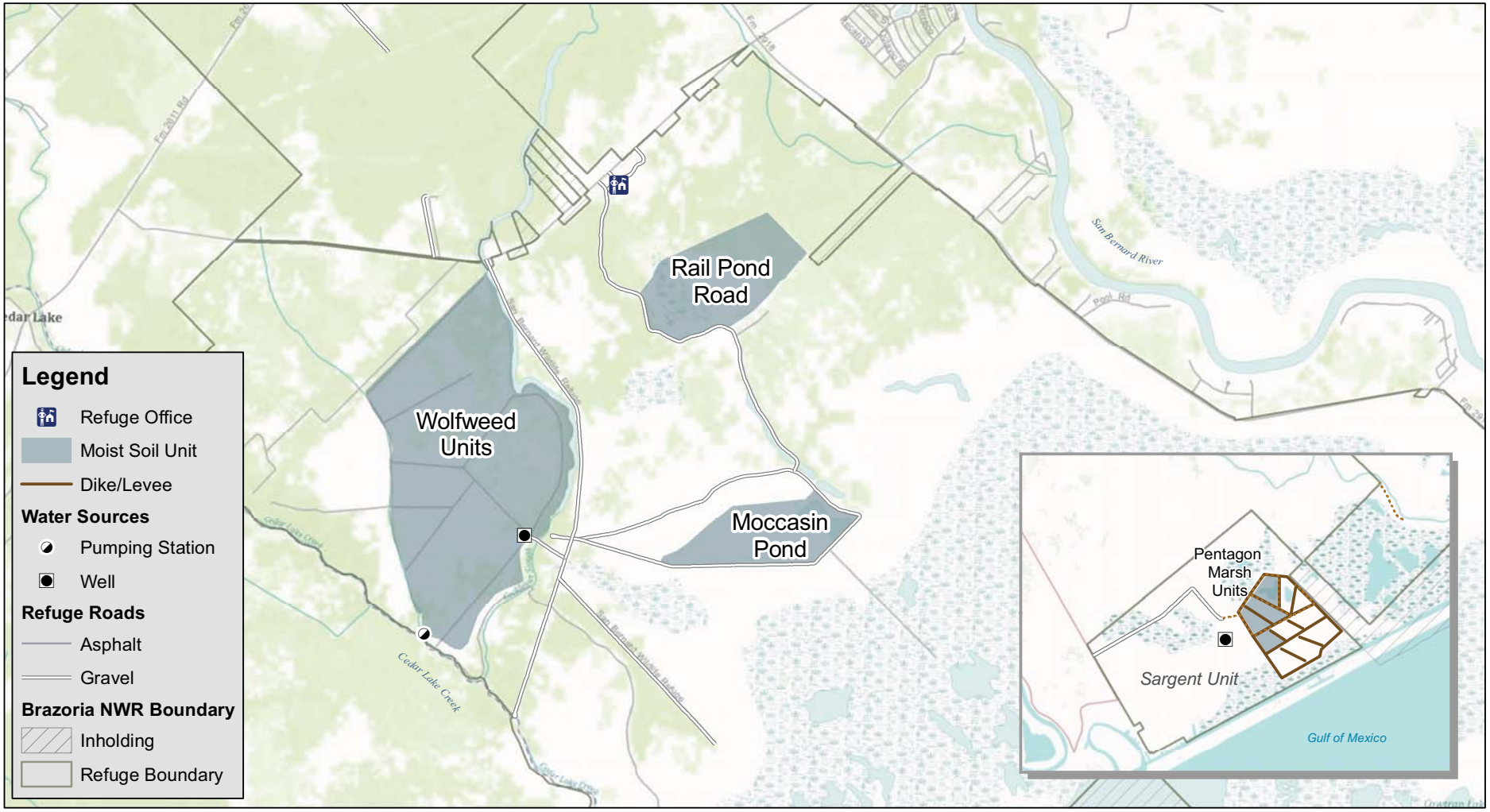
0 0.25 0.5 1 Miles
0 0.25 0.5 1 Kilometers

UTM Zone 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge
Brazoria and Matagorda Counties, Texas

Map 3-26. Moist Soil Units



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_MSU_5.25.11_shl

0 0.5 1 2 Miles
0 0.5 1 2 Kilometers

UTM Zone 15
NAD 83

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge

Matagorda County, Texas

Map 3-27. Moist Soil Units

PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: bbg_MSU_5.25.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

Wolfweed Wetlands on San Bernard and reestablishment of natural wetlands on future acquisitions near the Sargent Unit are being evaluated.

Water Delivery Canals

Brazoria NWR and Big Boggy NWR maintain irrigation canals on the refuges for water delivery and movement. The drainage district generally maintains ditches 1-14 on the Brazoria NWR, which includes Chinese tallow control, mowing and digging-out ditches. Several of the ditches are utilized for water delivery as well. There are no irrigation canals on San Bernard NWR.

Water Purchases

Brazoria NWR and Big Boggy NWR have the ability to purchase and receive water. Brazoria NWR may purchase water from the Gulf Coast Water Authority and Big Boggy NWR from Lower Colorado River Authority. Water purchase is dependent on rainy seasons and may not be an option in extreme drought years. During droughts, water is extremely limited and may not be purchased for agricultural use. Water purchases are determined on an annual basis and highly dependent on funding. Freshwater from rice fields is captured and can provide wetland habitat below the rice fields. Brazoria NWR purchased approximately $15,000 and $18,000 worth of water in 2008 and 2009, respectively. Big Boggy NWR purchased approximately $5,000 worth of water for the 2008 and 2009 fall/winter seasons. In 2011, Brazoria spent $30,000 to purchase water during the drought and provide a limited freshwater source. San Bernard NWR does not purchase water due to lack of infrastructure in place to support this operation.

Irrigation Wells

Brazoria NWR manages three irrigation wells but regularly uses only the two 4-inch wells at Teal Pond. During drought situations, these small pumps may provide the only freshwater in the Big Slough area. Water from this pump can be diverted to Teal, Olney, or Crosstrails Ponds. San Bernard NWR regularly utilizes two large irrigation wells. The 8-inch well at Wolfweed is a backup to the Cedar Lake Creek diversion pump and is used when Cedar Lake Creek is salty. A 12-inch pump at Sargent is utilized to provide fresh water in the moist-soil units in the Pentagon Marsh. This pump is essential to providing freshwater in this salt marsh habitat. There are no wells on Big Boggy NWR.

<u>Bottomland Hardwood Forest</u>

The bottomland hardwood forests are both a mix of old growth, sustainable habitats and newly regenerative habitats. The old growth forest habitat of the San Bernard NWR (parts of Dance Bayou, Bird Pond, Big Pond, McNeil, Wilson, and other units) largely require no direct management to maintain dynamic ecological processes. Many units previously cleared for tree harvesting and cattle grazing are susceptible to non-native species invasion. Invasive species control coupled with a propensity for regeneration has allowed many units to overcome extensive habitat damage. The San Bernard NWR has over 24,000 acres of bottomland hardwoods and associated habitats with continuing accrual of additional habitat and all the wildlife it harbors, under the auspices of the Austin's Woods Conservation Plan.

Dune and Beach

San Bernard NWR has approximately four miles of beach habitat between the mouth of the San Bernard River and Cedar Lakes Cut. Due to re-dredging of the San Bernard River in January 2010, the Cedar Lakes Cut has since silted-in, enabling vehicle access to the San Bernard Beach from the Sargent Beach during lower tides. To access the Cedar Lakes cut, vehicles traverse above the vegetation line due to the erosion of Sargent Beach. Prior to the silting-in of the Cedar Lakes Cut, the San Bernard Beach had been accessible only by boat for the past 12 years. The Complex is extremely concerned about the beach resources, where unlimited access is contrary to refuge purposes. San Bernard NWR is currently working with the Texas General Land Office to further protect the San Bernard Beach. Bollards were installed in 2011 to notify the public that the upper beach is part of Refuge and limit access. The Service needs to continue to educate the public on the importance of beach resources.

3.6.3 Wildlife Management

Threatened and Endangered Species

There are three birds (Attwater's prairie-chicken, piping plover, and whooping crane), one fish, (smalltooth sawfish), and five reptiles (Atlantic hawksbill, green, Kemp's ridley, leatherback, and loggerhead sea turtles) that are all listed under the Endangered Species Act, which potential habitat in or adjacent to the Complex. The Service identifies the Complex as having potential re-introduction areas for both the Attwater's prairie-chicken and the whooping crane. Biological staff conducts coordination and studies to determine the best potential management direction to maximize success if reintroductions occur on the Complex. The Service identified portions of the Complex as critical habitat for the piping plover. With current and proposed management actions, habitat restoration efforts are providing larger tracts of functional native habitat that have the potential to eventually provide suitable habitat for other listed species that have been historically documented in the vicinity of the Complex.

San Bernard NWR assists with the implementation of the Kemp's Ridley Sea Turtle Recovery Plan. This includes beach sea turtle surveys during nesting season (May–July), flipper tagging, excavating sea turtle nests and transporting them to the incubation facility at Padre Island National Seashore. The refuge monitors and responds to calls regarding sea turtles on Gulf Coast beaches between the mouth of the Colorado River and Quintana Beach.

Management of Invasive Species (Fauna)

Invasive species such as feral hog, nutria, red imported fire ants, and Rasberry crazy ants have negative effects to both wildlife and wildlife habitat. In addition, areas disturbed by feral hogs become prone to the establishment of exotic plant species. Nutria are rare, but are present in Complex water impoundments. Alligators generally hold their population in check. Red imported fire ants throughout the southeastern U.S. have seriously impacted numerous ground-dwelling species such as northern bobwhite quail. Researchers in the academia and land management arenas are evaluating their impact on mottled ducks and black rails. Populations of Rasberry crazy ants have not yet been located on the Complex. Impacts to tree and ground nesting birds, and reptile nests could be devastating if they move into refuge habitats.

Feral Hog
The Complex continues to issue special use permits for feral hog hunting with the aid of hounds or trapping in accordance with the Feral Hog Management Plan (2004). Permits are issued on a 6-month or 1-year time frame for a specific area on the Complex, including bottomland units. Hunters and trappers must provide harvest reports on a monthly basis to the appropriate refuge manager.

Brazoria and San Bernard NWRs partner with the Texas Youth Hunting Association and hold a youth feral hog hunt on two weekends per year. The refuges hold the hunt in February at San Bernard NWR and in March at Brazoria NWR. Through special use permits and youth hunting, approximately 150 hogs are removed from Brazoria NWR and over 500 removed from San Bernard NWR annually. In December 2011, a contract aerial hunting service was employed to remove hogs on Brazoria and San Bernard. The contractor removed 83 hogs on Brazoria during eight hours of flight and 305 off San Bernard in about eight hours of flight. A follow up flight in March 2012 removed in additional 125 hogs on San Bernard NWR.

The U.S. Department of Agriculture Wildlife Service continues to include Big Boggy NWR in their aerial hunting to control feral hogs in Matagorda County. Aerial hunting removes less than five hogs annually from the refuge.

