Bon Secour National Wildlife Refuge

U.S. Fish and Wildlife Service

HABITAT MANAGEMENT PLAN

Photo: USFWS

JULY 2006

Habitat Management Plans (HMPs) are dynamic working documents that provide refuge managers a decision making process; guidance for the management of refuge habitat; and long-term vision, continuity, and consistency for habitat management on refuge lands. These plans detail program planning levels that are sometimes substantially above current budget allocations and, as such, are primarily for Service strategic planning and program prioritization purposes. The plans do not constitute a commitment for staffing or operational increases.

Habitat Management Plan
Bon Secour National Wildlife Refuge

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1.0 Introduction

Throughout the century of its existence, the National Wildlife Refuge System has established a reputation as premier ground for the refinement of habitat management techniques. Ever since the establishment of Pelican Island National Wildlife Refuge in 1903, refuge employees have taken pride in developing the latest tools for wildlife conservation with limited resources. Some of the first examples of rocket nets and airboats, equipment now considered essential for wildlife management, were developed by refuge employees. The first prescribed fire on refuge lands was conducted in 1927 at a time when the benefits of this natural process were not well recognized and most federal agencies still considered fire to have "no place in any forest" (USFS 2004).

As the discipline of wildlife management evolved, largely through the efforts of Aldo Leopold with his publication of *Game Management* in 1933, it was recognized that a greater emphasis needed to be placed on making decisions that are based on the best science of the day, while retaining some of the artful intuition that comes from years of field experience. Sound wildlife management will always involve the skillful integration of science and art in disciplines as diverse as biology and sociology.

Habitat is defined as simply "the physical and biological surroundings of an organism" (Bolen and Robinson 1995). It includes all of the natural components of an ecosystem that are essential for survival including food, cover, and water. The processes that shape barrier features along the Gulf of Mexico, including Bon Secour National Wildlife Refuge, are complex and dynamic. This Habitat Management Plan was developed to provide a clear, science-based outline for managing the Refuge in this challenging environment. To this end, a Habitat Management Plan was developed as a first step in closing the gap between the needs of Refuge wildlife and the knowledge of its stewards.

1.1 Planning Process

Habitat Management Plans (HMP) are dynamic working documents that provide refuge managers a decision making process; guidance for the management of refuge habitat; and long-term vision, continuity, and consistency for habitat management on refuge lands. Each plan incorporates the role of refuge habitat in international, national, regional, tribal, State, ecosystem, and refuge goals and objectives; guides analysis and selection of specific habitat management strategies to achieve those habitat goals and objectives; and utilizes key data, scientific literature, expert opinion, and staff expertise.

The statutory authority for conducting habitat management planning on National Wildlife Refuges is derived from the National Wildlife Refuge System Administration Act of 1966 (Refuge Administration Act), as amended by the National Wildlife Refuge Improvement Act of 1997 (Refuge Improvement Act), 16 U.S.C. 668dd - 668ee. Section 4(a)(3) of the Refuge Improvement Act states: "With respect to the System, it is the policy of the United States that each refuge shall be managed to fulfill the mission of the System, as well as the specific purposes for which that refuge was established ..." and Section 4(a)(4) states: "In administering the System, the Secretary shall monitor the status and trends of fish, wildlife,

and plants in each refuge." The Refuge Improvement Act provides the Service the authority to establish policies, regulations, and guidelines governing habitat management planning within the System.

An HMP is a step-down management plan of the Refuge Comprehensive Conservation Plan (CCP). The CCP describes the desired future conditions of a refuge or planning unit and provides long-range guidance and management direction to achieve the purpose(s) of the refuge; helps fulfill the mission of the System; maintains and, where appropriate, restores the biological integrity, diversity, and environmental health of each refuge and the System; helps achieve the goals of the National Wilderness Preservation System, if appropriate; and meets other mandates. The CCP for Bon Secour NWR was finalized in 2005.

HMPs comply with all applicable laws, regulations, and policies governing the management of National Wildlife Refuge System. The lifespan of an HMP is 15 years and parallels that of refuge CCPs. HMPs are reviewed every 5 years utilizing peer review recommendations, as appropriate, in the HMP revision process or when initiating refuge CCPs. Annual Habitat Work Plans (AHWP) will contain management specifics and are prepared annually.

The Refuge solicited comments on the Plan by requesting a scientific peer review from several of its partners. Representatives of the Alabama Department of Conservation and Natural Resources, The Nature Conservancy, and the University of Southern Mississippi were consulted and given an opportunity to review and comment on the draft Plan. Fish and Wildlife Service offices that reviewed this Plan include the Mississippi Sandhill Crane National Wildlife Refuge Fire Program and the Daphne Ecological Services Field Office.

1.2 Refuge Purposes

The purposes of a national wildlife refuge, as established by Congress or the Executive Branch, are the barometer by which all actions on that designated public land are measured. Habitat management, public use, and all other programs are required to fulfill the established purposes of the refuge.

Bon Secour National Wildlife Refuge was established in 1980 for these purposes:

> "... to ensure the well-being of these (nationally endangered and threatened species, such as the brown pelican, bald eagle, and several species of sea turtles, as well as many more species identified by the state to be of special concern) and other species, to serve as a living laboratory for scientists and students and to provide wildlife-oriented recreation for the public."
>
> "...to conserve an undisturbed beach/dune ecosystem which includes a diversity of fish and wildlife, and their habitat."

94 Stats. 483, 484, dated June 9, 1980 (Act to establish the Bon Secour National Wildlife Refuge)

In addition to the specific purposes that were established for each refuge, Congress passed the National Wildlife Refuge System Improvement Act in 1997. This legislation provides clear guidance for the mission of the Refuge System and priorities wildlife-dependent public uses. The Act states that each Refuge will:

- Fulfill the mission of the National Wildlife Refuge System;
- Fulfill the individual purposes of each refuge;
- Consider the needs of wildlife first;
- Fulfill requirements of comprehensive conservation plans that are prepared for each unit of the Refuge System;
- Maintain the biological integrity, diversity, and environmental health of the Refuge System; and
- Recognize that wildlife-dependent recreation activities, including hunting, fishing, wildlife observation, wildlife photography, and environmental education and interpretation are legitimate and priority public uses; and allow refuge managers authority to determine compatible public uses.

1.3 Refuge Vision

The Refuge vision was developed for the Comprehensive Conservation Plan:

Bon Secour National Wildlife Refuge, which includes a diversity of flora and fauna, was established to preserve fragile barrier features along the rapidly developing Gulf Coast. The refuge is vital to the future of wildlife conservation in south Alabama and will protect habitats that are critical to the survival of threatened and endangered species, migratory birds, and resident native fish and wildlife. Refuge staff will identify, conserve, manage, enhance, and restore populations of native fish and wildlife species and the natural diversity, abundance, and ecological functions of refuge habitats while promoting conservation through innovative partnerships, private landowner cooperation, and existing land protection programs to complete acquisition within the approved refuge boundary. By managing a healthy refuge, the Service will also facilitate compatible public uses for school children, refuge neighbors, vacationing families, and residents. Partnerships with local communities, agencies, and citizens will be developed to increase public awareness of the environmental issues facing all partners and will foster stewardship of the natural and cultural resources found on the Fort Morgan Peninsula and in coastal Alabama. The envisioned future is one of increased staff and facilities, habitat restoration and protection, and involving people so they can enjoy the refuge as a rare and valuable resource.

1.4 Relationship to Other Plans

A Comprehensive Conservation Plan (CCP) was finalized for Bon Secour National Wildlife Refuge in 2005, which includes broad goals and objectives for Refuge management over a 15-year period. The purpose of the Habitat Management Plan is to

provide more specific guidance that will facilitate the selection of prescriptions for implementing the goals and objectives of the CCP. In order to maintain consistent strategies for managing wildlife and habitats on the Refuge, several other planning documents were used in the development of this Plan.

Refuge endangered species with approved Recovery Plans include Alabama beach mouse (USFWS 1987), loggerhead sea turtle (*Caretta caretta*) (NMFS and USFWS 1991), and piping plover (*Charadrius melodus*) (USFWS 2003). Whenever possible, priority actions identified in recovery plans were incorporated into the goals, objectives, and strategies of the Habitat Management Plan.

The Refuge is an important stopover site for Neotropical migratory birds and has been designated as a Globally Important Bird Area by the American Bird Conservancy. Plans that were consulted for Neotropical migratory bird habitat priorities include the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004), Draft Bird Conservation Plan for the East Gulf Coastal Plain (Partners in Flight 2005), and A Blueprint for the Future of Migratory Birds: Migratory Bird Program Strategic Plan 2004-2014 (USFWS 2004). For shorebird habitat objectives, the U.S. Shorebird Conservation Plan (Brown et al. 2001) and the Southeastern Plains-Caribbean Region Report of the U.S. Shorebird Conservation Plan (Hunter 2003) provided essential guidance.

The Alabama Department of Conservation and Natural Resources (ADCNR) is a critical partner in the effort to implement conservation strategies on the Alabama Gulf coast. In 2005, ADCNR published the Draft Alabama Comprehensive Wildlife Conservation Strategy (CWCS), which identified the priority actions for the state's imperiled species. The CWCS was consulted during the development of this Plan and shares similar habitat and wildlife objectives.

This Plan also incorporates the recommendations of other approved station plans including the Fire Management Plan (USFWS 2001) and the Biological Review (USFWS 2000). Prescribed fire strategies detailed in this Plan will be incorporated into the next revision of the Fire Management Plan.

Some conflicts between plans do exist. For example, washout areas between dunes are favored by nesting shorebirds and are identified in the Southeastern Coastal Plains-Caribbean Region Report of the U.S. Shorebird Conservation Plan (Hunter 2003) as areas that should be preserved. The Alabama Beach Mouse Recovery Plan lists restoration of dunes and vegetation as a top priority. However, the focal species for habitat management varies among refuge units. For example, the habitat requirements of the beach mouse constitute the primary focus of this Plan on the Fort Morgan Peninsula while the wintering piping plover is the principal resource of concern on Little Dauphin Island. In any case, even the most intensive dune restoration efforts leave many washout areas and additional shorebird habitat is created by tropical storms each season.

1.5 Plan Outline

The HMP contains a description of the proposed management program as follows:

Section 1 – Introduction
Provides an overview and introduction to plan purposes

Section 2 – Environmental Setting and Background
Provides a review of site history and a description of physical setting along with regional and local ecological issues

Section 3 – Resources of Concern
Provides a description of Refuge biological communities and ecological significance that includes endangered species and unique biological communities.

Section 4 – Habitat Management Goals
Provides a overview of Refuge management goals, strategy and the formulation of management objectives.

Section 5 – Habitat Management Objectives and Strategies
Provides a description of management goals and specific objectives proposed for accomplishing goals.

Section 6 – Management Strategy Resources and Constraints
Provides a description of resources needed to accomplish management goals along with management constraints and regulatory compliance.

2.0 Environmental Setting and Background

The name, Bon Secour, means "safe harbor." French explorers first used the phrase to describe a sheltered cove near the eastern shore of Mobile Bay. Just to the south, Bon Secour National Wildlife Refuge lies at a much more precarious location on the Fort Morgan Peninsula that juts out into the Gulf of Mexico. The Refuge contains the best example of an intact coastal barrier ecosystem in Alabama, which has critical importance for a variety of native wildlife. Individual components of this ecosystem—beach/dune/swale, maritime forest, pine flatwoods—can be found elsewhere along the Gulf of Mexico, but rarely do these constituents transition uninterrupted across the landscape as they do at Bon Secour.

Refuge habitats are particularly important for endangered species. Bon Secour has the largest contiguous tract of endangered Alabama beach mouse (*Peromyscus polionotus ammobates*) habitat, including areas that have been designated as critical habitat (USFWS 1987). The Refuge also contains critical habitat for the wintering piping plovers (USFWS 2003). For nesting sea turtles, the Refuge represents some of the best remaining habitat in the state.

Bon Secour is an important link in a chain of barrier islands and coastal oak mottes that provide Neotropical migratory birds with crucial stopover habitat. Birds migrating

between the Yucatan Peninsula and the Northern Gulf Coast depend on significant patches of habitat to rest and refuel before continuing across the Gulf to their tropical wintering grounds or returning to their North American breeding grounds. The maritime forest protected on the Refuge stands as an oasis of habitat on the highly fragmented and developed Alabama Gulf coast.

2.1 Location

Bon Secour National Wildlife Refuge is located 9 miles west of the city of Gulf Shores in Baldwin and Mobile Counties on the Alabama Gulf coast. The cities of Mobile, Alabama, and Pensacola, Florida, are approximately 50 miles from the Refuge to the north and east, respectively. Most of the Refuge lies on the narrow, 15-mile long Fort Morgan Peninsula (Figure 1). The Little Dauphin Island Unit is located in western Mobile Bay. These five units total 6,978 acres within the 12,570-acre acquisition boundary.

2.2 Management Units

Refuge units represent several distinct habitat-types and transition zones. Beginning at the Gulf of Mexico, the first areas encountered are the beaches, dunes, and swales that encompass an extremely dynamic habitat subject to periodic destruction and reformation due to tropical storms. To the north lies a dune scrub transitional zone, a much more stable habitat consisting of substantial vegetation and increased elevation. This transitional zone eventually cedes to a maritime forest which acts as a foundation for the entire barrier island ecosystem. Freshwater marshes intersperse with pine flatwoods that eventually give way to the estuarine marshes that follow the margins of Mobile and Bon Secour Bays.

Recent acquisitions of property have involved oak hammock, pine flatwoods, and small patches of relic dunes. Acquisition priorities focus on endangered species habitat for the Alabama beach mouse and sea turtles; however these areas comprise some of the most valuable real estate on the coast. The Fort Morgan Peninsula is the last sizeable area on the Alabama Gulf coast that has not been fully built out and, as a result, it is under a tremendous amount of development pressure.

Perdue Unit

This is the largest unit (2,628 acres) and is bordered to the east and west by high density residential development, to the north by State Highway 180 (Fort Morgan Road), and to the south by the Gulf of Mexico. Little Lagoon, a saltwater inlet which opens to the Gulf through a small manmade pass and periodic hurricane cuts, also forms much of the eastern boundary of the unit.

The Perdue Unit is further subdivided into fire compartments (Appendices A and B). Besides their role in prescribed burning, these compartments are used for wildlife monitoring and research to evaluate the effectiveness of various habitat management treatments. Fire compartments within the Perdue Unit include Gator Nest (383 acres),

Gator Lake (244 acres), Jeff Friend (309 acres), Pine Beach Trail (204 acres), and East Headquarters (116 acres).

Mobile Street bisects the Perdue unit into eastern and western portions and serves as the main public access point on the refuge, which terminates at the sugar-white sand beaches along the Gulf of Mexico. Wildlife-dependent recreation includes surf fishing, birding, and observation of marine life including bottlenose dolphins (*Tursiops truncatus*), skates (*Raja sp.*), sea turtles, and even the occasional manatee (*Trichechus manatus*). Located only 9 miles from the center of Gulf Shores, this is the most popular area of the refuge for weekend tourists, winter visitors, and Spring Break revelers.

The Pine Beach, Gator Lake, Jeff Friend, and Centennial meander through scrub dunes, pond cypress (*Taxodium ascendens*) swamps, and oak hammocks along the shores of Little Lagoon. Hikers, photographers, birders, and anglers use the network of trails but the highest level of public use occurs on the beach at Mobile Street. The Perdue unit also represents the best example of intact beach/dune/swale habitat remaining in Alabama. As a result, it is the most important area for the endangered Alabama beach mouse across its range and has one of the highest density sea turtle nesting beaches in the state. To the north and west of Little Lagoon, this unit contains a large tract of maritime forest, marshes, and the 32-acre Gator Lake, one of the few freshwater lakes on the Alabama coast. The Perdue unit presents some of the greatest challenges for the protection of wildlife on the Refuge because of the overlap of high public use and sensitive endangered species habitat.

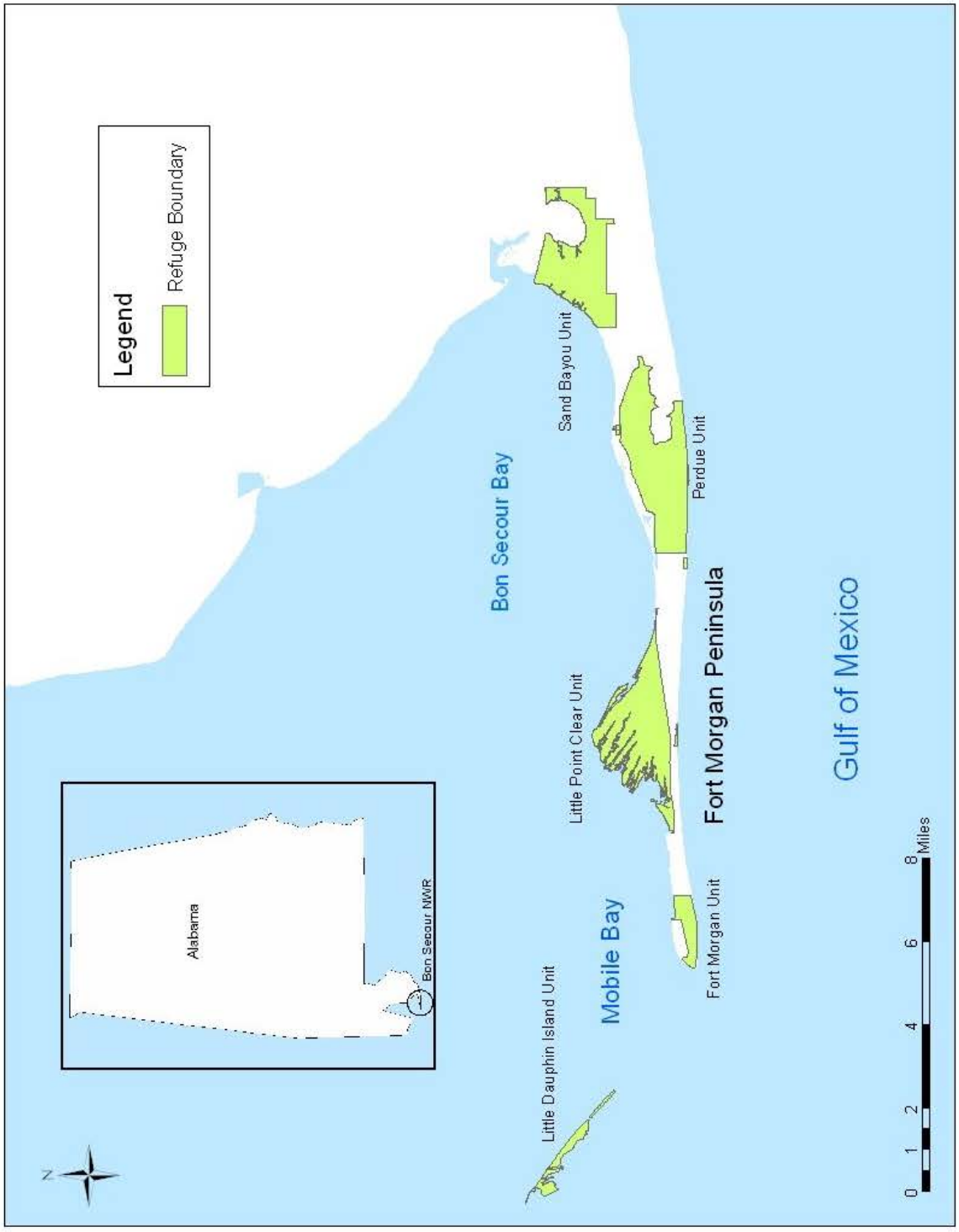
Fort Morgan Unit

The Fort Morgan Unit is located at the western tip of the Fort Morgan Peninsula (510 acres) and is bordered to the north by Mobile Bay, to the east by mostly low density residential development, to the south by the Gulf of Mexico, and to the west by Mobile Bay and Fort Morgan, a National Historic Site administered by the Alabama Historical Commission. The natural areas surrounding the fort, which comprise the Fort Morgan Unit of the refuge, are managed by the Service through a cooperative agreement with the State of Alabama.

Known regionally for the seasonally abundant redfish population at its western end, public use on the Fort Morgan unit is centered on recreational fishing. Due to its acclaimed reputation for fishing and its more remote location 21 miles west of downtown Gulf Shores, the Fort Morgan Unit is more frequented by local anglers rather than the weekend visitors that bask on the beaches of the Perdue Unit.

Habitats on the Fort Morgan Unit represent a compressed version of the peninsula as a whole. Gulf beaches transition to dune/swale habitats before progressing to scrub, pine flatwoods, and marshes along the shore of Mobile Bay. Wildlife research and monitoring conducted on this unit indicate that this area functions quite differently than the Perdue Unit (Sneckenberger 2001, Boyd et al. 2003). The Fort Morgan Unit is lower in elevation

Figure 1. Bon Secour National Wildlife Refuge, Baldwin County, Alabama.



than the Perdue Unit and is located on a very narrow portion of the peninsula so much of the area overwashed during tropical storms. As a result, the plant communities, dune structure, and wildlife population dynamics are considerably different than those of other Refuge units. The western tip of the unit, known as Mobile Point, contains some of the best shorebird habitat on the Refuge.

No fire management compartments have been established on the Fort Morgan Unit and prescribed fire is not expected to be a major habitat management tool in this area. Small management units may be designated at Fort Morgan to evaluate the effectiveness of habitat treatments.

Sand Bayou Unit

The Sand Bayou Unit is a 1,287-acre tract bordered to the east by Oyster Bay, to the north by the Intracoastal Waterway, to the west by Bon Secour Bay, and to the south by low density residential development. This unit includes tracts managed by the Refuge through cooperative agreements or leases with The Nature Conservancy and the City of Gulf Shores.

A substantial portion of this unit is dominated by brackish marsh along Oyster and Bon Secour Bays. Upland habitats that form the central north-south ridge of this unit are dominated by a haunting maritime forest that contains remnants of the ancient coastal hammocks of live oaks and magnolias draped in Spanish moss. The southern portion of this unit contains hints of nearly vanished landscape that once provided the grassy understory preferred by the gopher tortoise (*Gopherus polyphemus*) and the threatened eastern indigo snake (*Drymarchon corais couperi*).

Invasive species are a significant concern in this unit. Surveys for Chinese tallowtree (*Sapium sebiferum*), conducted for the first time in 2005, found high concentrations in the northern one-third of the Sand Bayou Unit. Control of this exotic tree, which displaces native hardwoods used by migratory birds, will be a primary management focus of this area.

Three fire compartments have been established within the Sand Bayou Unit, including Miller Cemetery, Bon Secour Bay, and Oyster Bay. In addition to prescribed burning, these compartments are used to evaluate habitat management techniques by comparing wildlife populations in treated versus untreated areas.

Little Point Clear Unit

This unit consists of 1,990 acres bordered to the east and west by high density development, to the north by Mobile Bay, and to the south by State Highway 180. The Little Point Clear unit includes land managed by the Refuge through leases with the Alabama Mental Health Board and the Alabama Coastal Heritage Trust.

Habitats characteristic of this unit include relic dune ridges, swales, and a large expanse of slash pine (*Pinus elliottii*) flatwoods. Extensive brackish "finger" sloughs with open water and sawgrass (*Cladium jamaicense*) marshes run southeasterly through the area. Open stands of slash pine are superficially similar to wet pine savannas but lack the poorly drained, acidic soils of that ecosystem. Evidence of previous land use practices in this area is minimal and the Little Point Clear Unit remains a relatively isolated tract of semi-wilderness that exhibits fewer signs of the effects of nearby development than many other areas on the refuge. Development pressures are mainly confined to the southeastern and southwestern corners of the unit. The Little Point Clear Unit is the best example of a semi-wilderness area on the refuge.

No fire compartments have been established in the Little Point Clear Unit. Due to the size of this unit and its proximity to residential areas along its southern border, permanent fire lines will have to be established and the unit will have to be divided into several compartments to accomplish prescribed fire objectives.

Little Dauphin Island

Little Dauphin Island, which is entirely owned by the Refuge, consists of 850 acres in western Mobile Bay, just north of the highly developed eastern end of Dauphin Island. Along with the Perdue Unit, Little Dauphin Island was one of the first tracts acquired by the refuge in 1981.

Consisting mainly of saline and brackish marshes, mudflats, and submerged bottoms, the island also has small upland ridges of pine flatwoods and low dunes. This area, along with Mobile Point at the terminus of the Fort Morgan Peninsula, represents some of the best shorebird habitat on the Refuge.

No fire compartments have been established in the Little Dauphin Island Unit and prescribed burning is not expected to be a major habitat management tool on the island.

2.3 Physical Features

2.3.1 Climate

> "The weather, Lizzy, that unfailing subject for conversation, demands a 'mere-mention' to-day, as having attained to the sixth degree of comparison—for some time it has progressed steadily through the other five—hot hotter hottest Hottentot Hottentotter—but yesterday it arrived at the stage which can only be described as the very hotten-tottest, that is compatible with existence to any one but a Salamander or the Fire King, who went into the oven with his hands full of poultry, shut the door—and brought them out roasted to a turn…Not a breath of air is stirring—away up the bay the thunder is rumbling to call our attention to the dark rain cloud which don't offer to come any nearer…and the very dogs have abandoned their usual occupation of hunting for cats, and are panting under the houses with tongues extended to the utmost—"

—Letter from James M. Williams, Confederate soldier, 21st Alabama Infantry Volunteers, to his wife while stationed at Fort Morgan, August 16, 1863 (Folmar 1981).

For much of the year, the Refuge climate is hot and humid, with dew dripping from the canopy of southern magnolias (*Magnolia grandiflora*) and live oaks (*Quercus virginianus*) at sunrise. The average maximum high monthly temperature is 88.9 degrees (F) in July and the average low minimum temperature is 44.3 degrees (F) in January (Southeast Regional Climate Center 2005). The relative humidity is regularly 60-80% during the day and often approaches 100% at night. Mobile, Alabama, shares the highest annual rainfall totals in the United States with the Pacific Northwest. On average, the Refuge receives about 64 inches of rain per year and annual rainfall amounts of 80 inches or greater are not uncommon (Table 1). July is typically the wettest month. This region also has some of the highest hurricane frequencies of any coastal area in the U.S. (Neumann et al. 1999).

Hurricane season officially begins on June 1 and ends November 30, with the peak of activity in mid-September. Nearly every year, the Refuge is affected by a tropical storm. Hurricane frequency, timing, intensity, and distribution may change dramatically over the next century as a result of global climate change and sea level rise (Webster et al. 2005, Emanuel 2005), although significant debate remains in the scientific community about the relationship between these factors and recent hurricane seasons. Wetland ecosystems may also experience long-term alterations if local weather patterns are reflective of global climate change (Michener et al. 1997). Any increase in the number and intensity of these storms that impact the Refuge could have profound effects on wildlife. In the short term, major hurricanes can be devastating to coastal ecosystems. The resulting accumulation of hazardous materials, mortality of plant and animal life, and damage to dune structure can significantly alter the Refuge environment. These effects, while temporary, are combined with extensive habitat loss due to increasing development in the region and may be a recipe for serious declines for species with restricted distributions such as the Alabama beach mouse.

Table 1. Monthly climate summary, 1 Aug 1975 to 31 Mar 2004, Dauphin Island 2 weather station (Southeast Regional Climate Center 2005).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Average Max. Temperature (F)	57.5	60.7	67.2	73.9	81.1	86.4	88.9	88.6	85.4	77.2	69.0	60.7	**74.7**
Average Min. Temperature (F)	44.4	48.0	55.2	62.6	70.7	75.7	77.6	77.7	74.6	65.4	56.6	47.8	**63.0**
Average Total Precipitation (in.)	5.80	5.11	5.88	4.30	4.98	5.29	7.52	6.95	5.17	4.20	4.59	4.22	**64.0**

2.3.2 Geology

The landforms along the Alabama Gulf coast are representative of its dynamic history. Considered to be of late Pleistocene to Recent (Holocene) origin, many details of the geologic record are hidden beneath the ocean after thousands of years of sea level rise (Smith 1986). The area is characterized by the Citronelle formation, which resulted from the deposition of alluvial fans across coastal areas from Louisiana to Florida.

On the Sand Bayou Unit, the ridge that runs north-south separating Oyster and Bon Secour Bays is believed to be the remnants of a sand bar that was located just offshore from the coastline of the ancient Pamlico Sea (Smith 1986). Eventually, the sea retreated to approximately 125 meters below the present sea level and left a system of dune ridges and wetlands that extended for 60 miles south of the current Alabama coastline (Smith 1986). Only in the last few thousand years did the ocean reach its current level and there is much debate among geologists about how recent the beach/dune/swale system along the Alabama coast was established.

Sharply defined dune ridges south of Little Lagoon are considered much younger than the eroded, relict ridges found north of Little Lagoon, which are believed to be from the Pleistocene age (Smith 1986). Little Lagoon developed when a spit was formed between the Lagoon and the Gulf (Smith 1986). Gator Lake was probably once part of Little Lagoon until a spit developed separating the two bodies of water (Smith 1986). The Fort Morgan continues to erode along Mobile Bay as a reminder that its future shape and location will undoubtedly be very different than it is today.

2.3.3 Topography and Hydrology

The Fort Morgan Peninsula is nearly flat, with most elevations lower than 10 feet above sea level, and the terrain generally slopes to the Gulf of Mexico (Smith 1986). The Refuge is located along the Gulf Coast of Alabama and the Mobile Bay Estuary. The Mobile Bay watershed includes 65 percent of the State of Alabama, and portions of Mississippi, Georgia, and Tennessee (USFWS 2005).

Refuge lands are a fragile combination of barrier islands, low-lying marshes, and highly erodible mainland shores. In addition to sea-level rise, winter storms, and altered sediment supplies, hurricanes frequently damage or destroy the human developments and infrastructure that line the coast. Frequent and large storms rejuvenate the barrier ecosystem. The Refuge is part of an unstable land mass, constantly shifting and moving due to the frequent hurricanes that pummel the coastal area of the Fort Morgan Peninsula (USFWS 2005).

Rivers and important estuaries including the Mobile River Basin are bisected by levees and flow is restricted by flood control projects and agricultural diversion. Water quality is significantly impacted by agricultural and municipal runoff. Rivers and water bodies throughout this area support a small fraction of the once abundant aquatic resources (USFWS 2005).

The bay is additionally influenced by tidal changes that average less than 0.5 meters throughout the year. All of these factors, combined with highly variable river flows, contribute to a hydrology that is dynamic, complex, and necessary to support the variety of plants and animals existing in the Mobile Bay Estuary.

2.3.4 Soils

Refuge soils are generally sandy, well-drained, and low in nutrients. Soil surveys conducted by the U.S. Department of Agriculture in Baldwin (1964) and Mobile (1980) counties are still relevant today. Uses for many Refuge soils are described in the surveys as "a resort area and as sites for summer cottages," with no suitability for agriculture. The St. Lucie series, characterized by deep, acidic sands, dominates most soils and is associated with several other soil types on the Refuge that provide varying degrees of low to moderate amounts of organic matter (see Section 3.1, Refuge Natural Communities, for specific soils found in each habitat type). To a farmer, none of these soils would be considered "good" for growing anything. As a result, the plants that have adapted to this harsh environment are remarkable for their hardiness and resilience.