Red Imported Fire Ants and Rasberry Crazy Ants
Throughout the Complex, staff treat rookery areas for red imported fire ants using methoprene (insect growth regulator) bait like Extinguish®. Treatments occur before nesting season in October-November when moisture starts and ants begin surfacing. At Brazoria NWR, staff treat Wolf Lake Skimmer Lot rookery with the same chemicals. San Bernard NWR staff treat Cedar Lakes rookery. At Big Boggy NWR, staff treat Dressing Point Island rookery.

The Complex is monitoring the Rasberry crazy ant, a recently discovered invasive species, for presence and wildlife impacts on the Brazos River Unit of San Bernard NWR. The ants are in a nearby hayfield, but have not been located on the Complex. Currently, no field treatment has been developed for these ants. As research and treatments become available, the Complex will use the best available science to control them. The Service partnered with the Gulf Coast Bird Observatory in 2010 to conduct initial monitoring of the Brazos River Unit for Rasberry crazy ants. A follow-up monitoring is scheduled in 2012.

3.6.4 Visitor Service and Infrastructure

Providing recreational opportunities, environmental education, and interpreting the unique natural resources of the Complex for visitors are important elements of the Service's mission and the goals and objectives of the Refuge System. As stated in the Refuge Improvement Act of 1997, six wildlife-dependent recreational uses were determined to be priority public uses on national wildlife refuges. These are hunting, fishing, wildlife observation and wildlife photography, environmental education and interpretation. These six uses, when compatible with each refuge purposes, are the focus of the Complex's public use activities.

The Complex may consider other public uses compatible if they are found to be supportive of the six wildlife-dependent recreational activities. The following describes public use opportunities on the Complex. Map 3-28 depicts the public use areas for Big Boggy National Wildlife Refuge. Maps 3-29 and 3-30 depict the public use areas for Brazoria National Wildlife Refuge. Maps 3-31 and 3-32 depicts the public use areas for San Bernard National Wildlife Refuge

Brazoria and San Bernard NWRs each receive approximately 35,000 visitors annually. About a quarter of the visitors come during the spring season (March–April) to view birds and enjoy the coastal prairie habitat when a variety of flowering plants are blooming. Approximately 5,000 visitors come to Big Boggy NWR for hunting and fishing opportunities.

3.6.4.1 Wildlife-Dependent Recreation Opportunities

Hunting

In 1966, and again in 1997, Congress recognized the legitimacy of hunting on national wildlife refuges. The Service is dedicated to providing opportunities for hunting as well as other compatible wildlife-dependent recreation. Hunting is an important wildlife management tool used to control populations of some species that might otherwise exceed the carrying capacity of their habitat and threaten the well-being of other wildlife species, and in some instances, that of human health and safety. The guiding principles that the Refuge System uses to manage quality hunting on refuges are: 1) to manage wildlife populations consistent with approved management plans; 2) to promote visitor understanding of and increase visitor appreciation for America's natural resources; 3) to provide opportunities for quality recreational and educational experiences; and, 4) to minimize conflicts with visitors participating in other compatible wildlife-dependent recreational activities.

The Complex strives to provide safe and high quality waterfowl hunting opportunities. Waterfowl hunting is a traditional, and still very popular, outdoor recreational activities in the region. Refuges and other public lands along the Texas Gulf Coast play a key role in providing hunting opportunities to the public.

<u>Brazoria NWR</u>

Brazoria NWR has two public waterfowl hunting areas. The Christmas Point Public Waterfowl Hunting Area lies southeast of the GIWW and encompasses approximately 4,000 acres. Access is by boat only. The Middle Bayou Public Waterfowl Hunting Area encompasses approximately 1,500 acres and allows boat or walk-in access to this site. The hunting of coots, ducks, geese, and mergansers is permitted in these designated areas, but pits and permanent blinds are prohibited (50 C.F.R. § 32.63). Hunters are required to use non-toxic shot. Hunting areas are open during the early teal season (September) and regular waterfowl season, which runs from late October through mid-January. Hunting Areas are open for hunting in accordance to state regulations during the Conservation Order Light Goose Season, following regular waterfowl season (Map 3-33 Brazoria National Wildlife Refuge Hunt Areas and Map 3-34 Brazoria National Wildlife Refuge Middle Bayou Hunt Areas).

San Bernard NWR

San Bernard NWR has three designated public waterfowl hunting areas and one permit hunting area. All of the public hunting areas are accessible by boat only, and open for the pursuit of coots, ducks, geese, and mergansers. They include the Cedar Lakes Public Waterfowl Hunting Area (2,400 acres) south of the GIWW and the Smith Marsh Public Waterfowl Hunting Area (1,400 acres) on the west side of Cedar Lakes Creek. Salt Bayou Public Waterfowl Hunting Area encompasses 3,600 acres and is accessible from Cedar Lake Creek, the GIWW, or through the shallow Cowtrap Lakes system. The Sargent Permit Waterfowl Hunt also offers a controlled walk-in and boat access hunting opportunity on 4,000 acres.

The public waterfowl hunting areas are open during the early teal season (September) and regular waterfowl season, which runs from late October through mid-January. The public waterfowl Hunting Areas are open for hunting in accordance to state regulations during the Snow Goose Conservation Hunt following regular waterfowl season (Map 3-35 San Bernard National Wildlife Refuge Hunt Areas).

Big Boggy NWR

Big Boggy NWR has two public hunting areas: the Pelton Lake Public Hunting Area, encompassing 1,100 acres on the east end of the refuge, which is accessible from Chinquapin Road or by boat, and the Matthes Field Public Waterfowl Hunting Area located at the north end of the refuge along Chinquapin Road. The Complex maintains this 200-acre area primarily for goose hunting, but both areas are open for the hunting of ducks, mergansers, geese, and coots. The public waterfowl hunting areas are open during the early teal season (September) and regular waterfowl season, which runs from late October through mid-January, and are open for hunting in accordance to state regulations during the Conservation Order Light Goose Season, following regular waterfowl season (Map 3-36 Big Boggy National Wildlife Refuge Hunt Areas).

Youth Hunts

In cooperation with TPWD and the Nannie M. Stringfellow WMA, San Bernard NWR permits TPWD to use the McNiel/Ducroz/Stringfellow Units during their youth hunts, held three weekends per year. The refuge provides this opportunity to youth hunters enabling standby hunters in excess of available blinds on the Stringfellow WMA to hunt. The Complex allows no baiting in association with the hunt. The refuge maintains nine hunt blinds on Service property for this cooperative hunt.

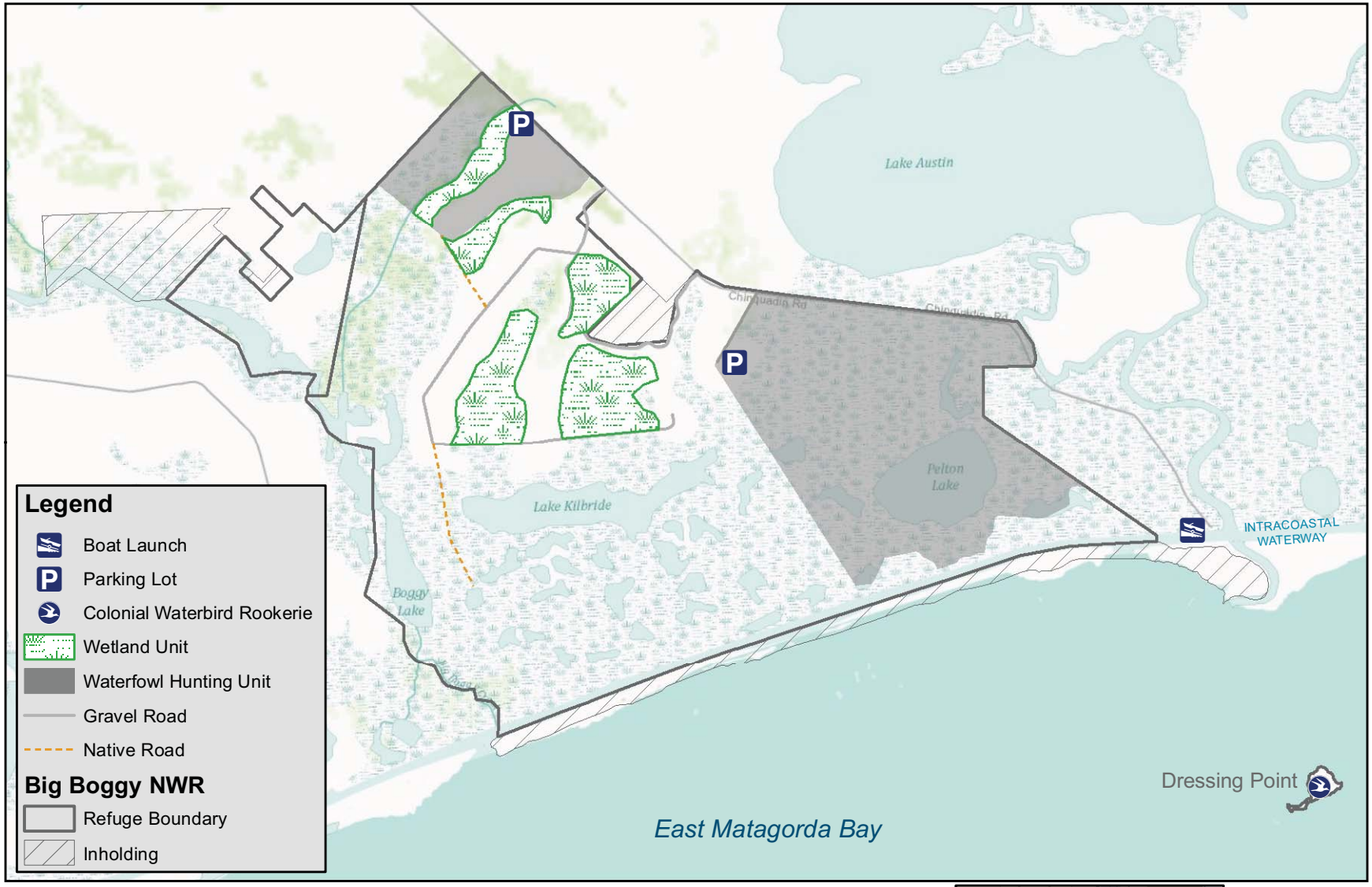
The Complex partners with the Texas Youth Hunting Program (TYHP) to provide up to two additional weekends of hunting opportunities for feral hogs at San Bernard and Brazoria NWRs. At San Bernard NWR, TYHP uses the same blinds as used by TPWD during their youth hunts. A special use permit issued to TYHP enables them access to the blinds, and for baiting during the hunt. At Brazoria NWR, TYHP erects portable blinds within Otter Slough and along ditches. The hunt has been successful over the past three years in removing an average of 35 feral hogs per year from the Complex.