2.3.5 Physiographic Region

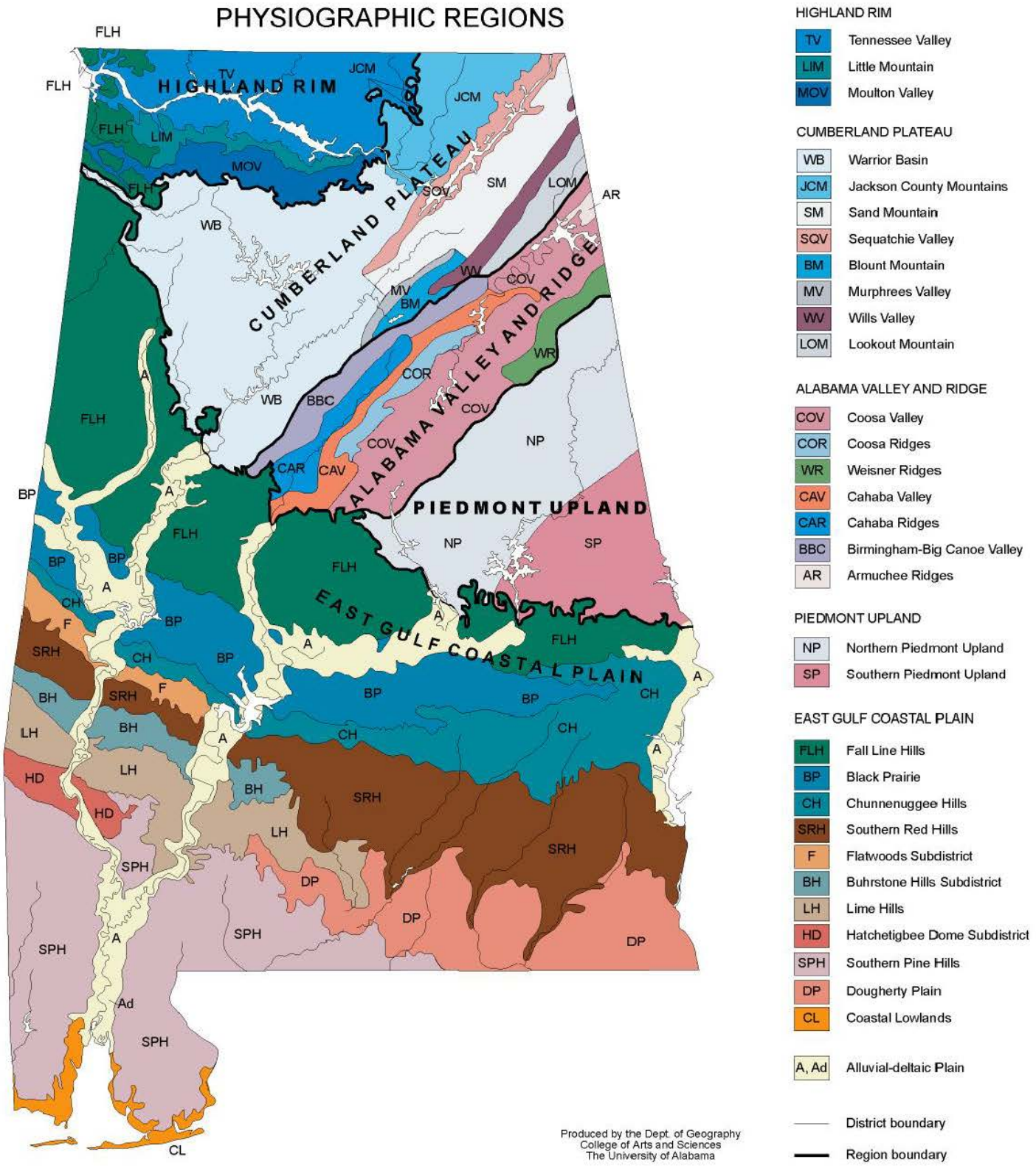
The Fort Morgan Peninsula functions as a Gulf coast barrier feature. The entire Alabama Gulf coast, including the Peninsula, became an island when it was severed from the mainland following construction of the Gulf Intracoastal Waterway in the 1920s. The Alabama Gulf coast is in the Coastal Lowlands province of the East Gulf Coastal Plain physiographic region (Figure 2).

2.4 History of Refuge Lands

The purpose of habitat management is often to restore an area to the historical conditions that were present before the land was substantially altered by humans. In some regions, where development has occurred continuously for centuries, the baseline period to use for comparison is often pre-European settlement. On the Alabama Gulf coast, however, significant human development has only occurred in the last 100 years. More recently, most of the habitat loss on the Fort Morgan Peninsula has occurred during the last 30 years. However, there are other human effects on the environment that are less conspicuous than development but can result in severe degradation of habitat. For example, fire suppression in a fire-adapted plant community can cause a succession of habitat types that eventually leads to the exclusion of wildlife that depend on the ecosystem for their survival. When this occurs, no dramatic die-off of animals is observed. Rather, the subsequent gradual downward trend in reproduction can result in the extirpation of a species from its native range.

In order to define objectives for habitat management on the Refuge, a substantial effort was made to determine the historical condition of Refuge lands. Journals dating to the 1770s, botanical collections, master's theses, and aerial photographs are among the pieces of historical literature that were consulted during the development of this Plan. Several

Figure 2. Physiographic Regions of Alabama.



lifelong members of the community also provided essential recollections about fire history and the remote, nearly uninhabitable landscape that defined the Fort Morgan Peninsula throughout most of the 20th century.

Some archaeological surveys detail prehistoric life in coastal Alabama. In addition, several prominent naturalists and explorers visited the Fort Morgan Peninsula in the late 18th and early 19th centuries and their writings provide some glimpse of the habitats and culture of the area during this period.

2.4.1 Cultural History

While its population density was probably always quite low, the Fort Morgan Peninsula has been nearly continuously occupied due to its abundant fisheries and its militarily strategic location at the mouth of Mobile Bay. Two tribes believed to be descended from the Pensacola complex, the Tomeh (Tohome) and Mobile Indians, lived along Mobile Bay at the time of European contact (USFWS 2005, Knight 1984).

At the north end of the Bay in the Mobile Delta, subsistence by native groups consisted of hunting, fishing, horticulture, and gathering (USFWS 2005). Small farms were somewhat nomadic with movements based on seasonal flooding, while a more permanent community was located on the bluff adjacent to the delta (USFWS 2005). Knight (1984) identified key elements that were used for site selection by the tribes including access to mast-bearing forests, shellfish beds, and tidal bays.

Closer to the present-day Refuge, a large town was reported near the mouth of the Bay in the early 16th century (Swanton 1946). The arrival of refugees from tribes including northwest Florida groups (Apalachee, Chatot, and Tawasa) and cultures west of Mobile Bay (Taensa, Chitimacha, and Choctaw) in the18th century resulted in the diverse ceramic styles that can be found in the area today (Knight 1984).

Fort Morgan was constructed between 1819 and 1834 at the western terminus of the peninsula to defend the United States against a British invasion, although it is best known as the site of the bloodiest naval battle of the Civil War. By 1864, Mobile was one of the few major Confederate ports remaining on the Gulf coast (USFWS 2005). The Union fleet had blockaded Mobile since 1860 but Fort Morgan was finally attacked under the command of Admiral Farragut in August 1864. Fort Morgan was surrendered after one day of fierce fighting that resulted in several breaches of the fort's brick masonry walls and the burning of nearly all of its wooden buildings (Anderson 1962, Neilsen 2000, USFWS 2005).

Pilot Town was a permanent settlement near the western boundary of the Little Point Clear Unit at Navy Cove in St. Andrews Bay. Residents of this small community were mainly bar pilots, who provided guide services for visiting ships to navigate the channels and bars of Mobile Bay. The site has a long marine history, serving as a resupply depot for American ships during the War of 1812 and as an important Union supply point during the Battle of Mobile Bay (USFWS 2005). The town was destroyed by the Hurricane of 1906.

Even the area surrounding the Refuge headquarters has a rich history. A Native American village called Achuse was located near the present site of the Shell Banks Baptist Church, which lies 200 meters west of the Refuge office. In nearby Collins Bayou, pirates reportedly landed their ships and hanged their prisoners from a large magnolia called the Hanging Tree (Bonkemeyer 1985).

2.4.2 18th and 19th Century Naturalists

William Bartram. The first naturalist to explore the Alabama Gulf coast, then considered part of Florida and still under British control, was William Bartram in the late 18th century. In his extensive travels of the Southeast, Bartram recorded detailed observations of the region's flora and fauna (Slaughter 1996). Although Bartram's account of his visit to the Fort Morgan Peninsula is brief, he does provide some glimpse of the landscape (and its ubiquitous biting insects) while camping at Mobile Point in 1775 on the present-day Fort Morgan Unit of the Refuge:

> "Set sail early on a fine morning, and having a brisk leading breeze, came to in the evening just within Mobile point; collected a quantity of drift wood to keep up a light and smoke away the mosquitoes, and rested well on the clean sandy beach until the cool morning awoke us. We hoisted sail again, and soon doubled the point or East promontory of the cape of the bay, stretching out many miles and pointing towards Dauphin island, between which and this cape is the ship channel."

Bartram originally published his journals in 1791 and it gave readers on the East Coast the first descriptions of habitats and wildlife in the foreign lands along the Gulf of Mexico.

Charles Mohr. A century later, Charles Mohr contributed the next significant body of work to the biological knowledge of Alabama. Mohr's exhaustive treatment of botany in the state, *Plant Life of Alabama* (1901), remains to this day the most comprehensive book on the subject. Mohr was a prolific botanist, collecting numerous specimens from the Gulf coast and the rest of the state, which became the nucleus for the University of Alabama Herbarium. One section of the book, titled "Plant Distribution in Alabama," contains some particularly useful descriptions of habitats as they existed in the late 19th century.

By the 1890s, human-influenced habitat changes along the Gulf coast were already well underway. In his writings, Mohr laments the removal of virgin longleaf pine (*Pinus palustris*) stands and their subsequent replacement by the faster-growing slash (or Cuban) pine, which is preferred by the timber industry. Some natural processes were apparently still present in the landscape at this time, based on Mohr's descriptions of the open pine canopy that he observed:

> "...open groves of Cuban [slash] pines cover the flats behind the dunes, merging frequently into the pine meadows of the coast plain" (Mohr 1901).

The habitat condition that Mohr describes could only have been achieved with periodic wildfires. In the absence of fire, open, herbaceous groundcover is converted into a dense, woody understory. Mohr also describes the presence of longleaf pine in the maritime forest

between Bon Secour and Perdido Bays, a species which requires frequent, low intensity fires to effectively germinate and is nearly absent from the Alabama coast today.

One indication of the habitat alterations that have occurred since Mohr's time can be found in his specimen list from the Gulf coast. Two species, *Rynchospora dodecandra [R. megalocarpa*] and *Carex dasycarpa* (described as rare by Mohr), were collected along the forest edge and have not been documented on the Refuge. West Indian red cedar (*Juniperus barbadensis*), commonly found by Mohr on shell banks along the coast, is difficult to find near the Refuge today. Other species, such as old growth bald cypress (*Taxodium distichum*) and live oaks were harvested in large quantities by the late 19th century (Mohr 1901). Chinese tallowtree, an invasive species that poses a major ecological threat to the refuge today, was already well established as an ornamental along the Alabama coast when Charles Mohr published *Plant Life of Alabama*.

Our knowledge of the historical condition of the Alabama coast before substantial human development is the result of the tireless work of Charles Mohr. While collecting specimens for *Plant Life of Alabama*, Mohr's descriptions came at a unique transitional period in the history of the Alabama coast, when the succession from wild frontier to turpentine plantations and ultimately to resort community was just beginning to occur.

2.4.3 1900-1979

Prior to the catastrophic Hurricane of 1906, the landscape was in a climax condition after a relatively long period of time without a major storm:

> "Before the storm of 1906, the Gulf beach had high sand dunes and large hammocks of trees. Some trees were so large that a man could not reach around them. The next morning the beach was barren and few trees have grown there since."
>
> —recollections of a 1906 hurricane survivor (Buskens 1986)

Following the hurricane, this period was characterized by the gradual development of the Alabama Gulf coast. Structures built during this era consisted of a small number of single family homes. Gulf Shores became known as a quiet resort town with only a few amenities but with some of the most beautiful white sand beaches on the central Gulf coast.

Agriculture, which was never a common land use on the poor coastal soils, reached its zenith along the coast in the early 20th century in the form of silviculture when turpentine was in high demand. Resin was extracted from pine trees and transported by livestock to local stills, including one that operated on Fort Morgan Road at Knob Hill, just west of Highway 59 (Buskens 1986). Turpentine was used in many products, including medicine and paint thinner, and was often called naval stores in reference to its strong demand by the military for caulking the seams of ships. Evidence of turpentining can be found on the Refuge, where remnants of the galvanized metal aprons and pans used to collect the sap are still nailed to slash pines.

Fire was also a common feature of the landscape in the early 20th century. Fort Morgan resident Chan West (pers. comm.) remembers seeing fires frequently in Baldwin County while driving from Mobile to Gulf Shores in the 1930s and 1940s. Ms. West recalls that there were so few roads in Baldwin County during this time that fire suppression was not an option since there was no access to most wildfires. Heyward (1939) described the common use of fire in the Southeast for at least the last few centuries by Native Americans for the purposes of rounding up game and for habitat management related to turpentine production.

Accounts of wildlife by local residents during this period are sparse but do provide information about some species. Wild hogs (*Sus scrofa*) , which are found in limited numbers on the Sand Bayou Unit today, were said to be numerous throughout the Fort Morgan Peninsula during the early 20th century (Buskens 1986). Large leatherback sea turtles (*Dermochelys coriacea*) were frequently observed and captured with fishing gear in the late 1800s and early 1900s (Buskens 1986). It was during this time that several important descriptions of the plant and animal life of coastal Alabama were published.

Arthur Howell.

Arthur Howell was an assistant biologist for the Bureau of Biological Survey, which later became the U.S. Fish and Wildlife Service, when he authored a landmark series of publications on Alabama wildlife. In 1921, Howell published *A Biological Survey of Alabama* in two volumes, Physiography and Life Zones, and The Mammals (see Appendix D and Section 3.2.1 for his mammal list and Alabama beach mouse observations, respectively). *Birds of Alabama* (1924) followed soon after and was heralded as the first comprehensive list for the state (see Appendix E for coastal birds that were included on Howell's list). The first volume of *A Biological Survey of Alabama* contains some intriguing descriptions that confirm the presence of the open pine habitats of Mohr's writings:

> ". . . on the flats along the coast is found an open forest of pines, chiefly the swamp pine (*Pinus elliotii*). In the hammocks--slightly elevated tracts rising from the swampy flats--occurs a profusion of large timber trees, including the magnolia, beech, holly, water oak, laurel oak, and the magnificent live oak, a true characteristic of the coastal region. About the borders of the hammocks and in the small swamps is found a dense growth of shrubs, including the titi and the leatherwood (*Cyrilla racemiflora*)."

Based on Howell's description of the maritime forest in the 1910s, it is clear that fire was still an important selective force that kept the canopy open along the Alabama coast. Thirty years later, the barrier island ecosystem of the Fort Morgan Peninsula remained mostly intact but gradually began to reflect the recent history of fire suppression in its plant life.

William Stallard.

Beginning in 1949, William Stallard, a University of Alabama graduate student, collected botanical specimens on the Fort Morgan Peninsula for his master's thesis. Stallard's

observations provide some of the only scientific descriptions of Refuge habitats during this period.

Along the Gulf of Mexico, Stallard describes an extensive dune system that covers an area from one-half to one mile inland (Stallard 1950). The landward distribution of dunes delineated by Stallard, generally much greater than it is today, is probably indicative of the relatively long period of time since the last major hurricane had impacted the peninsula.

Stallard's descriptions of forest habitats evoke the beginning of a new legacy of fire suppression. Sand pine, which is poorly adapted to fire, is found in "almost monotypic stands" (Stallard 1950). Elsewhere, remnants of a fire-adapted ecosystem are evident. Wiregrass (*Aristida stricta*), a species that will not produce fruit except following a growing season burn (Clewell 1985), dominated the ground cover of pine flatwood habitats on the Fort Morgan Peninsula (Stallard 1950).

Reaffirming Kurz's (1942) assertion, Stallard observes that the climax community of the Fort Morgan Peninsula is the hardwood hammock (Stallard 1950), rather than the dense jungle of slash and sand pines that proliferate the area today. Besides the lack of fire in the ecosystem, another significant natural selective force, a major hurricane, would lie dormant for decades before upheaving the Alabama Gulf coast in late 1979.

Hurricane Frederic made landfall near the Mississippi-Alabama border on September 12, 1979, with sustained winds of 130 mph. Fort Morgan and Gulf Shores were within the eastern eye wall and received some of the worst damage. The area was completely devastated and Frederic would become the yardstick by which all other hurricanes were measured along the Alabama coast for another 25 years. In many ways, there are the pre- and post-Frederic eras in Gulf Shores. The storm had great significance with respect to property damage and loss of life, but also because it led to the rapid intensification of development and habitat loss in the area.

2.4.4. 1980—present

Following the destruction left by Hurricane Frederic in 1979, substantial federal funding was sent to the area in the form of disaster relief, federal flood insurance, and small business loans. The result was a building boom that continues to this day. Between 1990 and 2000, the population in Baldwin County increased by more than 50 percent (Mobile Bay National Estuary Program 1999). Prior to Hurricane Frederic, local conservation groups were becoming concerned about the vanishing natural resources of the area and this concern became much more heightened when the building frenzy began after the storm. The Nature Conservancy purchased the first tract of land that would become the nucleus for the Perdue Unit of the Refuge. Bon Secour National Wildlife Refuge was established by Congress in 1980.

Throughout most of the 1980s and 1990s, the Refuge had limited staffing of one or two employees or was unstaffed and managed by the Mississippi Sandhill Crane National Wildlife Refuge office in Gautier, Mississippi. Habitat management was implemented on a

limited basis during this time and included sand fencing, hay bales to rebuild dunes following storms, and prescribed fire. In 2003, the Refuge was staffed with 5 employees. Habitat management has included efforts to reduce artificial lighting in sea turtle nesting areas, dune restoration using sand fencing and fertilizer, prescribed burning, and invasive species control.

On September 16, 2004, Hurricane Ivan made landfall on the Perdue Unit of the Refuge (Figures 3 and 4) as a major Category 3 hurricane with sustained winds of 130 miles per hour. The storm surge, estimated between 12-16 feet, leveled the primary and secondary dunes that constitute critical habitat for the Alabama beach mouse. All sea turtle nests that had not hatched prior to the storm were destroyed. Saltwater inundation, salt spray, and high winds caused substantial damage to the maritime forest on the Perdue and Fort Morgan Units. Many homes in the West Beach and Laguna Key areas of Gulf Shores were severely damaged or completely washed away. Because of the southeasterly direction of the storm surge, much of this debris, everything from boats to hazardous materials to lumber, was pushed to the northern and western ends of Little Lagoon and onto the Refuge. Congressional funding was appropriated to the Refuge to remove storm debris and this project was completed in early 2006 at a cost of 3.9 million dollars.

Real estate values, already quite high before the storm, skyrocketed following Hurricane Ivan and development pressures on the Fort Morgan Peninsula increased. As a result, purchase of lands within the Refuge acquisition boundary since the hurricane has been difficult. The Refuge has entered into cooperative agreements with inholders in recent years including the State of Alabama, the City of Gulf Shores, the Nature Conservancy, and the Alabama Coastal Heritage Trust in an effort to continue land conservation during this period when acquisition by fee title is unlikely.

Today, the Refuge has a staff of 3 permanent employees. Each summer, 2 volunteer interns and approximately 45 sea turtle volunteers also assist with Refuge programs. Increasingly, habitat management will be conducted within Refuge units that function as islands surrounded by development. This urban interface will have implications for invasive species control, prescribed fire, increased public use, and many other issues.

3.0 Resources of Concern

3.1 Refuge Natural Communities

In many ways, the habitat types of the Fort Morgan Peninsula are an extension of the Florida Panhandle and share more common features with this region than with mainland Alabama. A number of plants and animals found on the Refuge, such as beach mice, sand pine, Florida cricket frog (*Acris gryllus dorsalis*), and Florida softshell turtle (*Apalone ferox*) reach the western limit of their ranges at Mobile Bay.

Plant associations listed for each habitat type are from the U. S. National Vegetation Inventory (USNVI), as given in the Nature Serve database (Nature Serve 2005). Ecological systems and descriptions developed by Nature Serve are referenced in each

Figure 3. Hurricane Ivan makes landfall on the Alabama Gulf coast, September 16, 2004 (Photo: NOAA).

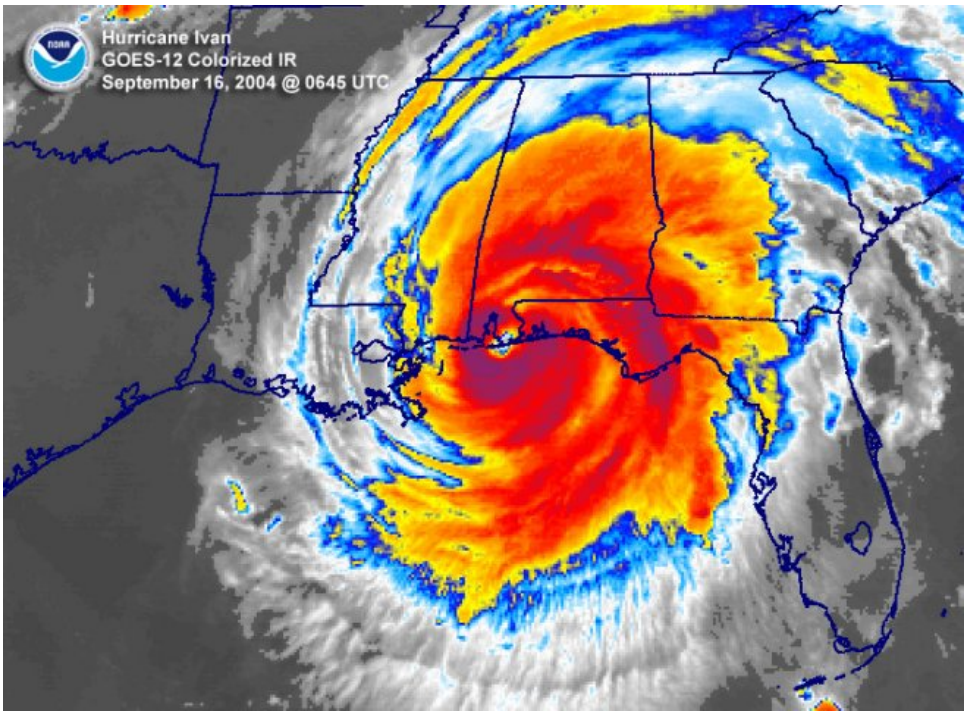


Figure 4. New pass from Little Lagoon into the Gulf of Mexico along the eastern boundary of Bon Secour NWR, created by storm surge from Hurricane Ivan, September 16, 2004 (Photo: USGS).

habitat category in order to provide consistency between the various habitat types. On a coarser scale, habitat types were developed from multiple sources. Because of the shared attributes of Alabama coastal and Florida Panhandle plant communities, the Florida Land Use, Cover, and Forms Classification System (FLUCCS) (Florida Department of Transportation 1999) was a useful tool for some habitat divisions. Scientific literature, as well as USFWS planning and environmental documents also provided information for certain habitat types, especially those used by Alabama beach mice. Staff field observations were used to classify habitats into categories.

An important need exists for comprehensive mapping of Refuge habitat types. The distribution of these habitats will continue to be refined as mapping projects are completed that incorporate detailed analyses of aerial photographs, satellite imagery, and corresponding field plots. Refuge plant species on the Perdue and Fort Morgan Units were catalogued by West and Moffett (unpublished data) and Boyd et al (2003).

3.1.1 Beach/Dune Community

Perhaps the greatest significance of the beach/dune community on the Refuge is that it occurs nowhere else in Alabama as an intact, naturally functioning ecosystem. While strips of frontal dunes and patches of coastal scrub can be found elsewhere in the state, these remnants of an ecosystem lost are disconnected from each other and cease to carry on the interdependent, eloquent relationship of sand migration, saltwater inundation, and carbon reshuffling that once defined this landscape. This community was singled out as a resource of concern by the refuge establishing legislation.

The Baldwin County Soil Survey (USDA 1964) places the sand along the tidal zone in the generalized soil type of Coastal Beaches. Other principal soil types for the beach/dune community include:

Psamments. This soil type is found primarily in areas that have been dredged and filled. Characterized by mostly white sand, this soil has very little use for shorebirds because of its steep slopes (up to 15%). Psamments soils are found at the manmade, southern portion of Little Dauphin Island.

Beaches. These soils are routinely flooded with tidal surge, contain shell fragments, and consist of white sand with very little or no vegetation. Beaches are low in water capacity, natural fertility, and organic matter but contain invertebrates, mollusks, and other prey that are important to shorebirds. The beaches at Mobile Point on the Fort Morgan Unit and on the east side of Little Dauphin Island are preferred by shorebirds on the Refuge.

St. Lucie-Leon-Muck Complex. This is the primary soil of the dune and scrub areas of the Refuge. The complex is described as deep, strongly acidic, and excessively drained soils. St. Lucie soils are typical of the frontal dunes and contain very low quantities of organic matter. The interdunal and scrub areas are perhaps more represented by the Leon and Muck portions of the complex, which contain moderate and high amounts of organic

matter, respectively. However, these three soils are inseparable in the beach/dune community due to their complex, interwoven presence in the soils of the area.

St. Lucie Sand. This soil is found in a relatively small area on the Perdue Unit south of Little Lagoon from the Pine Beach Trail area east to the Refuge boundary. St. Lucie Sands are very low in fertility and organic matter. The Baldwin County Soil Survey (USDA 1964) considered this soil to be unsuitable for cultivation and useful only for resorts and summer cottages.

The beach/dune community consists of three main components: primary and secondary (or "frontal") dunes, interdunal swales, and tertiary/scrub dunes.

Beaches and frontal dunes. The beaches and dunes along the Gulf of Mexico are the main attraction for the public and must share the Refuge's visitors and its most imperiled wildlife. This habitat is found on the Perdue and Fort Morgan Units of the refuge along 5 miles of shoreline. The primary and secondary dunes comprise the principal habitat for the endangered Alabama beach mouse (ABM) (Holler 1992). Critical Habitat for ABM was described in its 1987 Recovery Plan (USFWS) and was restricted to the primary and secondary dunes, defined throughout most of the species' range as 500 feet landward of the mean high tide line. The beaches of the Fort Morgan and Little Dauphin Island Units are also federally designated Critical Habitat for wintering piping plovers.

The beaches and frontal dunes have been described by various researchers as the "the strand" (Mohr 1901), "drifting sand dunes" (Howell 1921), and "sand dune system" (Holliman 1983). The FLUCC system classified this habitat in the category of Coastal Scrub, which is described as a cover type found in dune and white sand areas and includes species such as live oak, sea oats (*Uniola paniculata*) , and sea purslane (*Sesuvium portulacastrum*). The Beach/Dune community description in this Plan is derived from the ecological systems defined in NatureServe (2005) under the names of East Gulf Coastal Plain Dune and Coastal Grassland, Southeastern Coastal Plain Interdunal Wetland, and Florida Panhandle Beach Vegetation.

Vegetation in this zone consists primarily of grasses, forbs, and low shrubs. The first rows of dunes located immediately adjacent to the beach, the primary dunes, are dominated by sea oats, beachgrass (*Panicum* spp.), and coastal bluestem (*Schizachyrium maritimum*). Some species that are typical of wetlands such as marsh hay (*Spartina patens*) and knotgrass (*Paspalum distichum*) are found on dry sites or intermittent swales in this community. Plant density generally decreases while species richness increases in a landward direction from the primary dunes. Beaches and frontal dunes are found on the Perdue and Fort Morgan Units. Narrow, bayside strips of beach habitat can also be found along the Little Dauphin Island and Sand Bayou Units. This habitat is dominated by herbaceous vegetation and shrublands that are strongly influenced by sand movement, salt spray, and saltwater inundation from storm overwash (NatureServe 2005).

Hurricanes affect this plant community more than any other on the Refuge. The successional stages of beaches and frontal dunes ranges from lush plant growth on

substantial primary dunes to the complete absence of vegetation on a flat, moonlike landscape and is determined by the length of time since the last major storm. Prior to Hurricane Ivan in 2004, primary and secondary dunes were in a climax condition with dense stands of seashore elder (*Iva imbricata*), sea oats, and golden aster (*Chryopsis godfreyi*). Hurricanes Ivan, Dennis, and Katrina have since returned the habitat to the same condition described by Holliman (1983) following Hurricane Frederic in 1979.

Tropical storms are necessary, however, to sustain this plant community and its associated wildlife. Storm surges deposit *Sargassum* and other carbon-rich debris into the dunes, providing the recharge of organic matter in this otherwise nutrient poor environment. Habitat management has focused on efforts to rebuild the dunes after tropical storms. Installing sand fence, planting native vegetation, and applying fertilizer are among the techniques that have been used. This Plan recommends discontinuing the use of sand fence on the Refuge because of its frequent destruction from tropical storms and the availability of recent literature that suggests that this technique is not effective for increasing plant cover and diversity (Boyd et al. 2003). However, if other studies find that there are significant wildlife and habitat benefits from the installation of sand fencing then its use will be reconsidered. Prescribed fire is not an effective management tool in this plant community due to the lack of fine fuels to carry fire and the presence of intermittent and permanent swales.

Threats to the beach and dune community include increasing public use, development, and contaminants. Public use, which has been low in recent years due to the impact of hurricanes, has the potential to negatively influence these habitats. Disturbance to shorebirds that use Refuge beaches and dune blowout areas for nesting and roosting may result in reduced reproductive success or migration fitness. Indirect effects from coastal development also pose a threat to Refuge beaches and dunes. For example, artificial lighting from nearby condominiums and single-family homes increases the likelihood that loggerhead sea turtle hatchlings will become disoriented or that adults will be deterred from nesting on the Refuge. Contaminants from offshore gas rigs in the event of an accident and hazardous materials washed up as hurricane debris may pose a significant threat to Refuge resources. Invasive species, while not currently a major problem in this habitat, is an ongoing threat. Refuge staff has documented the spread of cogongrass (*Imperata cylindrica*) from roadsides to secondary dunes. Other invasive species may be introduced to the Refuge through adjacent development or from seeds and rhizomes carried by tropical storm surges.

Typical USNVC plant associations for this habitat include:

- *Uniola paniculata - Panicum amarum* var. *amarulum - Iva imbricata*
- *Cakile constricta*
- *Schizachyrium maritimum - (Heterotheca subaxillaris)*
- *Fuirena scirpoidea - Panicum spp. - Dichanthelium spp. - Andropogon spp.*
- (*Iva imbricata) / Sporobolus virginicus - Spartina patens - (Paspalum distichum, Sesuvium portulacastrum)*
- *Spartina patens - Schizachyrium maritimum - Solidago spp.*

Interdunal Swales. This habitat is characterized by permanent or semi-permanent swales that are found between dune ridges. Typical plants include *Xyris,* phragmites (*Phragmites australis*), and marsh hay (*Spartina patens*). Interdunal swales are best represented on the western Perdue Unit, where deep, nearly permanent east-west swales can be found between the ridges of scrub dunes. Shallower, more seasonal swales are located between frontal dunes on the Perdue and Fort Morgan Units. The Little Point Clear Unit contains swales between ridges of relic dunes at the southeastern portion of the unit. Like their associated frontal dunes, the interdunal swales probably did not experience periodic fires, with the possible exception of a rare wildfire during periods of extreme drought and low humidity conditions. Instead, this habitat is shaped by frequent saltwater inundation from storm surges, blowing sands, and flooding. Fluctuations in water salinity represent the most important natural influence in this community. Snyder and Boss (2002) found that plant communities in swales were the most stable among the components of the dune ecosystem..

Interdunal swales are found from the Coastal Plain of Texas to Virginia and are characterized by permanently or semipermanently flooded wetlands that are primarily freshwater but receive frequent saltwater intrusion (Nature Serve 2005). Most freshwater wetland plants are possible in these areas and interdunal swales share more in common with similar habitats inland than with the surrounding dunes.