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge

Matagorda County, Texas

Map 3-28. Public Use



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: bbg_public_use_8.5by11_5.19.11_shl

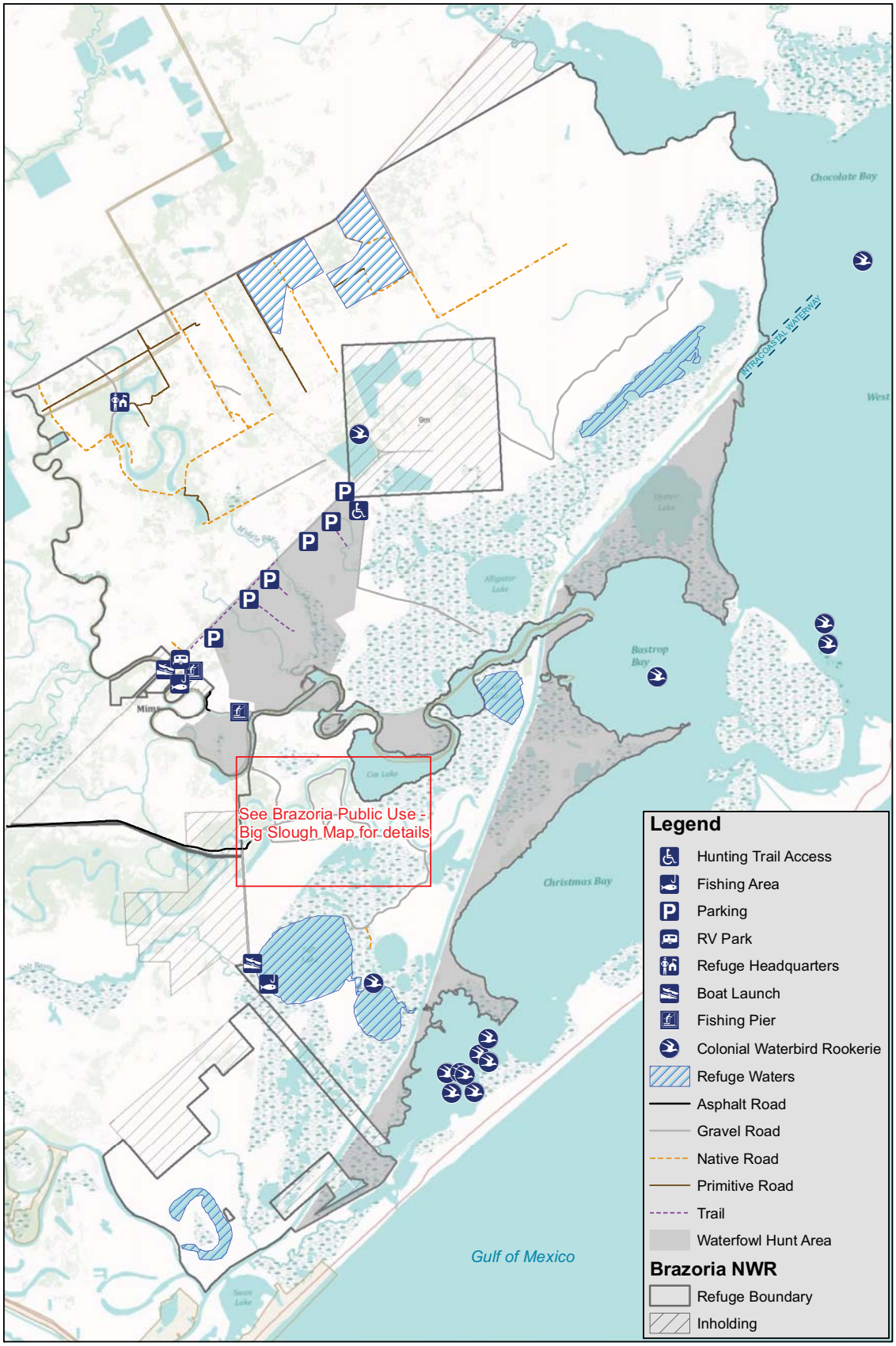
0 0.375 0.75 1.5 Miles

UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge
Brazoria County, Texas

Map 3-29. Public Use



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_public_use_5.19.11_shl

0 0.5 1 2 Miles
0 0.5 1 2 Kilometers

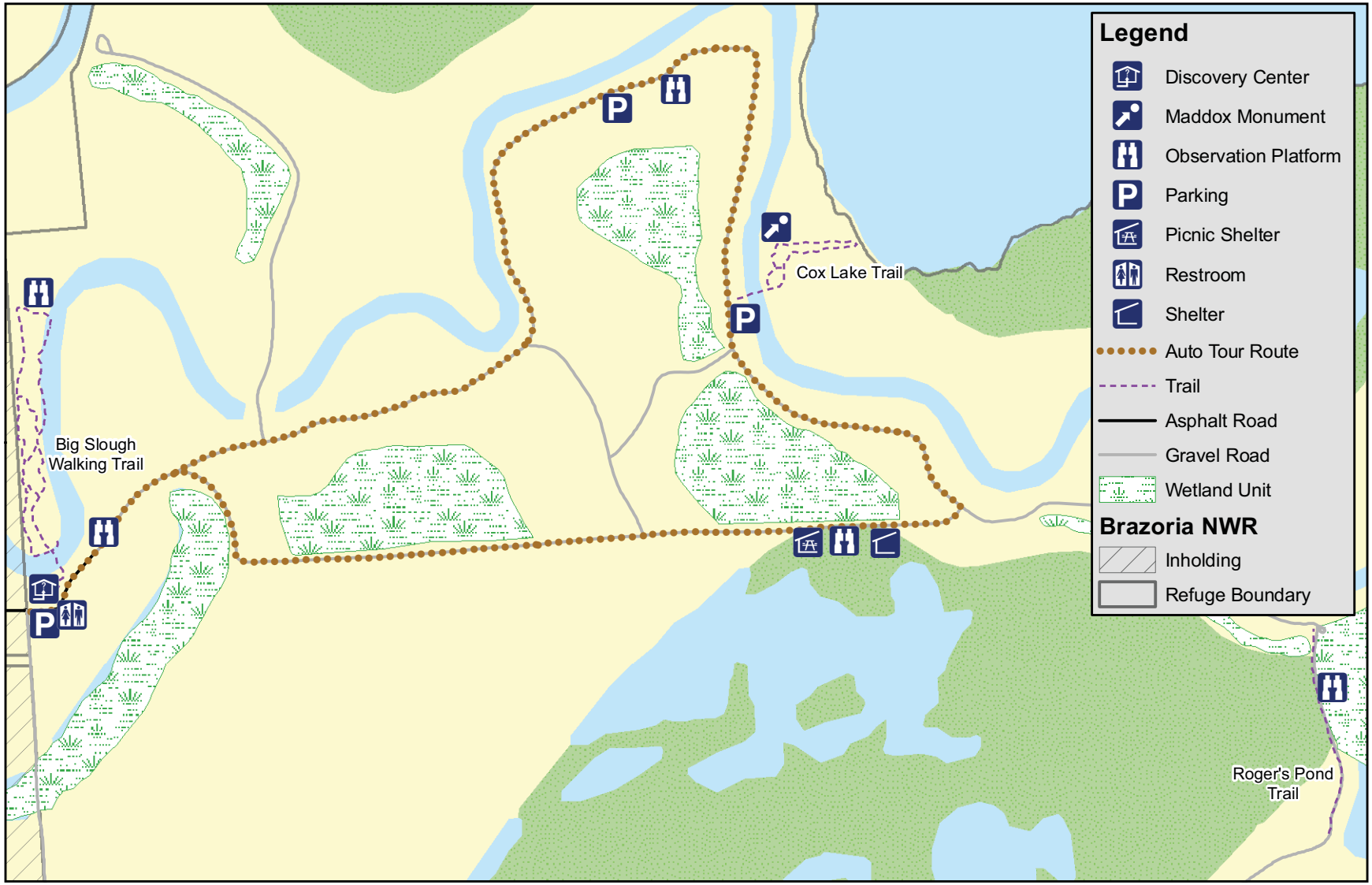
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge

Brazoria County, Texas

Map 3-30. Public Use - Big Slough Area



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_big_slough_pub_use_8.5by11_5.19.11_shl

0 0.2 0.4 0.8 Miles

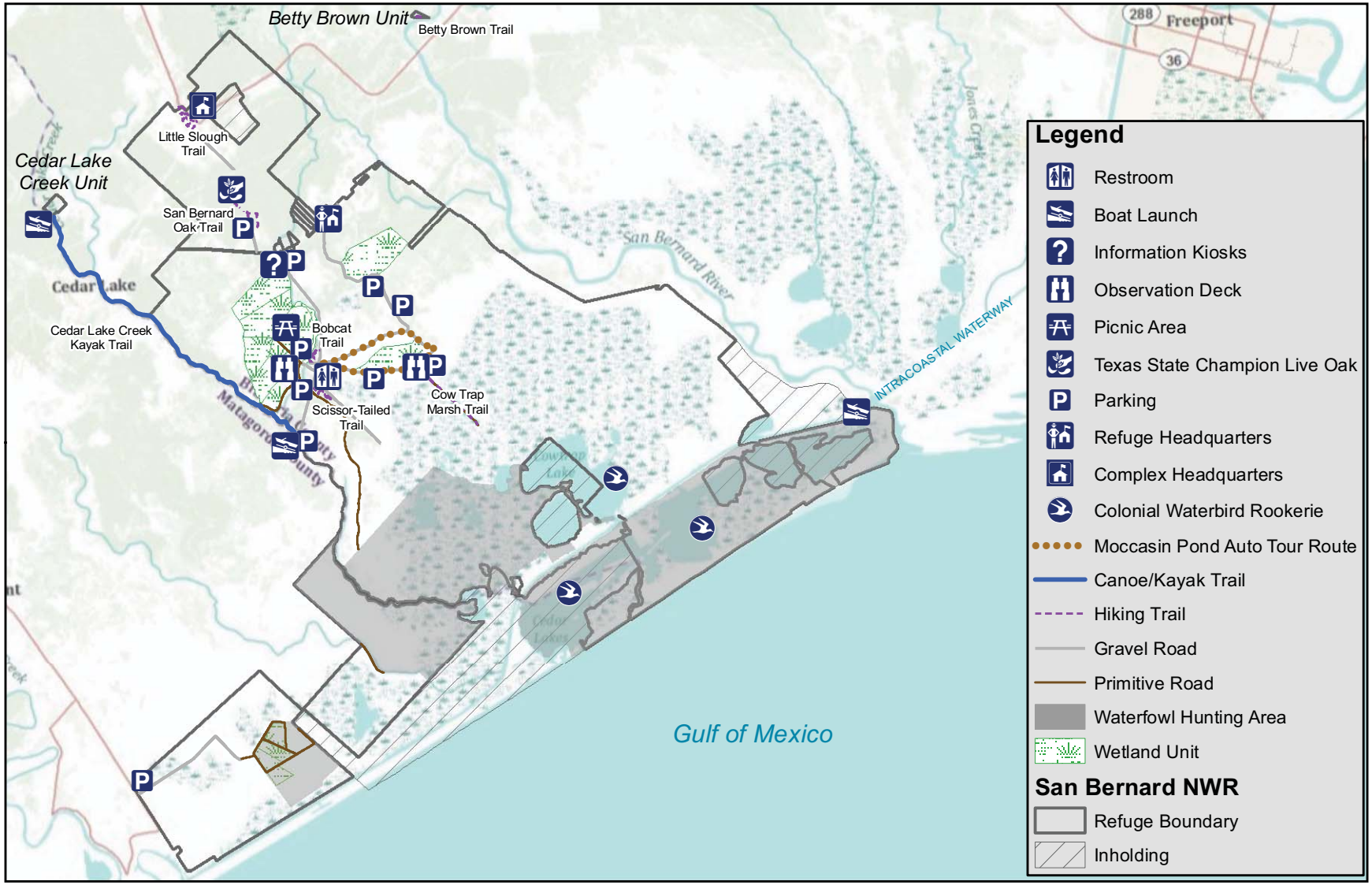
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