The distribution of phragmites, an aggressive plant with both native and non-native haplotypes, is particularly sensitive to salinity levels. Vasquez et al. (2005) found that the non-native haplotype of this species is more salt-tolerant than the primarily freshwater native haplotype. Recent tropical storm activity on the Alabama Gulf coast may have created conditions that are ideal for the invasion of non-native phragmites. This habitat has a high potential for the introduction of other invasive species through storm surges, which can carry exotic wetland plants into this community. Other potential threats to interdunal swales include contaminants and changes in hydrology from nearby development.

This habitat would likely be classified as Intermittent Ponds under the FLUCC system, which describes this community as a seasonal waterbody that is dependent upon runoff or precipitation. USNVC plant associations often found in interdunal swales on the refuge and described in the ecological system, Southeastern Coastal Plain Interdunal Wetland (NatureServe 2005), include:

- *Myrica cerifera - Vaccinium corymbosum*
- *Hypericum reductum - Licania michauxii / Andropogon spp. - Polygonella gracilis - Xyris caroliniana*
- *Fimbristylis castanea - Paspalum distichum*
- *(Myrica cerifera) - Panicum virgatum - Spartina patens*
- *Phragmites australis*
- *Fuirena spp.-Rhynchospora spp.*
- *Spartina patens - Fimbristylis spp. - (Panicum virgatum)*

Scrub and Tertiary Dunes.

> "When viewed under the glare of the noonday sun, the dark-green foliage of the stunted live oak, with gnarled limbs, stands out in strong contrast with the glistening sands."
>
> --Charles Mohr, *The Plant Life of Alabama* (1901)

These large, stable dunes are often the only surviving component of the beach/dune community following a major storm (Holliman 1983). Tertiary dunes, the tallest features in the dune environment, often reaching heights of 9 meters or greater (Boyd et al. 2003), are best represented on the Perdue Unit and are characterized by sparse vegetation including species such as sand live oak and *Conradina*. Smaller, but fairly substantial tertiary dunes can also be found on the Fort Morgan Unit where they are restricted to a narrow strip north of Fort Morgan Road. The southern half of the Perdue Unit, northern Fort Morgan Unit, and southeastern Little Point Clear Unit contain dune scrub habitat.

Scrub habitat has been referred to by various researchers as "scrub/transition" (Swilling et al 1998), "scrub/shrub" (Pearlstine et al. 1995) and "interior scrub" (Sneckenberger 2001). Under the FLUCC system, this habitat falls under the Coastal Scrub category, which includes representative species such as sand live oak (*Quercus geminata*), myrtle oak (*Quercus myrtifolia*) , prickly pear (*Opuntia humifusa*), and yaupon (*Ilex vomitoria*). The FLUCC categories, Sand Pine and Live Oak, also include representative components of this habitat type. Howell (1921) first identified the use of this habitat by Alabama beach mice while conducting mammal surveys for the Bureau of Biological Survey. Swilling et al. (1998) documented the movements of surviving ABM from frontal dunes into the scrub with pre- and post-hurricane trapping. Sneckenberger (2001) suggested that scrub may have multiple functions depending on the quality of the frontal dunes including as a "sink" during times of high frontal dune occupation by ABM, a refugia during storms due to its higher elevation, and as a "source" for ABM to repopulate the primary and secondary dunes as they slowly recover following hurricanes. USNVC plant associations that are typical of scrub dunes, which are described under the ecological system, East Gulf Coastal Maritime Forest (NatureServe 2005), include:

- *Pinus clausa / Quercus geminata - Quercus myrtifolia - Conradina canescens*
- *Pinus elliottii / Ilex vomitoria - Serenoa repens - Myrica cerifera*
- *Pinus elliottii/ Spartina patens - Juncus roemerianus - (Panicum virgatum)*

Tertiary and scrub dunes are generally not considered fire-adapted communities. Bare sandy spots are usually interspersed throughout these habitats which, along with the general lack of fine fuels to carry fires from one ridge to the next, prevent fires from burning large areas. Prescribed burns on the Refuge are directed towards the major portion of the compartment that is characterized by oak hammocks or pine flatwoods and typically no attempt is made to either encourage or discourage fire from entering the scrub. This management scheme is similar to the history of fire in the area, which would likely have burned scrub only when it reached a climax state.

Despite the persistence of tertiary and scrub dunes following most hurricanes, the effects of storms on this transitional zone is still dramatic. Standing on top of the largest tertiary

dunes and looking to the north, a sea of red covers the landscape due to the widespread mortality and stress of scrub vegetation after the relentless pounding of storm surge, salt spray, sand, and high winds. However, these species are well adapted to this unusual, harsh environment and are accustomed to surviving the inhospitable conditions of coastal habitats.

Chinese tallowtree and cogongrass are encroaching on the fringes of this habitat. At this time, invasive species are not replacing significant areas of the tertiary and scrub dunes on the Refuge but the potential exists for this threat to increase in the future.

3.1.2 Maritime Forest

> "The spruce [sand]-pines relate the past; the young magnolias predict the future"
> —(Kurz 1942)

On barrier features such as the Fort Morgan Peninsula, the maritime forest anchors the fragile dune system to the south and provides a foundation to this otherwise highly dynamic environment. Without a substantial maritime forest community, barrier islands are frequently severed by tropical storms such as the breach of Ship Island, Mississippi, by Hurricane Camille in 1969, which created East and West Ship Islands, and the multiple breaches of the western end of Dauphin Island, Alabama, by Hurricane Ivan in 2004. The maritime forest community is a resource of concern due to its high value for Neotropical migratory birds and its potential restoration value for gopher tortoises and eastern indigo snakes. Soils of refuge maritime forests are dominated by three types (USDA 1964):

Lakewood Sand. This soil is deep, excessively drained, and low in organic matter. Restricted to slopes of 0-5%, the depth ranges from 2-30 inches and water permeates rapidly through the soil. Lakewood sands are commonly found on upland areas of the Perdue Unit north of Little Lagoon and dominate the ridge that runs along the north-south county road on the Sand Bayou Unit.

St. Lucie-Leon-Muck Complex. St. Lucie soils are low in organic matter and excessively drained. Leon soils are moderately higher in organic matter and characterized as poorly drained. Muck soils are extremely poorly drained and higher in organic matter than the other two types. These three soils form a complex that cannot be separated. The complex is generally very low in nutrients and contains extremely acidic soils. The St. Lucie-Leon-Muck Complex is abundant in the swales of the northern Perdue Unit and the Little Point Clear Unit.

Leon Sand. This soil is found in depressions between relic ridges that run parallel to the shoreline. Characterized as acidic and poorly drained, Leon Sands are located the flatlands (0-2% slope) of the Sand Bayou, Perdue Units, and Little Point Clear Units. This soil appears to function as a transitional area between the uplands and marshes.

Other soil types that are less commonly found in Refuge maritime forests include Hyde and Bayboro and Muck, and St. Lucie Sand. Rolling Frip Sands are found on small upland areas of Little Dauphin Island. A relatively small but intriguing component of the soils on

the Sand Bayou Unit is the Plummer Loamy Sand type, which is associated with pitcher plant bogs. Pitcher plants have been extirpated from the area due to fire suppression for many years. Areas on the Sand Bayou Unit that contain Plummer soils may have some potential for the restoration of pitcher plant bogs by conducting growing season burns.

Oak Hammock. Perhaps more than any other, this habitat type evokes the landscape associated with the Deep South. Characterized by a canopy of venerable live oaks and southern magnolias draped in Spanish moss, oak hammocks usually have a scrub/shrub understory consisting of species such as myrtle oak, saw palmetto (*Serenoa repens*), yaupon, and blueberry (*Vaccinium spp.*). Oak hammocks are some of the most vulnerable habitats to development on the Alabama Gulf coast because they have no special protection. In most other habitat types on the Fort Morgan Peninsula, such as dune scrub and wetlands, some development restrictions are in place due to endangered species or wetlands regulations. As a result, the pressure to develop the uplands of this ancient forest has been intensive. Neotropical migratory birds can be observed using even the smallest patches (<0.5 acre) of oak hammocks during spring migration fallouts and these stopover sites may be critical to the survival of birds that fly nonstop over the Gulf of Mexico.

Classic oak hammock habitat is located along the ridge that forms the upland portion of the Sand Bayou Unit and the northern Perdue Unit (north of Little Lagoon). Pine flatwoods and freshwater marshes are so closely associated with oak hammock communities that the three habitat types are indistinguishable from each other in many areas.

Research that investigates the effects of prescribed fire on oak hammock habitats has produed mixed results (see section 3.2.4, Migratory Birds) and is limited mainly to the response of breeding or resident birds, which are not the primary focus of refuge management activities. Breininger and Smith (1992) found that some shrub-dependent species such as white-eyed vireo and Carolina wren had lower densities in recently burned oak hammocks. In the same study, red-bellied woodpeckers and eastern towhees had higher densities in areas that had been treated with fire. Habitat management actions will prioritize habitat for transient landbirds and future research on the effects of prescribed fire on the Refuge will have a similar focus.

The effects of hurricanes on oak hammocks are mixed as well. Selective forces seem to have removed most species from barrier islands that are intolerant of salt spray and high winds. Live oaks are extremely resilient after tropical storms, which explains their dominance in coastal areas throughout the Southeast. Other species, such as sand pine and groundsel trees (*Baccharis glomeruliflora*), suffer mortality in areas that are one-half mile or more from the coast. In some oak hammocks, the effects of hurricanes are similar to those of fire and probably constitute an important and necessary influence on the successional stages of this community.

Mechanical treatments, such as thinning, may be considered in the future but are not recommended at this time. Invasive species, including cogongrass and Chinese tallowtree, should be aggressively controlled in oak hammock habitats. Chinese tallowtree poses the

greatest invasive species threat to this plant community since it frequently invades forest interiors after gaining a foothold on the periphery.

FLUCC categories that apply to this plant community include Live Oak, Sand Pine, Xeric Oak, and Mixed Oak. A category that is unique to the FLUCC system is Palmetto Prairies, which refers to the dense stands of saw palmetto that are often found interspersed in oak hammocks on the Refuge. USNVC plant associations that are typical of oak hammocks are described under the Nature Serve (2005) ecological systems, East Gulf Coastal Plain Maritime Forest, East Gulf Coastal Plain Near-Coast Pine Flatwoods and Atlantic Coastal Plain Southern Maritime Forest. The latter system, designated for habitats along the Atlantic coast, nevertheless contains several plant groupings that are appropriate for the Refuge. Representative associations include:

- *Quercus spp. - Magnolia grandiflora - Carya glabra / Ilex opaca*
- *Quercus virginiana - Pinus clausa / Carya (glabra, pallida) / Serenoa repens*
- *Quercus virginiana / Vaccinium arboreum - Ilex vomitoria*
- *Quercus virginiana - (Pinus elliottii* var. *elliottii, Sabal palmetto) / Persea borbonia - Callicarpa americana*
- *Pinus elliottii / Serenoa repens - Ilex glabra*
- *Quercus virginiana / Vaccinium arboreum - Ilex vomitoria*
- *Quercus geminata - Quercus myrtifolia - Serenoa repens - Persea borbonia*
- *Pinus spp. / Ilex coriacea - Cyrilla racemiflora*
- *Pinus elliottii - Taxodium ascendens / Polygala cymosa - Rhynchospora* spp.
- *Pinus spp. / Ilex glabra - Lyonia lucida - (Serenoa repens)*
- *Pinus spp. / (Quercus geminata) / Serenoa repens / Aristida sp.*

Pine Flatwoods. This habitat is dominated by a slash or sand pine canopy mixed with occasional hardwoods such as southern magnolia and live oak. Typical understory plants include saw palmetto, fetterbush (*Lyonia lucida*), and gallberry (*Ilex glabra*). Pine flatwoods are best represented on the Sand Bayou, Little Point Clear, and northern Perdue Units. As with oak hammocks, pine flatwoods occur on the Refuge in small patches and are often interspersed with other habitat types, making habitat delineation difficult or impossible in some areas.

Hurricanes seem to affect these habitats less than others because pine flatwoods are often located well inland. However, high mortality of sand pine communities was noted by Refuge staff in some portions of the Perdue Unit following Hurricane Ivan. Cogongrass poses a significant threat to pine flatwoods since its margins are preferred habitat for this invasive species.

In addition to prescribed fire, some areas of this habitat may have good potential for restoration efforts that seek to restore a grassy groundcover. Historically, fire-maintained plants such as wiregrass were an important component of the groundcover in pine flatwoods (Stallard 1950, see also Section 2.4, History of Refuge Lands). This habitat is associated with gopher tortoises, which still occur in small numbers on the Refuge. The threatened eastern indigo snake is almost certainly extirpated from coastal Alabama but this

species probably occurred on the Refuge since it is closely associated with gopher tortoise burrows and some records exist for Baldwin County (Mount 1975).

The pine flatwoods community has the highest natural fire frequency of any refuge habitat due to the combination of volatile fuels (sand pine, saw palmetto, greenbriar [*Smilax bona-nox*]) and lightning frequency in Alabama, which ranks fourth among all states in the number of lightning strikes (NOAA 2005). FLUCC categories that apply to this habitat type include Pine Flatwoods and Sand Pine. Pine flatwoods on the refuge fit neatly into the Nature Serve (2005) category, East Gulf Coastal Plain Near-Coast Pine Flatwoods ecological system. Representative USNVC plant associations include:

- *Pinus elliottii / Serenoa repens - Ilex glabra*
- *Pinus spp. / Ilex coriacea - Cyrilla racemiflora*
- *Pinus elliottii - Taxodium ascendens / Polygala cymosa - Rhynchospora* spp.
- *Pinus spp. / Ilex glabra - Lyonia lucida - (Serenoa repens)*
- *Pinus spp. / (Quercus geminata) / Serenoa repens / Aristida sp.*

3.1.3. Wetlands

Freshwater and brackish marshes are extensive on the refuge, providing habitat for species such as the gulf saltmarsh snake (*Nerodia clarkii clarkii*), king rail (*Rallus elegans*), and Nelson's sharp-tailed sparrow (*Ammodramus nelsoni*). These habitats are surprisingly diverse on the Refuge due to varying influences of salinity, tides, and proximity to major waterbodies. Pond cypress and black gum (*Nyssa biflora*) swamps are found throughout the Refuge but most are small, intermittent wetlands that are not treated separately due to the limited management alternatives for these isolated components of maritime forest. See Section 3.1.1 for a description of interdunal wetlands, which are associated with the beach/dune community in this Plan.

Soils found in Refuge marshes include:

Axis mucky sandy clay loam. Level, poorly drained soil associated with narrow bayous and manmade channels. Characteristic soil reaches a depth of about 7 inches with a high content of organic matter and moderately saline due to tidal flooding. This is the dominant soil found in the marshes of Little Dauphin Island.

Tidal marsh. A generalized soil type that covers most Refuge marshes, this soil is characterized by flat elevation with virtually no trees and either mudflats or dense stands of grasses and rushes. Tidal marshes are strongly acidic and are flooded by saltwater at high tide. Typical material is heavy or silty clay. This soil is found along the margins of Little Lagoon, Gator Lake, Oyster Bay, Bon Secour Bay, in the marshes south of Fort Morgan, and the finger sloughs of Little Point Clear along Mobile Bay.

St. Lucie-Leon-Muck Complex. This soil complex (see Section 3.1.2 for description) is found in some marshes on the southern Fort Morgan Unit, Perdue Unit, Little Point Clear, and Sand Bayou Units.

The effects of hurricanes on freshwater marshes are probably more pronounced than for tidal marshes, which have adapted to these periodic events. The system appears to be relatively tolerant of significant variations in salinity; however, other impacts from tropical storms may have more long-lasting consequences. After Hurricane Katrina in August 2005, a substantial amount of debris was deposited into the finger sloughs of the Little Point Clear Unit including lumber, hazardous materials, and household items. Hurricane Ivan deposited similar debris throughout the margins of Little Lagoon and Gator Lake in 2004. A massive effort to clean up Refuge marshes after Hurricane Ivan was initiated in 2005 but some debris will persist in wetlands.