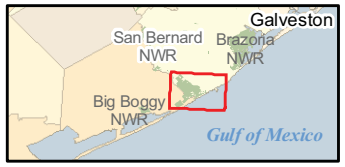
Brazoria and Matagorda Counties, Texas

Map 3-31. Public Use



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_public_use_8.5by11_5.20.11_shl

0 1.5 3 6 Miles



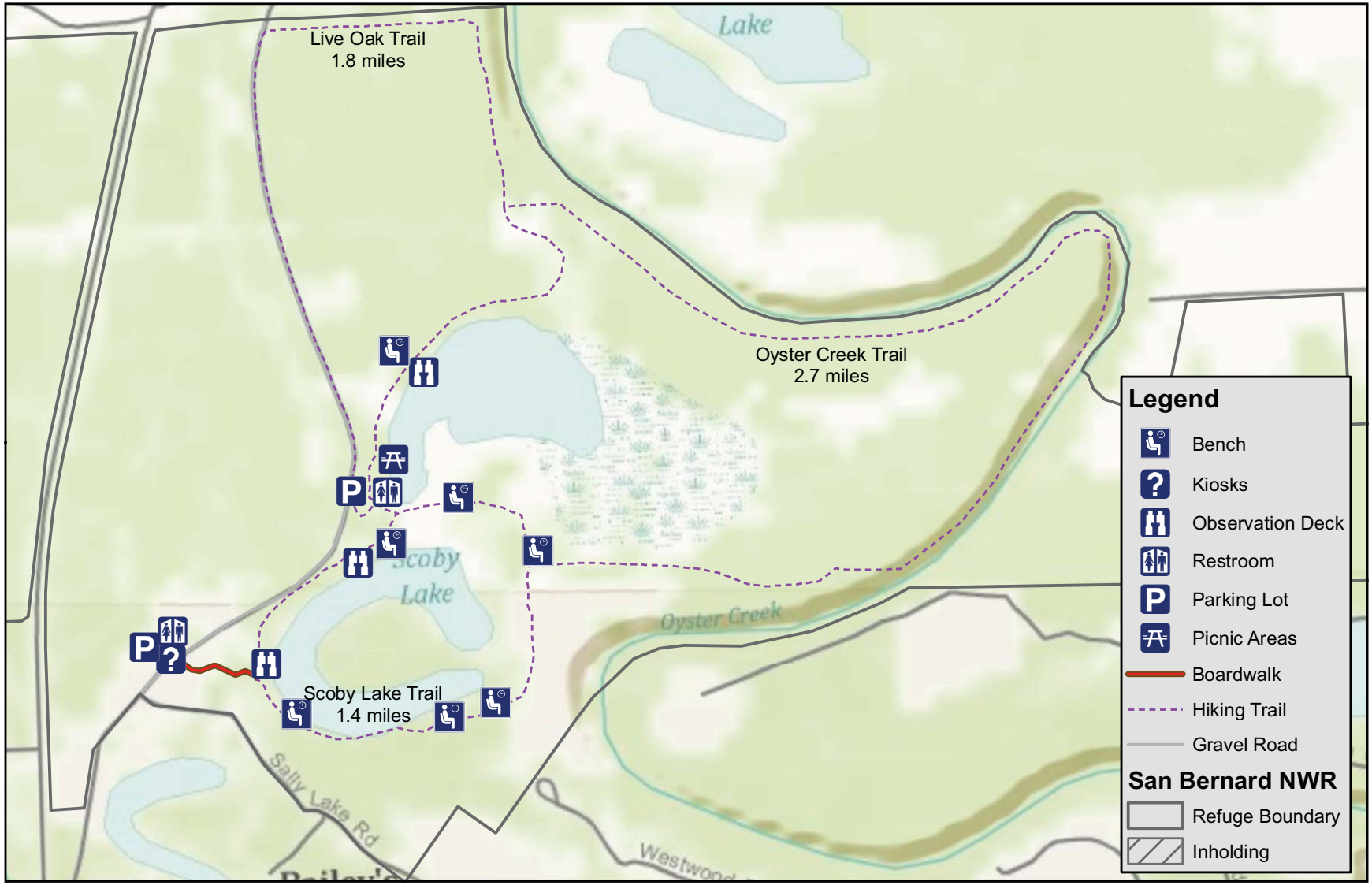
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria and Matagorda Counties, Texas

Map 3-32. Public Use - Hudson Woods Unit



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_hudson_wood_pub_use_8.5by11_5.20.11_shl

0 0.1 0.2 0.4 Miles

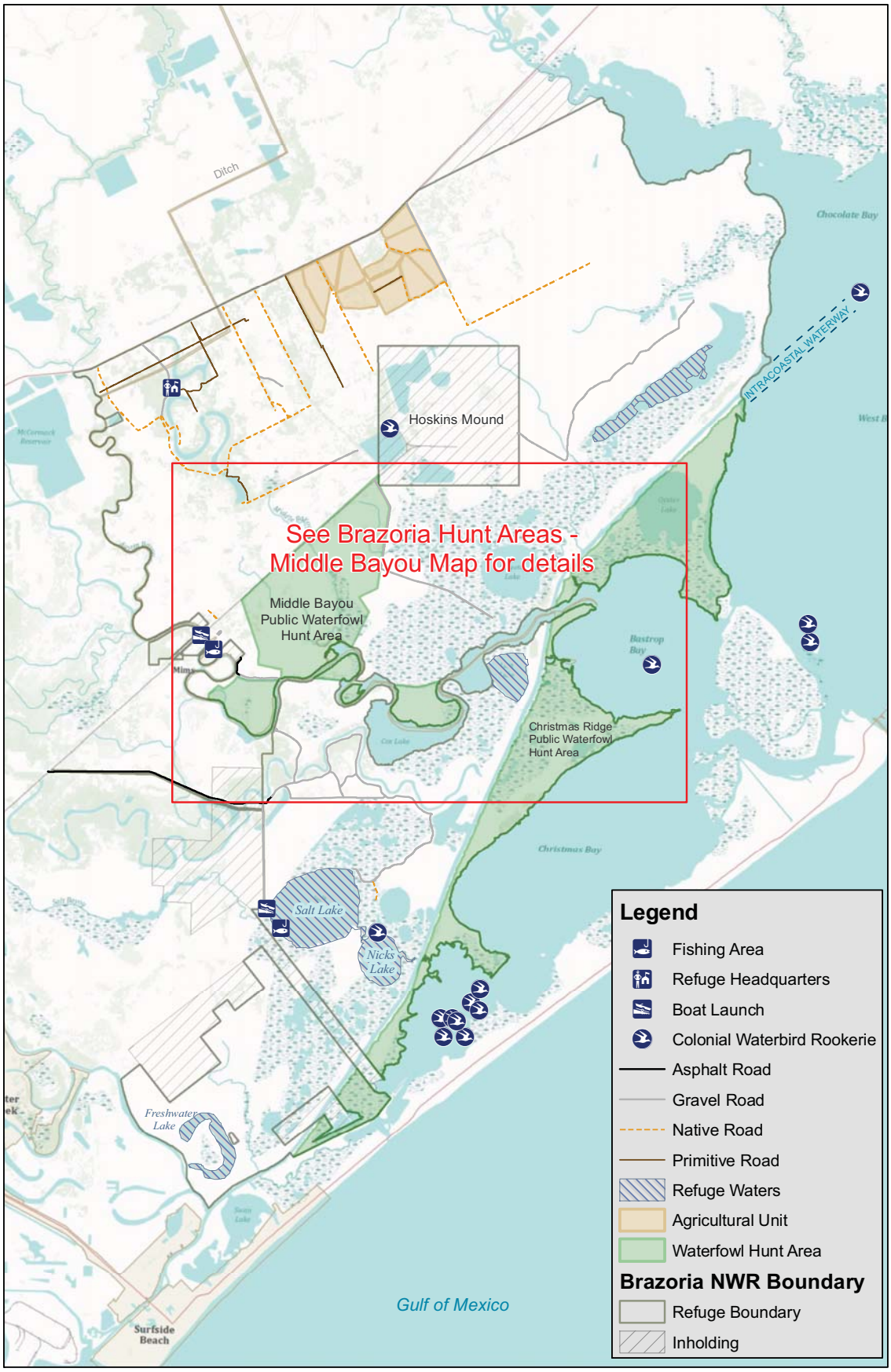
UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge

Brazoria County, Texas

Map 3-33. Hunt Areas



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_hunt_5.24.11_shl

0 0.5 1 2 Miles

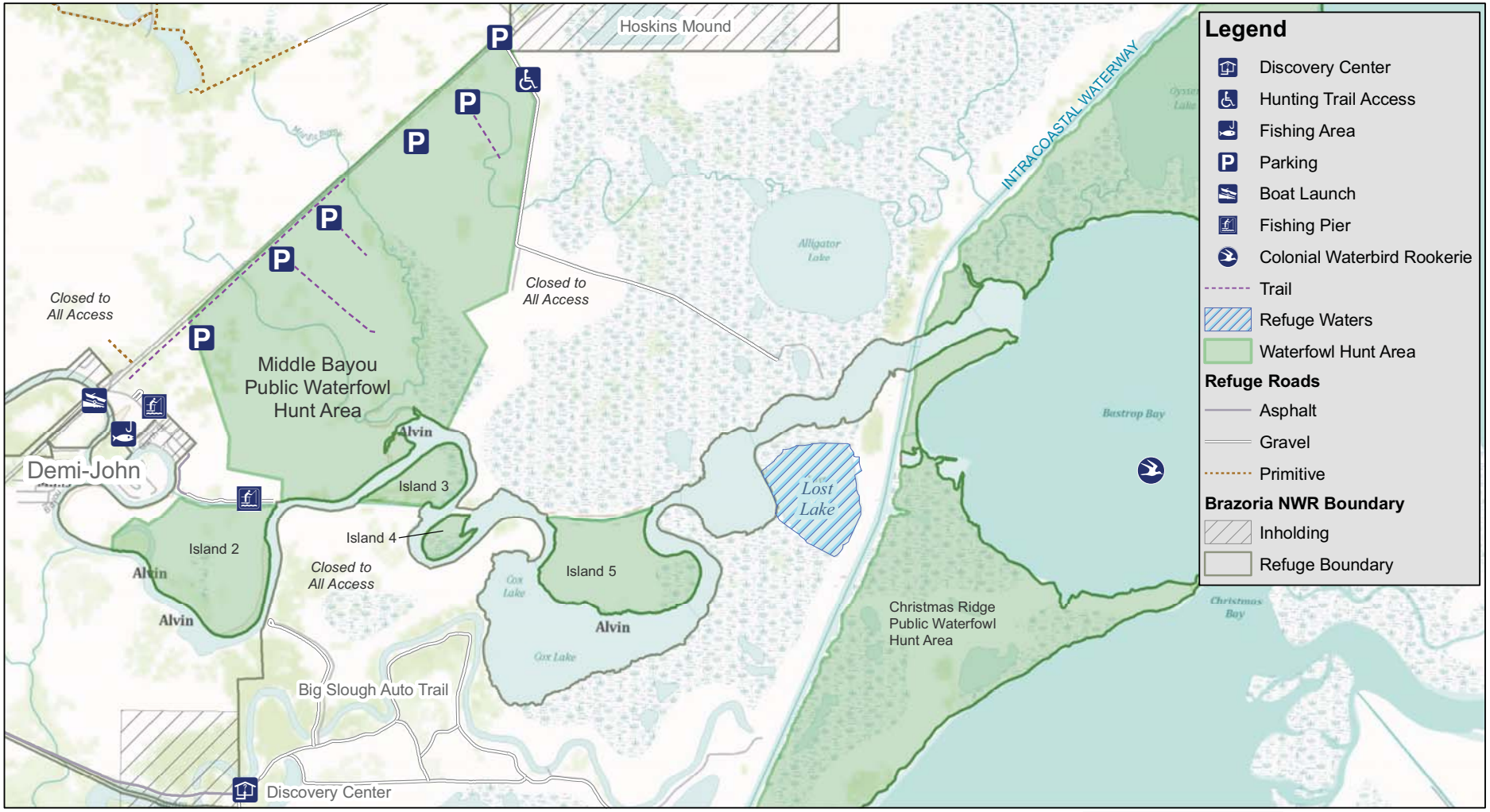
0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Brazoria National Wildlife Refuge
Brazoria County, Texas