Brackish Tidal Marshes. Characteristics of this habitat on the Refuge include low tidal amplitudes, protected inlets and bays, and dense vegetation. Black needlerush (*Juncus roemerianus*) is the dominant plant species. The role of fire in this environment is unclear and incorporating research findings from prescribed burns is essential for the prudent management of *Juncus* marshes. Mohr (1901) provides some of the only information available about the historical saltwater marshes in the area and he describes a landscape covered exclusively by black needlerush. Refuge Units that contain brackish tidal marshes include Little Point Clear, Little Dauphin Island, and Sand Bayou.

A potentially significant threat to tidal marshes is phragmites, especially the non-native haplotype (Vasquez et al. 2005; see also Interdunal Swales under Section 3.1.1), which can displace *Spartina alterniflora* and other native saltmarsh plants. Current efforts are underway to map and monitor the distribution of phragmites in both fresh and saltwater marshes on the Refuge to determine whether it is displacing native vegetation and may be in need of control.

Except in cases where habitat restoration is necessary, such as following contaminant spills or severe damage from hurricanes, active management of brackish marshes is not planned. The most similar ecological system to this Refuge habitat is Mississippi Sound Salt and Brackish Tidal Marsh (Nature Serve 2005). Saltwater Marshes, with Level IV subcategories of Cordgrass and Needlerush, would generally describe this community within the FLUCC system. USNVC plant associations, including shrubs along the edge of these marshes, include:

- *Cladium mariscus*
- *Juncus roemerianus*
- *Spartina alterniflora - Juncus roemerianus - Distichlis spicata*
- *Spartina spartinae - Sporobolus virginicus*
- *Ilex vomitoria - Quercus spp. - Myrica cerifera - Serenoa repens*

Freshwater Marshes. Invasive species are one of the primary threats to this Refuge habitat. Cogongrass thrives on the margins of wet areas, especially near roads, and has the potential to replace native vegetation during periods of drought in seasonally-flooded wetlands.

Hurricanes can have devastating short-term impacts on freshwater marshes. Hurricane Ivan pushed an estimated 12 foot storm surge across Little Lagoon and into freshwater wetlands that are 200 meters or greater inland. In addition, massive amounts of hurricane debris were deposited into these marshes so habitat restoration in the form of low-impact cleanup operations and native plant restoration will always be a necessary component of habitat management in freshwater marshes.

The FLUCC system also refers to this habitat type as Freshwater Marshes, with Level IV subcategories of Sawgrass and Bulrush. Freshwater Marshes on the refuge are similar to the Nature Serve (2005) ecological systems, Southeastern Coastal Plain Interdunal Wetland and East Gulf Coastal Plain Southern Depression Pondshore. Representative plant associations include:

- *Myrica cerifera - Vaccinium corymbosum*
- *Hypericum reductum - Licania michauxii / Andropogon spp. - Polygonella gracilis - Xyris caroliniana*
- *Fimbristylis castanea - Paspalum distichum*
- *(Myrica cerifera) - Panicum virgatum - Spartina patens*
- *Phragmites australis*
- *Fuirena spp.-Rhynchospora spp.*
- *Spartina patens - Fimbristylis spp. - (Panicum virgatum)*
- *Hypericum spp. / Rhynchospora spp.*
- *Panicum virgatum - Andropogon spp. - Aristida spp.*
- *Fuirena scirpoidea - Rhynchospora spp.*
- *Rhynchospora spp. - Juncus spp.*

3.2 Wildlife

The collection of biological data on the Refuge has primarily focused on those species that were prioritized due to their status as federally endangered, state-listed nongame species, or Partners in Flight priority species. Throughout the discipline of wildlife management, some natural bias exists in favor of research and monitoring of certain wildlife species. Bolen and Robinson (1995) observed that 87 percent of the scientific articles appearing in the *Journal of Wildlife Management* in 1993 concerned birds or mammals. In recent years, an increased focus has been placed on other taxa, such as amphibians, which are monitored on the Refuge. One of the objectives of this Plan to is to focus on the management of ecosystems, including the species of concern that are listed here, in an attempt to recreate the historic landscape that encompasses the complex needs of its inhabitants.

3.2.1 Alabama beach mouse

The Alabama beach mouse is among only a handful of other endangered mammals whose existence depends on a single refuge. If the dune ecosystem of Bon Secour National Wildlife Refuge were lost, the Alabama beach mouse would almost certainly become extinct. A recently completed population and habitat viability analysis (Traylor-Holzer et al. 2005) for ABM demonstrated the importance of the Perdue and Fort Morgan Units for

the survival of this endangered species. As the largest contiguous tract of ABM habitat (Holliman 1983), the Perdue Unit provides the scrub and tertiary dunes that are crucial for the persistence of this animal through the nearly continuous assault by tropical storms. Similarly, high ground within the Fort Morgan Unit probably supplies the western half of the Fort Morgan Peninsula with a source population following catastrophic events, such as recent hurricanes.

The oldfield mouse (*Peromyscus polionotus*) consists of 16 subspecies, including 8 coastal forms that are collectively referred to as "beach mice" (Hall 1981, Lynn 2000). Five subspecies of beach mice are restricted to the coastal dunes and adjacent habitats of the Alabama Gulf coast and Northwest Florida. The Alabama beach mouse is a monogamous, brown or gray colored subspecies of the oldfield mouse. Two other existing subspecies of beach mice and one extinct subspecies have been known from the Atlantic coast of Florida. The Alabama beach mouse is considered semi-fossorial, since it lives much of its life in underground burrows, but comes aboveground to feed on many native dune plants including coastal bluestem (*Schizachyrium maritimum*), seashore elder, and sea oats (Sneckenberger 2001, Boyd et al. 2003).

Bowen (1968) found beach mice in well drained soils. A clay hardpan beneath some soil types seems to restrict their ability to successfully burrow (Bowen, 1968). In general, the Alabama beach mouse is lighter in color and has reduced dorsal coloration when compared to inland races of the oldfield mouse. The undersides are completely white and a dark stripe is present on a portion or all of the tail (10-80%). Bowen (1968) reexamined the taxonomic status of beach mice and assigned the population from Mobile Bay to Alabama Point, and Ono Island, to *P. p. ammobates*. The population east of Perdido Pass, from Florida Point to the Alabama-Florida state line, was described as the Perdido Key beach mouse (*P. p. trissyllepsis*) (Bowen 1968). The Alabama beach mouse was listed as an Endangered Species in 1985.

Weighing less than 25 grams, the Alabama beach mouse is a tiny symbol of the majestic dunes that still rise above the sea at Bon Secour but no longer form a vast swath along much of the Alabama Gulf coast. The historic range of ABM stretched from the western tip of the Fort Morgan Peninsula (Mobile Point) to Perdido Pass, including Ono Island, just west of the Florida State Line (Bowen 1968, Holliman 1983). Currently, ABM are mostly confined to the Refuge and the Gulf Highlands area of the Fort Morgan Peninsula following two decades of habitat loss and back-to-back severe hurricane seasons in 2004 and 2005. One of the earliest accounts of the historic range, habitat use, abundance of the Alabama beach mouse (then referred to as the white-fronted beach mouse) was written by Howell (1921) in his *Biological Survey of Alabama*:

> "...from Little Lagoon eastward to the mouth of Perdido Bay these mice occur in abundance; most numerous in the line of dunes nearest the surf....here their tracks and trails are seen everywhere in the sand; on the rolling sand flats nearer the bay, where the growth of bushes and palmetto scrub is more dense, the mice were found in smaller numbers; doubtless intergrades with *P.p. polionotus* (old-field mouse) in southern counties."

Today, the Alabama beach mouse occurs in about one-half of its historic range, of which a large portion is under tremendous development pressure. The Refuge has served as both an island of intact habitat and as a hub of research, beginning with Holliman's investigations in 1983.

3.2.2 Sea Turtles

Loggerhead turtles have a nearly worldwide, "antitropical" distribution including the Indian Ocean, eastern Australia, the southeastern U.S., Japan, the Mediterranean, Brazil, South Africa, and Oman (Lutz and Musick 1997). The loggerhead turtle was federally listed as a threatened species in 1978 (NMFS and USFWS 1991). In the U.S., most nesting occurs along the east-central Florida coast. Loggerheads favor beaches with steep slopes and gradually sloped offshore approaches (Provancha and Ehrhart 1987, Wood and Bjorndal 2000). Sea turtle nests in Alabama represent less than 1% of total loggerhead nesting in the southeastern U.S. each year. However, the Alabama Gulf coast may be regionally important for the production of male sea turtles. The Refuge is also essentially the westernmost loggerhead turtle nesting area in the United States. Each year, approximately 10-15 loggerhead sea turtle nests are found on Refuge beaches. The highest concentration of sea turtle nesting occurs on the Perdue Unit (Figure 5). The endangered Kemp's ridley sea turtle (*Lepidochelys kempii*) also nests occasionally on the Alabama coast (Phillips 2004).

Loggerheads lay between 23-198 eggs in a clutch with a mean of 112 (Van Buskirk and Crowder 1994, Phillips 2004). Each female nests 3-4 times per season as part of a strategy that enhances the probability for survival in an environment that occasionally subjects the nest to conditions such as storm surge, rainfall, and drought (Lutz and Musick 1997). When Refuge nests fail, the apparent cause is usually inundation from tropical storms or less frequently, infertility (Phillips 2003, 2004). One frequent suggestion for enhancing beaches is to increase sea turtle nesting success is beach renourishment; however, this technique has many negative effects.

The objectives of nearly all beach renourishment projects are to provide benefits to the human population of a coastal area. Specifically, these projects are designed to provide protection to private and commercial structures from tropical storms. A secondary goal of these projects is often to promote tourism by widening the beach for visitors. While improvements to wildlife habitat are often cited as additional benefits of these projects, the scientific literature either provides contrary evidence or states that the long-term, cumulative effects of these projects are unknown.

The negative impacts of beach renourishment projects to sea turtles are well documented. Rumbold et al. (2001) studied the effects of these projects in Florida and found that loggerhead turtle nests declined in the years immediately following beach renourishment. In addition, the number of false crawls, or non-nesting emergences, increased on these same beaches when compared to those that were not renourished. The use of heavy equipment and associated lights during beach renourishment projects can also interfere with nesting sea turtles. Other studies have found significant negative effects for marine

Figure 5. Sea turtle nest locations at Bon Secour National Wildlife Refuge, 2003-2005

mammals, shorebirds, and fish (Lindeman and Snyder 1999, Greene 2002, see also Section 3.2.3, Shorebirds) as a result of these projects.

The impacts of beach renourishment on most wildlife species are unknown and constitute an urgent research need (Nordstrum 2005). When studies on the effects of beach renourishment projects do occur, they are often species-specific with a short-term focus and do not address the cumulative effects of these large scale habitat modifications. Beach renourishment projects should be discouraged on public lands except in cases where severe, manmade habitat degradation has occurred. In these instances, it should be demonstrated that this degradation is directly related to a specific project. Generalized, unsubstantiated causes of erosion (e.g. nearby development) should not be used as justification for beach renourishment projects on public lands. Shoreline erosion has been documented in the Fort Morgan area (Douglass et al. 1999), particularly along Mobile Bay, and beach habitat restoration may be necessary in the future if there is a substantial net loss of shorebird habitat when balanced with areas where additional habitat may have been created by dune blowouts from tropical storms and natural accretion.

Appropriate habitat management techniques for sea turtles include many of those recommended for beach mice (see Section 5.0, Habitat Management Objectives and Strategies). Habitat restoration is critical for the survival of sea turtles since several studies suggest that hatchlings find the sea by crawling away from elevated natural silhouettes such as dunes (Limpus 1971, Salmon et al. 1992).

3.2.3 Shorebirds

Forty-one species of shorebirds are known or suspected to occur at Bon Secour. In 2001, Critical Habitat was designated for wintering piping plovers on the Little Dauphin Island Unit and on the western Fort Morgan Unit (Figures 6 and 7). Piping plovers breed in three distinct areas including the Atlantic Coast, Great Lakes, and Northern Great Plains (Ferland and Haig 2002). Nesting populations of the Atlantic Coast and Northern Great Plains are federally listed as threatened while the Great Lakes population is listed as endangered. Plovers from all three breeding areas winter along coastal areas of the U. S. from North Carolina to Texas, eastern Mexico, and several locations in the Caribbean. Banded piping plovers from the endangered Great Lakes breeding population have been identified at Fort Morgan (U. S. Fish and Wildlife Service 2003).

The protection of nesting, roosting, and foraging shorebirds was determined to be a high priority for the Refuge during the development of the CCP and this Plan. The Southeastern Coastal Plains-Caribbean Report of the U. S. Shorebird Conservation Plan (Hunter 2003) emphasizes the need to reduce disturbances to high priority roosting shorebirds, including piping and snowy plovers (*Charadrius alexandrinus*), in order to achieve population goals for these species (see Section 5.0, Habitat Management Objectives and Strategies) and to fulfill the mandates of the Refuge Improvement Act of 1997.

The Recovery Plan for the Great Lakes piping plover (U. S. Fish and Wildlife Service 2003) also calls for a reduction in the disturbance to piping plovers at wintering sites by

Figure 6. Designated critical habitat* for the piping plover, Fort Morgan Unit, Bon Secour NWR.

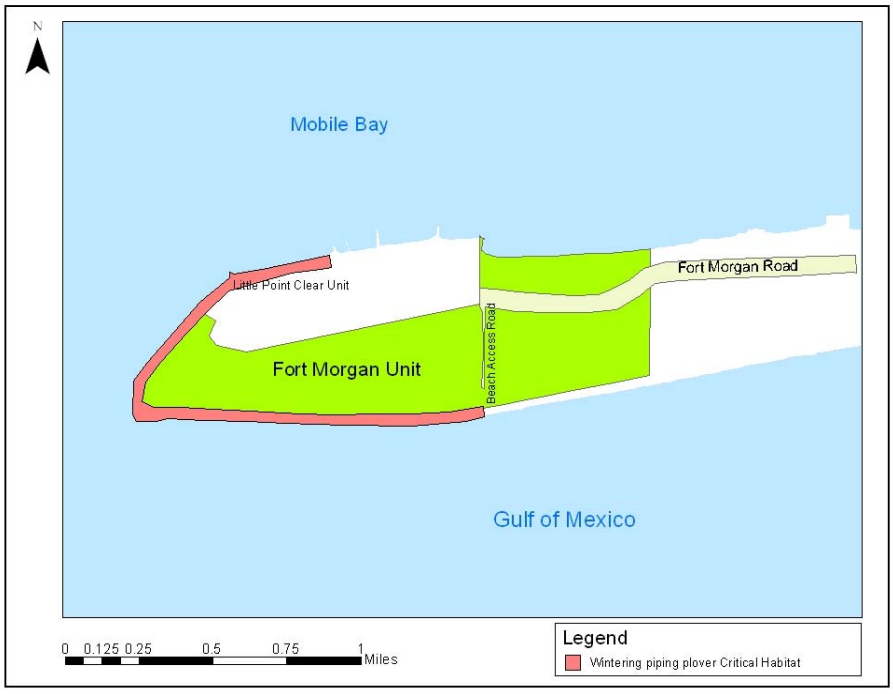
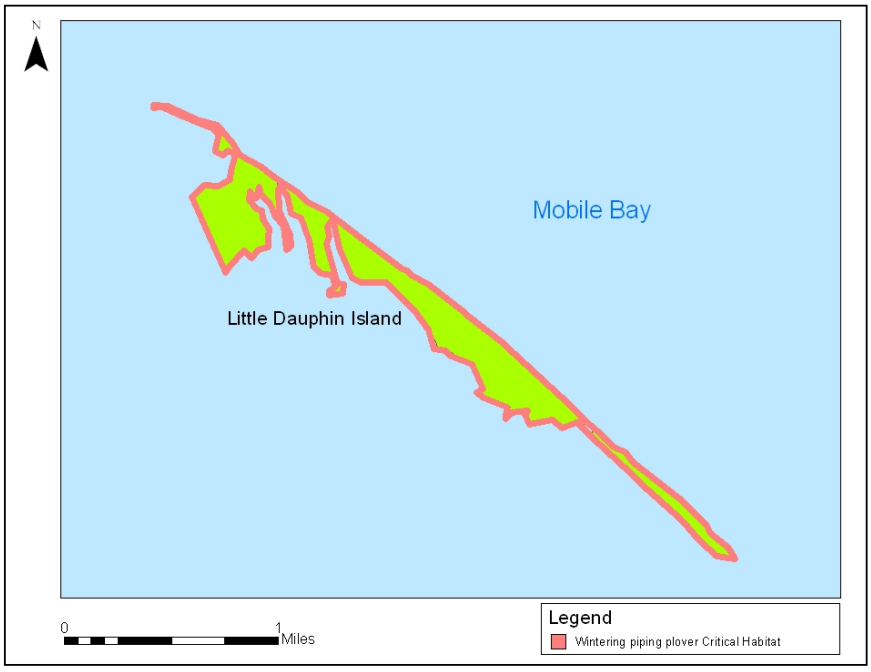


Figure 7. Designated critical habitat* for the piping plover, Little Dauphin Island Unit, Bon Secour NWR.