Map 3-34. Hunt Areas - Middle Bayou



PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: brz_middlebayou_hunt_5.24.11_shl

0 0.5 1 2 Miles
0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

San Bernard National Wildlife Refuge

Brazoria and Matagorda Counties, Texas

Map 3-35. Hunt Areas

PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: May, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: snb_hunt_5.24.11_shl

0 1.5 3 6 Miles

0 1.5 3 6 Kilometers

UTM ZONE 15
NAD 83

U.S. Fish & Wildlife Service

Big Boggy National Wildlife Refuge

Matagorda County, Texas

Map 3-36. Hunt Areas

PRODUCED IN THE DIVISION OF REFUGE PLANNING
ALBUQUERQUE, NEW MEXICO
LAND STATUS CURRENT TO: 5/31/09
MAP DATE: Nay, 2011
BASEMAP: N/A
MERIDIAN: N/A
FILE: bbg_hunt_5.24.11_shl

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

UTM ZONE 15
NAD 83

Fishing

The Complex offers exceptional recreational fishing and crabbing opportunities in a saltwater environment. Due to increasing populations in the Houston Metropolitan Area, the Complex expects demand for fishing opportunities to increase over the life of the CCP.

Forty percent of the visitation on the Complex is for salt-water fishing where anglers can saltwater fish on refuge waters throughout the year. Anglers are treated to some of the best fishing for redfish, spotted sea trout, black drum, sheepshead, and flounder in Texas. Refuge law enforcement officers have stepped up patrol to prevent littering and illegal taking of fish, while educational efforts such as visitor contacts and kiosks have been increased to encourage anglers to collect and discard excess and old fishing line, hooks, and sinkers, since wildlife are known to die after ingesting this debris.

Brazoria NWR

The refuge has three public fishing areas that allow land access to salt-water fishing. Bastrop Bayou Public Fishing Area is accessible and offers a 200-foot pier with fish attracting lights, five paved bank fishing pull-offs, an accessible toilet, paved parking, and night-lights. This area is open 24 hours a day; however, the refuge does not permit overnight camping.

Excellent crabbing is also available from the pier. The Clay Banks Public Fishing Area offers bank fishing along a one-mile segment of Bastrop Bayou and is open daily from sunrise to sunset. The Salt Lake Fishing Area offers bank fishing and a non-motorized boat ramp and is open daily from sunrise to sunset. The Complex permits canoes, kayaks, and boats on Nicks, Salt, and Lost Lakes and two county boat ramps are available. One boat ramp is located on the west bank of Bastrop Bayou, off CR 227, and another ramp is located off CR 257 on the refuge's southwestern boundary.

San Bernard NWR

Public fishing is allowed in two areas. The Cedar Lake Public Fishing Area offers an accessible fishing pier, a fishing trail that offers bank fishing, and a public boat ramp that gives visitors access to Cedar Lake Creek. The San Bernard Beach is open for surf fishing. The Complex permits canoes, kayaks, and boats on Cedar and Cow Trap Lakes, and on Cedar Lake Creek. Saltwater fishing and crabbing are allowed in designated areas in accordance with applicable state and federal regulations. The refuge plans a second canoe/kayak launch north of CR 318 on Cedar Lake Creek.

Big Boggy NWR

Public fishing is limited to navigable waters of Boggy Creek and Lake and the portion of the refuge bordering the GIWW.

Wildlife Observation

The Complex strives to provide safe, enjoyable, high quality, and accessible wildlife observation opportunities while promoting visitor understanding for America's natural resources. Almost half of all visitors hike a trail, drive the auto tour, or spend a few moments at a wildlife overlook. The Complex provides a wide range of wildlife observation opportunities, supporting a rapidly growing nature tourism industry in Texas.

Bird watching continues to be the most popular form of wildlife observation. Most people prefer to visit during the cooler months of November through March when large concentrations of waterfowl are present. The spring and fall bird migrations are also popular for viewing neo-tropical songbirds. There are many interesting resident bird species here in the summer such as the roseate spoonbill, but the extremely hot and muggy weather deters many people. The refuges are known for their easily observed population of alligators. This one species brings more visitors to the Complex than any other. Mammals such as raccoons, armadillos, coyotes, and bobcats are observed on a fairly regular basis. Butterfly, dragonfly, and wildflower identification is starting to become popular with visitors.

Brazoria NWR

Brazoria NWR offers a 7.5-mile gravel auto tour loop through the Big Slough Recreation Area, wrapping around Olney and Teal ponds, and accessing Big Slough and Rogers Pond. The tour loop includes boardwalks, observation platforms, vehicle pullouts, trails, and butterfly gardens for wildlife observation. The three-mile, paved entrance road from County Rd. 227 (which passes through private lands) also provides wildlife viewing. The auto-tour is open daily from sunrise to sunset accommodating vehicle and bicycle traffic.

Several viewing areas outside the Big Slough Public Use Area are available to the public. The Middle Bayou trail allows visitors to hike or bike along a two-mile trail that follows the abandoned Missouri Pacific Railway line. The elevated trail starts at the Bastrop Bayou Public Fishing Area and offers views across the rare bluestem coastal prairie. Mottled Duck Marsh, off CR 208 on the refuge's northern edge, rewards visitors on the lookout for views of waterfowl, wading birds, and shorebirds. The farm fields along CR 227 and FM 2004 offers wildlife-viewing opportunities from the public roadway.

San Bernard NWR

San Bernard NWR offers wildlife observation and hiking at several locations, which are open from sunrise to sunset. The San Bernard NWR auto tour and Moccasin Pond auto tour loop provide 9.4 miles of gravel roads with observation platforms, vehicle pull-offs, trails, boardwalks, and a butterfly garden. The Cocklebur Slough Road provides opportunities to see wading birds, raptors, and passerines, as well as resident wildlife, in a light forest and grassland habitat. Moccasin Pond loop is at the edge where the salty prairie meets the high marsh. From the loop road, a variety of fresh and saltwater, marsh and grassland habitats support an array of migratory and resident wildlife. Bicyclists are welcome on all refuge roads that are open to public vehicles. The San Bernard Oak trail, which is located .5 mile north of the public use area, provides a .6 mile trail through a mature bottomland hardwood forest to the largest live oak in Texas. The trail crosses a slough before reaching the tree, which provides excellent opportunity for viewing wildlife including wood ducks, reptiles, and songbirds.

Hudson Woods, located five miles west of Angleton, on SH 521 provides 5.9 miles of walking trails in early and mid-succession stage bottomland hardwood forest. Walking the trails provides excellent opportunities for viewing winter and migratory songbirds. Two oxbow lakes provide opportunities for viewing waterbirds including anhinga, waterfowl, and

egrets. An observation deck at Scoby Lake and the deck on the front of the Discovery Outpost provide excellent opportunities to view wetland wildlife species.

Betty Brown, the smallest unit on the refuge, has a 3/8 mile loop trail that takes visitors to the shore of the San Bernard River. This mature-growth forest provides excellent opportunities to see migratory songbirds as they move inland from the Gulf of Mexico.

Dow Woods is the most recent bottomland hardwood forest unit opened to the public for wildlife observation opportunities. The unit is located on the north side of the City of Lake Jackson. Currently, 2.8 miles of trail are available for wildlife observation through a recently protected forest that is being allowed to develop into an old growth forest and along the shore of Bastrop Bayou. Native wildlife, including deer, armadillos, and raccoons, are commonly seen along with migratory songbirds, woodpeckers, and owls.

Big Boggy NWR

Big Boggy NWR only provides wildlife observation opportunities from the county road. Matthes Field and Wetland provide opportunities for viewing winter waterfowl.

Wildlife Photography

The Complex provides opportunities for wildlife photography in conjunction with wildlife observation. Photographing wildlife in a natural or managed environment fosters a connection between visitors and natural resources. A photo contest in conjunction with the annual spring Migration Celebration has attracted many new photographers to the Complex. The Complex provides local, regional, national, and international visitors with a wide range of photography opportunities, supporting a rapidly growing nature tourism industry in Texas.

Brazoria NWR

At Brazoria NWR a nature photography activity has been added to the DEEP. The DEEP educational program helps children develop an interest in the natural world at a young age. The Friends Group funded cameras for structured and unstructured exploration of nature. Interpretive programs also use these cameras.

San Bernard NWR

The San Bernard NWR has a photo blind at the Hudson Woods Unit. This blind has enhanced the visitor's opportunity for a quality wildlife experience and limits wildlife disturbance with a protected walkway and blind.

Environmental Education

The environmental education program provides safe, accessible, and high quality opportunities for both children and adults to learn about the refuge and habitats of the Texas Gulf Coast. Educational programs improve the quality of the visitor's experience and provide them with a better understanding of the benefits, issues, and challenges of natural resource conservation in the coastal ecosystem. The programs meet local and State of Texas education standards, allowing professional development for teachers, provides community-based service organization programs, meets youth group merit badge requirements, and instills a sense of stewardship and understanding of conservation issues.

Education programs typically involve groups of students of varying ages participating in on-site activities led by teachers or docents about the geological, biological, or ecological importance. This program could potentially serve up to 7 additional school districts, with limited expansion dependent upon the number of available docents as well as the carrying capacity of the environment. In addition to the activities of the docents, the Friends has a fundraising campaign to direct the generosity of individuals, corporations, and foundations that wish to participate in this program. The Friends Group has made use of grants to provide the equipment and supplies required for a high quality field experience. These include seines and other nets to collect specimens, testing equipment to study water chemistry, stereomicroscopes, a video microscope projector, and binoculars, as well as high quality displays and an aquarium.

Students are naturally curious and enjoy being outdoors, and this program taps into their enthusiasm and directs it into a science learning experience. Texas Department of Education mandates that a significant percentage of science education be in the form of lab and field investigations. This program makes a perfect fit. The experience provided at the Discovery Center influence the lives of students, and helps them appreciate the gift of living on the Texas Gulf Coast.

In 2011, the Complex initiated the Refuge Junior Naturalist Program. This program takes 15-18 youth in the 5th and 6th grade and provides them a variety of opportunities to not only learn but participate in refuge activities. The youth are welcomed in to the program at the beginning of the summer and then have the opportunity to participate in 14 different programs over the next seven months. These programs including learning how to excavate sea turtle nests, band birds, identify and treat invasive species, produce a video interpretive trail stop and capture and band raptors. The youth will maintain a nature journal during the program and complete two projects.

Brazoria NWR

The Discovery Center at Brazoria NWR has been in service since 2005, serving as a meeting site for refuge staff and the Friends Group, as well as a visitor contact station. However, its primary function has been as the focus for the Complex's active environmental education program. The Discovery Center has received high praise from visitors and the classroom/lab, outfitted with stereomicroscopes and a video microscope projector, has become a highlight for visiting students and adults. During the fall and spring, visitors may encounter groups of students as they learn about the natural world.

DEEP has been functioning on the refuge since 1994. DEEP currently serves approximately 3,000 students and in future years may expand to 6,000 students as the population of the area increases. The expansion of this program and the increasing number of students served may necessitate the use of additional areas. While there are small numbers of organisms, like aquatic insects, that the program temporarily removes from the habitat for observation, they return these organisms and students are taught the ethic of leaving the refuge in an undisturbed state, including prohibitions on picking wildflowers or removal of bird feathers.

DEEP teaches students the importance of good wildlife observation techniques, including moving slowly and quietly to produce the least possible disruption to the environment. At some sites, students have been involved with habitat restoration.

Students learn about freshwater ecosystems and the invertebrates they support through hands-on learning. Photo Credit: USFWS

A partnership exists between the Friends Group and area school districts to help with the financial impacts of the program expansion. The Complex has a Memorandum of Understanding (MOU) with the Brazosport Independent School District for this program and expects additional MOUs with other school districts. To help accommodate increases in demand for the program, workshops will be available to train teachers to lead their students through a high quality outdoor experience.

San Bernard NWR

DEEP has been functioning at the San Bernard NWR since 2003. DEEP currently serves approximately 500 students, and in future years, may expand to 1,000 students as the population of the area increases. The expansion of this program and the increasing number of students served may necessitate the use of additional areas. Activities occur primarily at the Hudson Woods Unit, making use of a small building (Discovery Outpost), the entrance road, and various trails. The involved habitats are bottomland hardwood forest and freshwater marsh.

Interpretation

The refuge communicates fish, wildlife, habitat, and other resource issues to visitors of all ages and abilities through effective interpretation. The refuge tailors messages and delivery methods to specific audiences and presents them at the Discovery Center and other locations. Interpretation enhances opportunities for a quality visitor experience. It also promotes visitor understanding for America's natural resources by providing safe, enjoyable, and accessible interpretive opportunities. Interpretation at the Complex provide opportunities for visitors to make their own connection with the resource through talks, publications, brochures, fact sheets, species lists, signs, interpretive panels, and exhibits. Exhibits are easy to read, understand, and are accessible. They contain audio and tactile elements that can benefit everyone through multiple paths to learning.

The Complex has recently upgraded interpretive materials including fact sheets, brochures, wayside exhibits, and trail signs.

Brazoria NWR
Brazoria NWR has a self-guided auto tour CD. Interpretive services include Discovery Center programs, group presentations, guided talks and tours, and special events. Open houses are used to provide unique educational opportunities to families, groups, and individuals. Activities include live reptile displays, animal track casting, seining for aquatic insects, and viewing the micro world. Hunting and fishing information kiosks are located at Bastrop Bayou Fishing Area.

The Big Slough Trail has a corresponding interpretive trail guide. Teal Pond observation platform has three interpretive panels providing information on migratory waterfowl. The information pavilion near the Discovery Center has four interpretive panels on recreational opportunities and wildlife specific information and identification.

San Bernard NWR
San Bernard NWR has five interpretive kiosks located at Bobcat Woods, Auto Loop entrance, San Bernard Oak Trail, Hudson Woods, and Dow Woods. Hunting and fishing information kiosks are located at Cedar Lake Creek, Sargent Unit, and Big Boggy NWR. San Bernard Oak trail has a corresponding interpretive guide and trail brochure. Bobcat Woods, Hudson Woods, and Dow Woods units have interpretive panels along each trail. Cedar Lake Creek Paddling Trail has an interpretive trail guide. San Bernard Office and screened shelter provide interpretive panels to welcome and orient visitors and introduce them to refuge resources.

3.6.4.2 Other Recreational Opportunities

Outreach
Outreach efforts consist of staff and volunteers participating in many community activities throughout the area. The Complex provides programs on a per-request basis to schools and local conservation and civic groups. Refuge staff attend Chamber of Commerce meetings and serve on conservation committees. The refuge staff and Friends members manned a Complex exhibit at the Brazos Bend State Park Earth Day Celebration in the summer of 2011 for about 2,800 people. The Friends Group manned an exhibit at the Feather Fest in Galveston, seen by 400 people. In addition, the Friends Group presented the Birds of Prey program at local schools to over 10,000 students and teachers. In the summer of 2011, refuge volunteers and staff presented reptile programs for the county library system for approximately 650 people. In past years, the refuge staff manned a booth at the Texas Expo in Austin, and participated in Coastal Expo in Freeport and other outreach events.

Picnicking
Picnic tables are available at multiple locations across the Complex for refuge visitor use in conjunction with other wildlife-oriented public use opportunities. Organized group picnicking, events, or parties are prohibited.

Bicycling
The Complex allows bicycling along all tour roads, Dow Woods Trails, and Middle Bayou Trail.

Canoeing/Kayaking
The Complex allows canoeing and kayaking on all navigable waters and in Salt Lake.

Special Events
The Friends Group host the Migration Celebration (speakers, seminars, trade show, field trips, and other activities) at San Bernard NWR. The event occurs in April each year. Over 1,000 visitors regularly participate in the annual event.

Cooperative Programs
The objective for community outreach and partnerships is to promote conservation of natural resources by working effectively with partners in support of the Services management programs on the Complex, including habitat management and restoration, fish and wildlife population management, and providing public recreational and educational opportunities. The Complex has a partnership with the Friends Group and Brazosport Independent School District.

3.6.4.3 Public Use Areas

The following public use areas are available on the Complex:

- Cedar Lakes Public Hunting Area, 2,400 acres.
- Smith Marsh/Salt Bayou Public Waterfowl Hunting Area, 5,000-acres.
- Sargent Permit Waterfowl Hunting Area, 2,900 acres.
- Middle Bayou Public Waterfowl Hunting Area, 3,300-acres.
- Christmas Point Public Waterfowl Hunting Area, 4,600 acres.
- Big Boggy NWR Public Hunting Areas
- San Bernard NWR Public Use Areas. An expansion of public uses in Hudson Woods occurred in October 2004 and Dow Woods in 2010.
- Brazoria Public Use Area; originally opened only one weekend a month, public use opportunities were expanded to daily use in 1993.
- San Bernard NWR Beach, between Cedar Lakes Cut and the San Bernard River is open for fishing, wildlife observation, and beach combing. In order to protect sensitive habitat and wildlife, the beach is closed to motorized vehicles above high tide. Boats can anchor on the refuge at the San Bernard River and Cedar Lakes to access the beach.

3.6.4.4 Public Use Access

Roads

<u>Brazoria NWR</u>
Big Slough Entrance road is a three-mile asphalt surfaced road that starts at CR 227 and ends at the Discovery Center parking lot (daily public use). Big Slough tour loop consists of 7.5 miles of limestone roads that begin and end at the Discovery Center parking lot (daily public use). Salt Lake road consists of 1.5 miles of limestone gravel that begins at the Discovery Center and ends at Salt Lake fishing area (daily public use). Otter Slough road is a one-mile

limestone road that starts at FM 2004 and ends at the Refuge Headquarters (public use during office hours). Clay Banks road is a one-quarter mile asphalt and three-quarter mile limestone road that starts at CR 476 and ends at turn around point (daily public use). Bastrop Bayou public fishing pier has a 4,000 square foot asphalt parking lot with five additional asphalt pull-offs and is located off CR 476 (24-hour public use). The refuge maintains and owns the roads described above, which are used by the public.

San Bernard NWR

Cocklebur Slough Entrance Road is a three-mile gravel road welcoming visitors from County Road 306, and leading them to the refuge's public use area and associated facilities. Off of Cocklebur Slough Road, Moccasin Pond Loop is a 3.8-mile gravel road that guides visitors around and through some of the best wildlife viewing opportunities on the refuge. The gravel, 2.5-mile Rail Pond Road is a one-way exit from the Moccasin Pond Loop. An abandoned county road traverses Hudson Woods (east of SH521). Although generally closed to vehicle access beyond the parking lot, the road provides access to the Discovery Outpost during special events. Sargent Road provides hunters access to the Sargent Permit Waterfowl Hunting Area. A short .8-mile road provides visitors to the San Bernard Oak Trail Head. Hunters can access the gate entering this road by registering with the San Bernard NWR Office. The Complex keeps all remaining roads on the core refuge and on bottomland hardwood forest units are closed to the public.

Table 3-11. Refuge Roads Information

Big Slough Entrance Road	3 miles	Paved
Big Slough AutoTour Loop	7.5 miles	Limestone
Otter Slough Road	1 mile	Limestone
Clay Banks	1.5 miles	Paved/limestone
Salt Lake Road	1.5 miles	Gravel
Cocklebur Slough	3 miles	Gravel
Moccasin Pond Loop	3.8 miles	Gravel
Rail Pond Road	2.5 miles	Gravel
Hudson Woods	1.3 miles	Gravel
Sargent	3.0 miles	Gravel
San Bernard Oak	.8 miles	Gravel
Hunter Access Road	0.3 mile	Gravel
Remaining Refuge Roads	6.2 miles	Gravel/shell/unimproved

Big Boggy NWR

Big Boggy NWR has one road seasonally opened to the public. The Hunter Access Road is a 0.3-mile gravel road providing walk-in access to the Pelton Lake Hunt Area. The remaining refuge roads, 6.2 miles, are a mix of gravel, shell, and unimproved service roads used for management purposes.

Trails

San Bernard NWR

San Bernard NWR has a total of twelve hiking trails and one paddling trail. Bobcat Woods Trail (1.5 miles) offers an accessible boardwalk winding through shady woods along Cocklebur Slough. A hot spot for spring migrant birds, the trees also shelter year-round residents like barred owls. The boardwalk leads to an accessible platform that overlooks the reservoir and moist-soil units of the Wolfweed Wetland Project. At the trailhead are restrooms, interpretive displays, tables, and a demonstration native garden for hummingbirds and butterflies.