***Note:** These maps represent the general areas where wintering piping plover Critical Habitat has been designated at Bon Secour NWR. Refer to the narrative unit descriptions (50 CFR 23872 or part 17.95(a), 50 CFR) as the precise legal definition of critical habitat.

humans and pets (recovery task # 2.14). Pets were prohibited in the Refuge Comprehensive Conservation Plan. This policy was enacted to increase protection for shorebird populations, uphold the "Wildlife First" mandate of the Refuge Improvement Act, and to address public safety concerns.

Habitat management efforts for shorebirds will focus on the protection of federally listed and other high priority species (Table 2). Other management techniques, such as beach renourishment, are not recommended. Shorebirds, particularly nesting species, may be affected by the deposition of sand on eggs or hatchlings and the resulting sand composition may impact the ability of birds to extract food from the beach (Greene 2002). Nordstrum (2005) notes that even when benefits to shorebirds are observed from beach renourishment, such as when additional habitat is created, there is little or no understanding of how to replicate this effect since it is not consistent across projects.

Table 2. Priority List of Shorebird Species[1] Known Or Suspected to Occur on Bon Secour National Wildlife Refuge

Priority Level	Species	Life Cycle Activity[2]
Extremely High	Snowy Plover	**Breeding**, Wintering
	Piping Plover	**Wintering**, Migration
	Red Knot	Migration, Wintering
	American Oystercatcher	**Wintering**, **Breeding**
High	Wilson's Plover	**Breeding**, wintering
	Whimbrel	**Migration**, wintering
	Long-billed Curlew	wintering
	Upland Sandpiper	Migration, breeding
	Semipalmated Sandpiper	Migration, wintering
	Stilt Sandpiper	Migration, wintering
	Short-billed Dowitcher	Migration, Wintering
	Buff-bellied Sandpiper	Migration
	Marbled Godwit	Migration, Wintering
	Solitary Sandpiper	Migration
Moderate	Black-bellied Plover	Migration, Wintering
	American Golden Plover	migration
	Ruddy Turnstone	Migration, Wintering
	Sanderling	Migration, Wintering
	Western Sandpiper	Migration, Wintering
	Least Sandpiper	Migration, Wintering
	Pectoral Sandpiper	Migration
	Dunlin	Wintering
	Greater Yellowlegs	Migration, Wintering
	Lesser Yellowlegs	Migration, Wintering
	Willet	Migration, Wintering, Breeding
	American Avocet	Wintering

[1] Southeastern Coastal Plains-Caribbean Region Report, U. S. Shorebird Conservation Plan (Hunter 2002)

[2] Bold and underline=extremely important to species, bold=very important to species, lower case=present but not in high numbers

3.2.4 Migratory Birds

The Refuge is an important stopover site for Neotropical migratory birds, species that generally breed in North America and winter in Central and South America. During spring and fall migrations, the Refuge serves a vital role in providing habitat for birds to rest and refuel. The Refuge is particularly important for hatch-year birds during fall migration.

Each fall, approximately 80% or greater of individuals captured at the University of Southern Mississippi bird banding station, located on the Fort Morgan Unit of the Refuge, are hatch-year birds (Woodrey and Moore 1997). Bird use of the Refuge during spring migration is much more weather dependent. Large concentrations of birds, or "fallouts," during spring migration are associated with passing cold fronts. The variables that affect habitat use by Neotropical migrants at stopover sites are numerous and complex.

Somershoe and Chandler (2004) found that the size of oak hammocks was more important than vegetation structure or patchiness as a habitat value for Neotropical migratory birds. Larger oak hammocks (1.29—3.08 ha) had significantly higher numbers of species and individuals than smaller hammocks (<1.29 ha) (Somershoe and Chandler 2004). As a result, limited resources that are available for land acquisition and habitat management may be used for the conservation of larger tracts of oak hammocks. Several species including eastern wood-pewee (*Contopus sordidulus*), blue-gray gnatcatcher (*Polioptila caerulea*), American redstart (*Setophaga ruticilla*), and northern waterthrush (*Seiurus noveboracensis*) were detected significantly more often in large patches during the fall. Northern parulas (*Parula americana*) and palm warblers (*Dendroica palmarum*) did not use smaller hammocks during fall and some species (eastern wood-pewee, northern waterthrush) were not found in the two smallest hammocks at any time of the year (Somershoe and Chandler 2004).

For transient landbirds, the ability to find high quality food on the Refuge may not only predict a successful migration but also has implications for their subsequent reproductive efforts. Smith and Moore (2003) found that migrants achieved greater reproductive performance, as measured by such criteria as clutch size, egg volume, and nestling mass, if they arrived on their Michigan breeding grounds with good fat stores. Kuenzi et al. (1991) suggested that other factors, such as finding a safe place to rest exhausted muscles, may be as important as food availability at the selected site. Many trans-Gulf migrants depart their barrier island stopover site within one day of their arrival and birds that arrive in a fat-depleted state are no more likely to prolong the length of their stopover versus those individuals that arrive on the island with good fat stores (Kuenzi et al. 1991).

Molt migration, which involves a bird's movement to a site specifically for the purpose of replacing its flight feathers, is a phenomenon that may be common among Neotropical migrants (Leu and Thompson 2002). The northern Gulf coast is believed to be one of these sites for some species, such as the northern rough-winged swallow (*Stelgidopteryx serripennis*) (Yuri and Rohwer 1997). The Refuge may play an important role in this

migration strategy, which requires areas that are relatively safe from predators and provide adequate food resources during molt.

Neotropical migrants may be more sensitive to large-scale habitat fragmentation than resident species (Maurer and Heywood 1993). Habitat fragmentation has been implicated in poor nesting success for Neotropical migrants due to nest predation and brood parasitism by the brown-headed cowbird (*Molothrus ater*) (Donovan et al. 1995). Species that nest in the southeastern United States, which have breeding ranges that are often more restricted than those nesting in northern latitudes, were assessed a high score of vulnerability by Partners in Flight (PIF) (Rich et. al 2004) .

The response of migratory birds to various fire treatments in maritime forests is species-dependent and additional research is needed to determine habitat management techniques that provide the most benefits to species of concern. Most of the available research concerning the effects of prescribed fire on birds is restricted to breeding and resident species, which are not the primary focus of refuge management activities.

Habitat management actions may even require seasonal differences to accomplish objectives for species of concern. Yong et al. (1998) suggested that birds may be more vulnerable to habitat disturbances during fall migration than spring migration since these individuals are more likely to be immature, which is certainly the case at Bon Secour (Woodrey and Moore 1997).

Longleaf pine, which once dominated the forests of the southeastern United States, was likely an important component of the Refuge flora during pre-settlement times. Chapman (1932) reported that longleaf pine once covered one-half of the Coastal Plain from Virginia to Texas. Today less than 1% of the historic range of longleaf pine remains (Noss 1988, Simberloff 1993). In pine flatwoods, managing for the herbaceous groundcover associated with this fire-adapted community has the highest probability of benefiting the greatest number of species of concern (Table 3) within East Gulf Coastal Plain Avifaunal Biome (Partners in Flight 2005).

Wiregrass was the principal ground cover in the southern portion of the historic range of the longleaf pine (Chapman 1932). This species plays a critical role in the maintenance of fire-adapted communities since it comprises the primary fuel to carry fire between open stands of longleaf pine (Walters et al. 1994). Stallard (1950) regularly found wiregrass during his visits to the area before the encroachment of significant human development onto the Fort Morgan Peninsula. These wiregrass stands, now all but extirpated from coastal Alabama, represent the last remnants of a once flourishing, fire-adapted landscape on the present-day Refuge. Tucker et al. (2003) found that bird species of concern in oak hammocks and pine flatwoods benefited from fire treatments designed to restore longleaf pine communities while species that were negatively affected by similar management prescriptions were abundant in other habitats. Prescribed fire also reduces habitat suitability for some predators, such as raccoons (*Procyon lotor*), which may result in improved nesting success by woodland birds (Jones et al. 2004).

Holmes and Sherry (2001) recommend that successional changes should be closely examined when investigating the effects of management treatments in undisturbed or control areas since there is a natural decline in early and mid-successional species in these habitats. Species of concern are typically designated after a review of large-scale, persistent population declines or habitat threats. Determinations of Neotropical migratory bird declines on the Refuge should only be made after combining data with coarse-scale research, since local indications may be the result of normal fluctuations (Anders et al. 1997).

Due to the complex network of habitats found in maritime forest communities, the PIF Bird Conservation Plan for the East Gulf Coastal Plain indicates that traditional umbrella management of species suites and ecosystems may not be effective in this landscape since several studies (Moore et al. 1990, Moore and Woodrey 1993) have found that Neotropical migrants regularly use all of these microhabitats. The currently arranged partition of small fire compartments on the Refuge may be conducive to achieving recommended management objectives which favor fine-scale habitat manipulations. Partners in Flight (2005) suggests that the only clear direction for management in the absence of further research is for activities which promote the production of fleshy fruits.

As stopover sites for transient landbirds disappear, the increasing importance of providing good habitat during this vulnerable life cycle is clear. Sillett and Holmes (2002) estimated that seasonal mortality increased 15 times for black-throated blue warblers during migration, representing 85% of annual mortality.

Table 3. Landbird Species of Conservation Concern Known to Occur on Bon Secour National Wildlife Refuge.

Species	Life Cycle Activity	Action Level Needed	Status Noted[1]
Henslow's Sparrow	Wintering	Immediate	NALCP, EGCP[2],CWCS[6]
Golden-winged Warbler	Migration	Immediate	NALCP, EGCP[2]
Swallow-tailed Kite	Migration	Immediate	NALCP, EGCP[2],CWCS[6]
Brown-headed Nuthatch	Resident	Management	NALCP, EGCP[3]
Worm-eating Warbler	Migration	Management	NALCP, EGCP[2],CWCS[6]
Prairie Warbler	Breeding, Migration	Management	NALCP, EGCP[3]
Prothonotary Warbler	Breeding, Migration	Management	NALCP, EGCP[3]
Kentucky Warbler	Migration	Management	NALCP, EGCP[2],CWCS[6]
Cerulean Warbler	Migration	Management	NALCP, EGCP[2],CWCS[6]
Blue-winged Warbler	Migration	Management	NALCP, EGCP[3]
Wood Thrush	Migration	Management	NALCP, EGCP[2],CWCS[6]
Red-headed Woodpecker	Resident	Management	NALCP, EGCP[3]
Dickcissel	Migration	Management	NALCP, EGCP[3]
Painted Bunting	Migration	Management	NALCP, EGCP[4]
Willow Flycatcher	Migration	Management	NALCP
Seaside Sparrow	Resident	Long-term planning	NALCP, EGCP[2],CWCS[6]
Nelson's Sharp-tailed Sparrow	Wintering	Long-term planning	NALCP, EGCP[2],CWCS[6]
Swainson's Warbler	Breeding, Migration	Long-term planning	NALCP, EGCP[2],CWCS[6]
American Kestrel	Wintering	Immediate, policy, research[5]	NALCP, EGCP[2],CWCS[6]
Bewick's Wren	Wintering	Immediate, policy, research[5]	NALCP, EGCP[2],CWCS[6]

[1] NALCP=Partners in Flight Watch List Species of Continental Importance as identified in the North American Landbird Conservation Plan (Rich et al. 2004); EGCP=Partners in Flight Bird Conservation Plan for the East Gulf Coastal Plain; CWCS=Alabama Comprehensive Wildlife Conservation Strategy

[2] Highest overall conservation concern as listed in PIF Bird Conservation Plan for the East Gulf Coastal Plain.

[3] High overall conservation concern as listed in PIF Bird Conservation Plan for the East Gulf Coastal Plain.
[4] Local, state, or regional interest species listed in PIF Bird Conservation Plan for the East Gulf Coastal Plain.
[5] Action level needed described by PIF Bird Conservation Plan for the East Gulf Coastal Plain as "immediate management and/or policy action necessary rangewide" and "research is necessary to further clarify population status level or level of threat to species or habitat." Not listed as a species of concern in the PIF North American Landbird Conservation Plan (Rich et al. 2004).
[6] Species listed as Greatest Conservation Need in the Alabama Comprehensive Wildlife Conservation Strategy (CWCS).

Other transient landbird species of concern identified in the Refuge Biological Review (USFWS 2000) include Cape May warbler (*Dendroica tigrina*), mourning warbler (*Oporornis philadelphia*), bay-breasted warbler (*Dendroica castanea*), Louisiana waterthrush (*Seiurus motacilla*), northern parula, veery (*Catharus fuscescens*), and short-eared owl (*Asio flammeus*). Some of these species (e.g. Cape May warbler, Louisiana waterthrush, bay-breasted warbler) only migrate through the Refuge in small numbers incidental to their primary flyways while others (e.g. northern parula) comprise a substantial component of the Refuge migrant population and may benefit from management actions.

Marshbirds of concern identified include black rail (*Laterallus jamaicensis*), yellow rail (*Coturnicops noveboracensis*), king rail (*Rallus elegans*), and clapper rail (*Rallus longirostris*).

4.0 Habitat Management Goals

Throughout most of its history, the Fort Morgan Peninsula has been a nearly inaccessible barrier feature with an unforgiving climate. As a result, the present-day Refuge has been spared the legacy of depletive agricultural practices and destructive land uses that requires large-scale habitat restoration on many other public lands. However, there are natural processes, such as fire, that have been suppressed in the recent history of the Fort Morgan Peninsula and need to be reintroduced to restore the habitat to its historic condition. Today, the importance of fire in the maintenance of many ecosystems is well understood. However, every acre does not necessarily need to be under some sort of management prescription and the semi-wilderness aspect of much of Bon Secour should keep it safely out of the category of an intensively managed refuge. As Herman (2002) simply stated in his article that mourned the loss of natural history and restraint in modern wildlife science, "Sometimes the best management is no management at all."

In this spirit, an effort is made in this Plan to emphasize the use of control areas on the refuge. Without these areas where habitat manipulations will not occur, there can be no effective means of evaluating the subsequent response of wildlife and the refuge environment to management. One notable exception is the invasive species program, which will be employed in all Refuge units as necessary, but experiments may be conducted with biocontrol or other emerging strategies as they become available in the future for the purposes of comparison with the traditional use of pesticides or mechanical removal.

For habitats that require active management, goals and objectives were developed (USFWS 2000, USFWS 2005), which are expanded upon or combined in this Plan to fulfill the refuge purposes. A habitat management goal is a broad, qualitative statement that is derived from the established purposes and vision for the refuge:

- **Goal 1*:*** Manage dune and coastal scrub to maximize Alabama beach mouse habitat on the Perdue, Little Point Clear and Fort Morgan Units.

- **Goal 2*:*** Identify, manage, and enhance refuge habitats for a variety of avifauna, with an emphasis on habitats that support birds of conservation concern.

- **Goal 3*:*** Identify and maintain a diversity of native plant communities on the refuge, including forested systems.

- **Goal 4*:*** Conduct research to aid in the implementation of habitat management actions on the refuge.