Other trails along the San Bernard Auto Tour include the Cowtrap Marsh Trail, which provides an opportunity to hike from the high marsh through intermediate to low marsh habitat along a 1.5-mile long man-made levee. The trail crosses a huge marsh and prairie dotted with small potholes. Scissor-tail Trail (0.8 miles) provides an opportunity to stroll through a brush habitat that attracts numerous passerines. The Cedar Lake Creek Trail is a .20-mile trail following the creek for fishing or hiking opportunities. The 8-mile Cedar Lake Creek Paddling Trail starts at the boat ramp and goes up the creek through the shady bottomland hardwood forests. The terrain along the creek is flat, with fast water only after a hard rain. The Complex developed a trail guide brochure with 10 interpretive stops for the paddling trail.

Refuge trails in the bottomland hardwood forest units include: the .45-mile Little Slough Trail, which is next to the Complex office. The Betty Brown Trail is a .36-mile trail that passes through the bottomland hardwood forest, crosses a slough, and meanders to an overlook point on the San Bernard River. At San Bernard Oak Trail, visitors will experience the natural beauty of the wetlands and bottomland forests along this 0.7-mile trail. The Hudson Woods Unit has three hiking trails. Scoby Lake Trail is a 1.4 miles long loop, circles Scoby Lake. An accessible 800-foot boardwalk begins at the parking lot and winds through the woods to Scoby Lake with a small observation deck on the lake. The Live Oak Trail, 1.8 miles long, circles the north end of the property and follows Oyster Creek. The Oyster Creek Trail is a 2.7-mile trail following Oyster Creek.

Dow Woods includes Tveten trail, a 0.9-mile concrete loop, and Bayou Loop (1.9 miles) gravel trail.

Brazoria NWR

The Big Slough Boardwalk and Trail crosses over, and along the edges of a major slough. The gravel trail meanders through low forests of yaupon and hackberry trees and small clearings to an observation platform. The main loop is 0.6 mile long; other loops run 0.1, 0.25, and 0.5 miles. The trail begins and ends at the visitor Information Pavilion.

The .58-mile Cox Lake grass trail starts at Big Slough and meanders through salt cedars to the Maddox monument. This monument is the 1890 home site of Koger Thomas Maddox. From here, the trail wander over a salt grass prairie to Cox Lake then follows cedars back to the parking lot.

At the Middle Bayou Trail visitors can hike or bike along a two-mile gravel trail that follows the abandoned Missouri Pacific Railway line. The elevated trail starts and ends at the Bastrop Bayou Public Fishing Area.

Table 3-12. Summary of Refuge Trail Information

Big Slough	0.6 miles with additional loops	Boardwalk/Grass
Cox Lake	0.58 miles	Limestone
Middle Bayou	2 miles	Gravel
Clay Banks	1.5 miles	Paved/limestone
Bobcat Woods	1.5 miles	Boardwalk
Cowtrap Marsh	1.5 miles	Man-made levee
Scissor-tail	0.8 miles	Grass
Cedar Lake Creek	0.2 miles	Dirt
Cedar Lake Creek Paddling Trail	8 miles	Water
Little Slough	0.45 miles	Dirt
Betty Brown	0.36 miles	Dirt
San Bernard Oak	0.7 miles	Dirt
Scoby Lake	1.4 mile loop	800 Ft Boardwalk/Grass
Live Oak	1.8 miles	Dirt
Oyster Creek	2.7 miles	Dirt
Tveten Trail	0.9 miles	Concrete Loop
Bayou Loop Trail	1.8 miles	Crushed granite
No Trails on Big Boggy		

Waterways

Brazoria NWR

Public waterways surrounding the refuge include Basrop Bayou, Austin Bayou, GIWW, Chocolate Bay, West Galveston Bay, Bastrop Bay, Christmas Bay, Drum Bay, and Oyster Creek. Public waterways within the refuge boundary include Salt Lake, Nicks Lake, Cox Lake, Lost Lake, Alligator Lake, Oyster Lake, Essex Bayou, and Middle Bayou. Non-motorized boat launches exist at Salt Lake and Clay Banks fishing areas.

San Bernard NWR

Units of the San Bernard NWR adjoin the San Bernard River, Brazos River, GIWW, Cedar Lake Creek, Bastrop Bayou, Oyster Creek, and Linville Bayou, which are all public

waterways. The Cedar Lakes and Cowtrap Lakes are navigable estuaries within the boundaries of the refuge. In addition, several prominent sloughs, creeks, and wetlands are located within or adjacent to bottomland hardwood forest units. A boat launch is available at Cedar Lake Creek.

Big Boggy NWR
The GIWW and East Matagorda Bay border the refuge on the south and Boggy Creek on the west.

3.6.4.5 Public Use Facilities

Public Use Facilities
Access to the Complex is provided primarily to facilitate the six priority public uses of the Refuge System (hunting, fishing, wildlife observation, photography, and environmental education and interpretation). The Complex allows public access in designated areas and along designated routes of travel (e.g., roads, trails, waterways, and other routes). Designated routes of travel can be public roadways (e.g., state or county roads) and waterways or refuge roads, trails, and waterways. Various funding sources provide the maintenance, improvements, and additions to refuge routes of travel and access, with one of the main sources being the Refuge Roads Program (RRP).

Environmental Education Center
The Discovery Center is approximately 1,500 square feet and includes a visitor contact area, lab, and office. It supports up to 50 students at a time. It consists of interpretive displays and live animal exhibits and dioramas. It contains a large screen television and projection screen for interpretive programs. An open pavilion that overlooks Big Slough is behind the Discovery Center.

Interpretive Signs / Kiosks
The Complex provides 32 interpretive exhibits, 18 trailhead signs, and six orientation wayside exhibits. The Complex primarily uses directional signs, trail and tour loop stops, facility signs, refuge signs, and refuge unit signs constructed of recycled plastic to reduce climatic wear and tear.

Cedar Lake Creek enables kayakers a great opportunity to view wildlife and natural forested habitats along an inland waterway between two refuge launch areas.
Photo Credit: USFWS

Parking/Viewing Locations
Brazoria NWR has seven viewing locations. There are viewing locations at Crosstrails Pond, Teal Pond and Rogers Pond. The Big Slough Recreation Area has a viewing area at the Big Slough Pavilion. There are also viewing areas at Bastrop Bayou

fishing pier and at Salt Lake. Viewing shelters include three at Crosstrails three at Big Slough, and Maddox Monument. San Bernard NWR has eight viewing platforms; Cedar Lake Creek boat ramp, Wolfweed Reservoir, Moccasin Pond, San Bernard Oak Trail, Scoby Lake, two at Bobcat Woods, and one at Dow Woods.

Photography Blinds
The Complex constructed one photography blind at Hudson Woods on the Live Oak Trail.

Visitor Contact Station
An information pavilion is available at Big Slough when the Discovery Center is closed. During business hours, all offices (San Bernard and Brazoria NWRs, and the Complex office) provide visitor information.

Fishing Piers
The Bastrop Bayou Fishing Pier at Brazoria NWR is a 200-foot lighted pier, open 24 hours a day. In addition, five pull-offs are available for fisherman to pull up to the bank of the Bayou. A 20-foot-by-10-foot fishing pier is available at the Cedar Lake Creek boat launch for fishing and wildlife observation.

Restroom Facilities
Self-contained restroom facilities are available at Hudson Woods Cabin, Hudson Woods Parking area, Dow Woods, and Bobcat Woods. Port-a-can facilities are located at Bastrop Bayou and Salt Lake fishing areas and Crosstrails on the Big Slough Tour Loop. Restroom facilities are adjacent to the Discovery Center.

3.6.5 Special Management Areas

This section identifies special management areas designated within the Complex. The "special" status of lands within individual refuges may be recognized by additional designations (i.e., legislative or administrative). Special designations may also occur through the actions of other agencies or organizations. The influence that special designations may have on the management of lands and waters within refuges may vary considerably.

3.6.5.1 Wilderness Areas

The 1964 Wilderness Act (WA) recognized wilderness as a resource in and of itself and established a mechanism for preserving that resource in a national system of lands and waters. The definition of wilderness found in the WA provides a framework for identifying and describing wilderness values. According to the WA, the fundamental qualities of wilderness are: undeveloped, untrammeled, natural, and outstanding opportunities for solitude, or a primitive and unconfined type of recreation. In addition, the WA states that wilderness "may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value."

There are no designated wilderness areas on the Complex. Refuge planning policy 610 FW 4 requires a Wilderness Review as part of the comprehensive conservation planning process.

After completing the inventory phase of the Wilderness Review, the team determined that the Complex does not have any inventory units that meet the minimum criteria for a Wilderness Study Area. Therefore, the team does not recommend any land areas as designated Wilderness. The Complex's Wilderness Review is provided in Appendix H.

3.6.5.2 Research Natural Areas

The Service recognizes the importance of preserving plant and animal communities in a natural state for research purposes. Research Natural Areas (RNAs) on national wildlife refuges are part of a national network of research areas under various ownerships. This network is the result of a designation system recognized by other federal land administering agencies and the Federal Committee on Ecological Reserves. RNAs are intended to represent the full array of North American ecosystems; biological communities, habitats, and phenomena; and geological and hydrological formation and conditions. RNAs are areas where the Complex allows natural processes to dominate without human intervention. However, under certain circumstances, we use deliberate manipulation to maintain unique features that the RNA was established to protect.

The National Wildlife Refuge System Administration Act of 1966 delegates designation and management of RNAs to the Director of the Service. The Service administers 210 RNAs on refuges nationwide comprising a total of 1,955,762 acres. The Service's Southwest Region administers 27 RNAs totaling 59,940 acres on 14 national wildlife refuges. The Complex contains one RNA, Christmas Point Research Natural Area, totaling 175 acres.

General Management of RNAs
Service policy 8 RM 10.8 states that "RNAs must be reasonably protected from any influence that could alter or disrupt the characteristic phenomena for which the area was established." Activities on RNAs are limited to research, study, observation, monitoring, and educational activities that are non-destructive, non-manipulative, and maintain unmodified conditions. Policy encourages scientific use by scientists and educators, providing their activities do not impair or threaten the features of the areas; the refuge should discontinue public uses that contribute to modification of the areas or expressly prohibit them if such uses threaten serious impairment of research or education values. A natural area management plan should govern use of RNAs by what is compatible with established refuge objectives.

3.6.5.3 Other Special Management Areas

Western Hemisphere Shorebird Reserve Network (WHSRN)
WHSRN is an international strategy for saving shorebirds and their habitats. This strategy follows the simple idea that to sustain healthy populations of shorebirds, we must maintain the ecological integrity of key sites, those specific locations that provide the habitats and nourishment needs for survival (www.whsrn.org).

There are three designations recognized by WHSRN that include:

1. Sites/Landscapes of Hemispheric Proportions—Receives at least 500,00 shorebirds annually or at least 30 percent of a species bio-geographic population
2. Site of International Importance—Receives at least 100,000 shorebirds annually or at least 10 percent of a species bio-geographic population
3. Site of Regional Importance—Receives at least 20,000 shorebirds annually or at least 1 percent of a species bio-geographic population

In order to incorporate an area into one of these three designations, a partner or landowner nominates the area for one of these three categories of designation by the WHSRN hemispheric Council. Additionally, to qualify for a WHSRN designation, the sites landowner(s) must agree to:

1. Make shorebird conservation a priority
2. Protect and manage shorebird habitat
3. Keep WHSRN informed of any changes at the site

The Service recognizes the Complex as a Site of International Importance because it annually supports more than 100,000 shorebirds. The refuges include a myriad of habitat types, including tidal mud flats, shell beaches, fresh, brackish, and salt marshes, impoundments, rice fields, and moist-soil areas. Several thousand acres of both salty prairie and coastal prairie are also present.

The Complex hosts at least 30 shorebird species. Most common winter residents include: American avocet, willet, dunlin, dowitcher spp., long-billed curlew, and western sandpiper. Some piping plovers are always present on the San Bernard NWR Christmas Bird count. During spring migration, lesser yellowlegs, dowitcher spp., dunlins, and semi-palmated and western Sandpipers are most numerous. Stilt, least, and pectoral sandpipers, and black-necked stilts are also present in substantial numbers. Black-necked stilts and willets are most noticeable shorebirds that nest in the Complex; however, a few other species also nest in the area.

The freshwater wetlands, mudflats and beaches support more than 100,000 shorebirds of 30 species annually, giving the Complex a Site of International Importance designation by WHSRN. Photo Credit Dave Sanders

Marine Protected Areas

In 2010, all three refuges received designation as Marine Protected Areas under National Oceanic and Atmospheric Administration. Current efforts to create a Gulf of Mexico MPA

Network will aid in collaboration on issues associated with man-made and natural disasters, climate change, and outreach and education.

3.6.5.4 Concerns Regarding Special Management Areas

Natural and man-made disasters as well as threats from exotic flora and fauna threaten the diversity of the refuges and Special Management Areas. The additional challenges of climate change and the anticipated impacts of SLR also threaten the dynamics of these highly productive shorebird areas. Through multiple collaborative, research, and monitoring efforts, the refuges will need to proactively manage and protect resources.

3.6.6 Land Protection and Acquisition

Land interests are acquired only from willing sellers/donors and are subject to the availability of funding. The presence of a national wildlife refuge would not mean increased regulation of adjacent private land uses. The Service acquires lands and interests in lands, such as easements, and management rights in lands through leases or cooperative agreements, consistent with legislation or other congressional guidelines and executive orders, for the conservation of fish and wildlife and to provide wildlife-dependent public use for recreational and educational purposes. When land is needed to achieve those objectives, the Service seeks to acquire the minimum interest necessary to reach those objectives. If fee title is required, the Service gives full consideration to extended use reservations, exchanges, or other alternatives that will lessen the impact on the owner and the community. Donations of desired lands or interests are accepted. In all fee title acquisition cases, the Service is required by the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) to offer 100 percent of the property's appraised market value, as set out in an approved appraisal that meets professional standards and federal requirements.

We only propose fee acquisition when adequate land protection is not assured under other ownerships, active land management is required, or we determine the current landowner would be unwilling to sell a partial interest such as a conservation easement. Conservation easements leave the parcel in private ownership, while allowing the Service involvement in land management decisions in a way that enables us to meet our conservation goals, as well as being able to provide some assistance to the landowner with stewardship and management of their lands. Easements are a property right, and typically are perpetual. If a landowner later sells the property, the easement continues as part of the title. The structure of such easements would provide permanent protection of existing wildlife habitats while also allowing habitat management or improvements and access to sensitive habitats, such as for endangered species or migratory birds. These determinations are on a case-by-case basis, and negotiated with each landowner, the extent of the rights we would be interested in buying. Those may vary, depending on the configuration and location of the parcel, the nature of wildlife activities in the immediate vicinity, the needs of the landowner, and other considerations. In general, easement acquisition would maintain the land in its current configuration with no further subdivision or development.

Properties subject to easements generally remain on the tax rolls and taxes are still paid by the landowner. The Service does not pay refuge revenue sharing (i.e., funds the Service pays to counties in lieu of taxes) on easement rights. Easements generally work best when:

- only minimal management of the resource is needed, but there is a desire to ensure the continuation of current undeveloped uses and to prevent fragmentation over the long term;
- a landowner is interested in maintaining ownership of the land, does not want it to be substantially altered, and would like to realize the benefits of selling development rights;
- current land use regulations do not limit the potential for adverse management practices;
- the protection strategy calls for the creation and maintenance of a conservation area that can be accommodated with passive management; or
- only a portion of the parcel contains lands of interest to the Service.

On easement lands the opportunities for wildlife-dependent public uses, partnerships, or scientific research would be at the discretion of the landowner. These uses would be generally only considered on lands owned in fee by the Service.

While land owned by the U.S. Government is not taxable by state or local authorities, the federal government has a program in place to compensate local governments for foregone tax revenues. The Refuge Revenue Sharing Act of June 15, 1935, as amended (16 U.S.C. 715s) requires the Service to make payments to local taxing authorities, typically counties, to offset the loss of local tax revenues as a result of federal acquisition of private property. The Service makes annual payments to local taxing authorities, based on the estimated values of lands that the Service owns located in those jurisdictions. The actual refuge Revenue Sharing payment does vary from year to year because Congress may or may not appropriate sufficient funds to make full payment.

Land Acquisition – San Bernard NWR

Land acquisition activities are very active on San Bernard NWR. Land acquisition efforts focus on bottomland hardwood forests as described in the approved 1997 Austin's Woods Conservation Plan. Under the plan, 10 percent of the historical 700,000-acre bottomland forest habitat that existed at the beginning of the last century would be conserved through a community-based effort. As stated in the 1997 Decision Document, the Service may acquire up to 28,000 acres as its contribution to the effort. At the present time, the Service is approaching the 28,000-acre land base cap. It is estimated that by the end of 2012, approximately 33,000 acres will be conserved through the combined efforts of governmental and non-governmental entities, with approximately 28,000 acres of this total acreage protected as refuge lands. While this is a noteworthy endeavor, it is short of the original 10 percent, or 70,000 acres, goal. This necessitates the Service to continue its land acquisition efforts, if the goal is to be reached. In April 2011, a Preliminary Project Proposal was approved by Acting Service Director Dan Ashe to increase the Service's land base acreage from 28,000 acres to a total of 70,000 acres within the Columbia Bottomlands project area. The Service has prepared an LPP, which is included in Appendix I.

Opportunities continue to exit in working with private landowners and willing sellers within the approved project area. The real estate market for the project area has slowed considerably and there appears to be an increased interest and support from a variety of partners and landowners. The Service has identified numerous tracts of land, from willing sellers, that meet the biological qualifications for acquisition.

Funding for land acquisitions on the Complex come primarily from two sources, the Migratory Bird Conservation Fund (MBCF) and Land and Water Conservation Fund (LWCF). The MBCF derives its funds mainly from the sale of migratory bird hunting stamps, also known as "duck stamps". The LWCF derives its funds from the sales of offshore mineral leases. These funds are appropriated annually on a project by project basis, with the approval of Congressional budget. Other funding sources used to a lesser extent are donated funds from private sources and matching grants. Table 3-13 lists the tracts acquired under the Austin's Woods Conservation Plan

Table 3-13. Tracts Acquired Under the Austin's Woods Conservation Plan through 6/1/2012.

Palm Tract	7-31-96	23	Phillips additions	3-31-05	128.628
Dance Bayou	4- 4-97	657	Cameron	10-25-05	86.281
Eagle Easement	7-22-97	137	Cannan	12-6-05	740
Big Pond	3-29-99	2,378.591	Spears (easement)	12-30-05	249.74
McNeill	1-12-01	1,276.421	Munson	4-4-06	196.776
Bird Pond	12-19-01	100	Giese	5-24-06	1806.408
Phillips Petroleum	12-27-01	404	Muhm	9-18-06	10.0
Hudson Woods	8-24-02	1,093	Sturm	5-15-07	50.03
Swaggart I	12-23-02	608.786	Sebok	5-18-07	46.295
Gunn (Palm Tract)	1-24-03	23	Chapman (easement)	12-27-07	48.49
Bludworth	4-28-03	738	Griffith	3-19-08	516.972
Wilson	7-18-03	1,344.902	Theodore Smith	6-4-08	35.941
Swaggart II	4-15-04	101.72	Moore	9-18-08	49.73
Audubon Easement	5-20-04	63.06	Shepherd	10-31-08	94.447
Peterson	7-19-04	95.8	Sudderth	11-25-08	56.439
Parker	8-3-04	203.26	Dow Chemical Co.	12-30-08	329.911
GCBO tract	12-16-04	22.174	McGinnes	5-29-09	766.77
CLT	12-17-04	730.5881	Otto	9-14-09	1,116.284
Stringfellow Trust	1-18-05	933.260	Jenks	11-13-09	330.02
Wisch	9-07-10	119	Roy	12-15-09	36
Buchanan	10-20-10	174	Waterstone (easement)	12-15-11	110
Ted Smith	3-11-11	1.8	Palaez	5-4-11	1,315.334
Burke	6-2-11	56.439	Vickery	9-19-11	47.267
Eagle Nest Lake	2-15-12	4,471.01	Brothers (BRI)	5-4-12	498
TOTAL			**24,552**		

3.6.7 Cultural Resource Management

Cultural resources (archaeological sites, historic structures, and Native American traditional cultural properties) are important parts of the nation's heritage. The Service strives to preserve evidence of these human occupations, which can provide valuable information regarding not only human interactions with each other, but also with the natural environment. Protection of cultural resources is accomplished in conjunction with the Service's mandate to protect fish, wildlife, and plant resources.

The Service is charged with the responsibility under Section 106 of the National Historic Preservation Act of 1966 (NHPA), of identifying historic properties (cultural resources that are potentially eligible for listing on the National Register of Historic Places) that may be affected by our actions. The Service is also required to coordinate these actions with the State Historic Preservation Office, Native American tribal governments, local governments, and other interested parties. Cultural resource management in the Service is the responsibility of the Regional Director and is not delegated for the Section 106 process when historic properties could be affected by Service undertakings, for issuing archaeological permits, and for Indian tribal involvement.

The Archaeological Resources Protection Act of 1070 (ARPA) Section 14 requires plans to survey lands and a schedule for surveying lands with "the most scientifically valuable archaeological resource." This act also affords protection to all archaeological and historic sites more than 100 years old (not just sites meeting the criteria for the National Register) on Federal land and requires archaeological investigations on Federal land be performed in the public interest by qualified persons.

The Regional Historic Preservation Officer (RHPO) advises the Regional Director about procedures, compliance, and implementation of these and other cultural resource laws. The actual determinations relating to cultural resources are to be made by the RHPO for undertakings on Service fee title lands and for undertakings funded in whole or in part under the direct or indirect jurisdiction of the Service, including those carried out by or on behalf of the Service; those carried out with Federal financial assistance; and those requiring a Federal permit, license or approval.

The responsibility of the refuge manager is to identify undertakings that could affect cultural resources and coordinate the subsequent review process as early as possible with the RHPO and State, tribal, and local officials. Also, the refuge manager assists the RHPI by protecting archaeological sites and historic properties on Service managed and administered lands, by monitoring archaeological investigations by contractors and permittees, and by reporting ARPA violations.