5.0 Habitat Management Objectives and Strategies

Objectives are more quantitative than goals and provide some measurable statement that can be used to determine whether the action was successfully accomplished. Similar objectives listed in the Comprehensive Conservation Plan were combined in this Plan. Strategies are potential methods to accomplish the habitat goals and objectives. Land managers may select from the strategies listed in this Plan unless additional strategies need to be developed based on new information gathered from research and field observations. The preferred strategies are listed first under each objective along with rationale explaining their reasons for their priorities. Other potential strategies listed are considered to be feasible alternatives if supported by future research but the current literature does not support their selection. Recommended prescriptions for management of each refuge fire compartment are listed in Appendices A, B, and C. It is critical that this document, while providing specific guidance for habitat management, be as dynamic and adaptable to change as the shifting environment of the Alabama Gulf coast that it is meant to describe.

Goal 1

Manage dune and coastal scrub to maximize Alabama beach mouse habitat on the Perdue, Little Point Clear and Fort Morgan Units.

Objective 1: Restore beach dune habitat to a level that supports documented average annual increases in Alabama beach mouse populations for at least 5 years following a hurricane.

Strategy 1 (**preferred**): By 2010, improve and restore the beach dune ecosystem through recommended use of fertilizer and re-vegetation.

Rationale: This strategy is preferred due to the demonstrated benefits of fertilizer and the likely benefits of re-vegetation. Auburn University conducted a six-year study (Boyd et al. 2003) on the Refuge to investigate the effects of post-hurricane dune restoration techniques (sand fencing and fertilizing) on Alabama beach mice and dune vegetation. Measures of habitat quality in response to these restoration techniques included ABM densities and dune plant cover, species richness, dominance, and diversity. Their results indicate that fertilizing has a significant, preventative benefit in reducing the loss of dunes to tropical storms, presumably by strengthening roots of existing vegetation. In contrast, sand fencing had only localized effects and a significant difference could not be demonstrated between treated and untreated areas when ABM and plant values were used for measurement.

There are certainly some potential drawbacks to the routine use of fertilizers. Nitrogen-based fertilizers have been implicated as a likely contributing factor to the large area of apoxia or "dead zone" in the Gulf of Mexico near the mouth of the Mississippi River (CENR 2000). This Plan proposes to use of fertilizers for their preventative benefits related to dune protection at a minimum interval of every 3 years to reduce the possibility of any cumulative impacts of this application.

Miller et al. (2001) demonstrated an increase in sand accumulation in fenced areas but effects on plants other than transplanted vegetation or beach mice were not explored. While Boyd et. al (2003) could find neither significant positive nor negative effects from sand fencing, the substantial costs of this technique may be prohibitive given the lack of supporting data. In a 3 year period (2003-2005), sand fencing for the Refuge was rebuilt twice due to damage from tropical storms and would have been destroyed more frequently during this period (following Hurricanes Dennis and Katrina) if it had been immediately constructed following each storm.

Revegetating hurricane-damaged beaches is similar in cost to constructing sand fence along the same stretch of beach. Miller et al. (2001) noted that native vegetation has the unique ability to continue growing after being covered with sand. Sand fencing, on the other hand, is made useless once covered and may even constitute a hazard to wildlife and humans following a major storm.

Potential benefits of re-vegetation efforts to ABM or long-term dune recovery have not been demonstrated through research, however, the possible contribution of these projects in sustaining ABM through a genetic bottleneck period following hurricanes warrants an evaluation of their effects. Planting vegetation is also more conducive to the use of volunteer labor than sand fencing projects. Future research may clarify whether re-vegetation efforts provide significant benefits to Alabama beach mice. Control areas where no treatment will occur will be designated in conjunction with permanent trapping grids to assist in the evaluation of this method for ABM recovery. In addition to dune restoration projects, the protection of beaches from disturbance by heavy equipment following hurricanes is critical since surviving sea oat rhizomes are likely present in areas where no vegetation is visible (Miller et al. 2001).

Strategy 2: Construct sand fencing in a way that minimizes potential impacts to nesting sea turtles (i.e., 10 to 20 ft. sections at a minimum of 10 ft. apart), maintain and adjust sand fencing to maximize benefits, and remove derelict fencing immediately to prevent injury to humans and wildlife.

Objective 2: Provide high quality scrub habitat for the Alabama beach mouse and demonstrate effective connectivity of this habitat to frontal dunes through semi-annual trapping by 2009.

Strategy 1 (**preferred**): Protect scrub habitat through education and enforcement by posting signs along trails.

Rationale: Human disturbance is the most significant threat to this habitat. Interpretive signs designed to educate the public about the importance of scrub habitat to ABM and Neotropical migratory birds would be beneficial. Making sure that public use is restricted to the trails in this habitat would be the most effective habitat management in dune scrub.

Natural mechanisms that set back succession in this habitat are not well understood. Fire is unlikely to play a role in the scrub since there is insufficient fuel to carry fire from one dune ridge to another. In recent history, cattle grazed in the scrub dunes (Chan West, pers. comm.) but it is unknown whether wildlife grazing was an important ecological process in pre-historic times.

More than likely, the principle forces driving these areas into an early successional stage are hurricanes. Following Hurricanes Ivan and Katrina, large areas of scrub habitat were observed with burned vegetation well outside of the zone affected by storm surge. Instead, these plants were likely damaged by the incessant salt spray during landfall of the storm. Research previously proposed to investigate the effects of mechanical clearing of scrub areas to expand high quality ABM habitat would be beneficial. Until such information is available, however, a "no management" approach is appropriate for these areas of the refuge.

Strategy 2: Create beach mouse habitat through partial, manual clearing of scrub/shrub vegetation if research supports such action.

Goal 2

Identify, manage, and enhance refuge habitats for a variety of avifauna, with an emphasis on habitats that support birds of conservation concern.

Objective 1: Promote and maintain shrubs that are beneficial to transient landbirds by documenting increased fruit production on at least 50% of maritime forest within 5 years of management treatment when compared to control areas by 2012.

Strategy 1 (**preferred**): Promote fleshy-fruit producing shrub conditions through appropriate use of prescribed fire as described in the refuge's fire management plan.

Rationale: The presence of natural fires in the historic landscape of maritime forests along the Alabama Gulf coast is well documented (see Section 2.4, History of Refuge Lands). Timing and frequency of optimum fire conditions in these forests need further investigation, although some studies have been conducted. Some studies suggest that the natural fire frequency of sand pine scrub is 20-40 years or longer (Breininger and Smith 1992) while pine flatwoods that contain a dense scrub component are intermediate between sand pine scrub and the high fire frequency pine savanna (Abrahamson 1984). However, the explosive development of the Fort Morgan Peninsula and the associated habitat fragmentation has undoubtedly resulted in reduced fire frequencies in the area. Wildfires are currently suppressed to protect property and to provide for public safety. Lightning-ignited fires, which would have burned vast acres of forest before being naturally extinguished by a large waterbody or rainfall during pre-settlement times, are now likely to encounter a manmade firebreak (e.g. road) before burning large areas.

Effective management of this complex plant community, however, will require research and monitoring on an ecosystem scale across coastal Alabama and similar areas in the Florida Panhandle (PIF 2005). After a thorough evaluation of these efforts, habitat management prescriptions will likely be refined and incorporated into Refuge Annual Habitat Work Plans.

On the Refuge, wildfires have been observed to promote the growth of fleshy fruits in forest communities (USFWS 2000). In particular, this management technique may be most effective if a relatively low fire frequency is maintained. The Refuge proposes to conduct prescribed burning in oak hammock communities in experimental compartments on the Perdue Unit and Sand Bayou Units (see Appendices A, B, and C) in 5-year rotations with varying intensities and compare bird use in these areas with control plots. After habitat and wildlife monitoring has been completed following several burn cycles in this unit, prescribed fire may be conducted in control areas, however, leaving these areas untreated may be beneficial for a variety of habitat studies in the future.

Strategy 2: Determine the best long-term strategy to promote fleshy-fruiting shrubs in forested and shrub/scrub habitats on 500 acres of the refuge within the next 15 years to support good and dependable stop-over habitat for transient landbirds.

Objective 2: Determine and implement the best long-term strategy to promote and maintain dune scrub communities on 1,000 acres in the next 15 years.

Strategy 1 (**preferred**): No active management.

Rationale: Scrub dune communities do not appear to be fire-adapted. In this refuge plant community, wildfire occurrence is extremely rare and attempts to conduct prescribed burns in this habitat are unsuccessful. In addition, the back-to-back effects of two major hurricanes in the past two years (Ivan and Katrina) have provided sufficient disturbance to reduce woody plant density in these areas. Due to these factors, active management of this habitat is not recommended at this time.

Objective 3: Within the next 15 years, restore 25% of upland habitats on the Sand Bayou and Little Point Clear Units to a more diverse structure that includes a grassy-herbaceous ground cover as demonstrated through vegetative plot data.

Strategy 1 (**preferred**): Conduct growing season prescribed burns in pine flatwood habitats on a 3-5 year rotation to reduce woody vegetation and promote the growth of grasses and forbs.

Rationale: Growing season burns can be effective at slowing the rate of recolonization by woody plant species in an area where restoration of a grassy understory is the goal and are essential for the maintenance of some plant species (Clewell 1985). On the Sand Bayou Unit, wildlife species associated with open pine flatwoods that were once likely common in this area are now greatly reduced in numbers or absent altogether. One such species, the gopher tortoise, was documented on the southern portion of the Sand Bayou Unit in the 1990s and old burrows can still be found in the area. Today, gopher tortoises are probably extirpated from this unit of the refuge. Likewise, the threatened indigo snake, the largest snake in North America, is associated with gopher tortoise burrows and more than likely no longer occurs on the Refuge. Restoration of open pine flatwoods with a grassy understory could once again provide suitable habitat for the gopher tortoise and may even provide an opportunity for the re-establishment of the indigo snake. See Appendices A, B, and C for recommended burn cycles for each fire compartment.

Strategy 2 (**preferred**): Reduce stocking where necessary and encourage shrub/scrub understory. Select for hard and soft mast-producing trees by regulating stand composition. Basal area of slash pine should be reduced by 50% in flatwood and oak hammock habitats.

Rationale: Selective thinning should be implemented to complement the results achieved by prescribed burning as part of Stragegy 1. Historically, the distribution of slash pine, currently the dominant tree species throughout much of the refuge, was limited by its high mortality from natural fires and was primarily restricted to wet areas that did not burn. Fire suppression and silviculture have resulted in an unnatural density of slash pine in flatwood and oak hammock habitats. In contrast, the fire-adapted longleaf pine dominated flatwood habitats on the Refuge, which were composed of a more mixed hardwood-pine overstory. Management efforts would be directed towards reducing the slash pine basal area in the Sand Bayou and Little Point Clear Units. By reducing the basal area of slash pine in these habitats, the growth of hardwoods would be promoted, which are preferred by many Neotropical migratory birds.

There are potential problems with pursuing this strategy. Previous attempts to sell timber on the Refuge were unsuccessful. In addition, cut-and-leave projects would leave a substantial number of logs on the forest floor that would be difficult to burn using low or medium intensity prescribed fire. Creative approaches to remove the timber, such as firewood sales or public permits, may be necessary to accomplish Objective 3 using this strategy.

Objective 4: Ensure high quality, protected shorebird habitat through law enforcement and signs as measured by stable or increasing use of Little Dauphin Island, Fort Morgan, and Perdue Units by high priority species over a ten-year period.

Strategy 1 (**preferred**): Support high quality foraging, migration, and wintering habitat by reducing disturbances and maintaining washover habitat, as called for in the Southeastern Coastal Plain Shorebird Conservation Plan. Install signs over refuge-owned bottoms to deter access to important Little Dauphin Island nesting and roosting beaches on a seasonal basis.

Rationale: Little Dauphin Island comprises the most important shorebird habitat on the Refuge. This area, along with portions of the Fort Morgan Unit, is federally-designated Critical Habitat for wintering piping plovers and also supports nesting shorebirds. The land ownership situation at Little Dauphin Island presents a unique opportunity for the protection of important shorebird habitat since the Refuge owns 560 acres of submerged bottoms in addition to the 290 acres of visible uplands on the island. The Refuge has deeded jurisdiction over these bottoms and has the authority to regulate access.

The shores of Little Dauphin Island are popular for recreational fishing, crabbing, and oystering and these wildlife-dependent uses should be maintained. As a result, posted areas of the island would be restricted to those where shorebird use is concentrated. Some beaches on the island that are less favored by wintering piping plovers, may only need to be posted seasonally for nesting shorebirds, while important plover areas would need to be posted throughout migration and winter. Active management of the island is not necessary at this time; however, the Refuge frequently evaluates the potential impacts of nearby dredging and filling projects in western Mobile Bay and provides comments to the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service Daphne Ecological Services Field Office, and other agencies.

Strategy 2: Establish law enforcement presence to reduce disturbances to foraging habitat.

Strategy 3: Determine whether each washover and dune blowout site can be left alone (not in conflict with other resources) and avoid beach restoration as much as possible.

Strategy 4: Once management direction is determined, follow habitat changes with surveys to determine response by shorebird species.

Goal 3

Identify and maintain a diversity of native plant communities on the refuge, including forested systems.

Objective 1: Determine existing composition and distribution of Refuge plant communities by 2011 to provide a baseline for guiding habitat restoration efforts towards historical conditions.

Strategy 1 (**preferred**): Commission a survey of Refuge plant communities and identify those requiring special management considerations, including those that are unique or rare.

Rationale: Plant communities have not been systematically identified or mapped using standardized surveys. Besides describing common plant associations on the Refuge, the special focus of this survey would be to identify rare communities that may be disappearing from the landscape due to fire suppression, invasive species, habitat fragmentation, or other environmental factors. Once complete, a plant community survey may result in re-prioritizing refuge habitat management goals and objectives.

Strategy 2 (**preferred)**: Determine the historical fire regime for refuge plant communities and, to the extent practical, emulate those historical regimes unless there is a special need to do otherwise (e.g. to maintain a threatened/endangered species). By 2008, working with the Regional Fire Ecologist and other ecologists, develop conservation strategies for fire-adapted communities.

Rationale: A thorough understanding of the historic role of fire on the Fort Morgan Peninsula is critical to the effective management of refuge habitats. Several methods may cumulatively provide a clear picture of historic fire frequency in the area. Research geologists have expressed interest in determining the fire regime in the areas around Little Lagoon by analyzing core samples. Tree growth ring analyses may also provide some information about the history of fire on the Refuge. Historic lightning strike data may be useful in determining the frequency of wildfires when combined with weather data. Most importantly, effective monitoring of prescribed fires will indicate the plant species that have evolved with this ecosystem depending on their response to fire.

Objective 2: Maintain forest structure that will consist of a mosaic of open pine flatwoods and oak hammock that would provide suitable habitat for Neoptropical migratory birds and gopher tortoises in the Sand Bayou Unit as shown by survey data that demonstrates increased use by target species.

Strategy 1 (**preferred**): Contract the preparation of a Forest Management Plan for the Refuge by 2010.

Rationale: A completed Forest Management Plan would assist the Refuge with effective management of the forest resources. Since the Refuge does not have a Forester or Forestry Technician position, preparation of the plan would be contracted. This Plan should be preceded by a forest inventory and should include a description of the stands represented, ideal stand composition, and recommended methods to achieve the objectives of the Plan.

Strategy 2: Reduce basal area on 400 acres of ridge top forest to regionally acceptable levels which will provide optimum habitat for gopher tortoises and eastern indigo snakes.

Strategy 3: Use timber sales or other silvicultural techniques, as appropriate, to return stands to an open condition by 2013, which will benefit gopher tortoises and eastern indigo snakes.

Objective 3: Implement refuge prescribed burning program to optimize wildlife habitat (see also Fire Management Plan).

Strategy 1 (**preferred**): Design studies to refine prescribed fire program for the benefit of Neotropical migratory birds and other species of concern through the establishment of a minimum of 400 acres of unburned control areas by 2007.

Rationale: The appropriate use of prescribed fire can provide several important benefits to transient landbirds including Neotropical migratory birds, which breed in temperate climates such as the United States and Canada and winter in tropical climates such as Central America. Other taxa that are dependent on habitats with a significant component of grassland, such as eastern kingbirds (*Tyrannus tyrannus*), American kestrels (*Falco sparverius*), and gopher tortoises would benefit from growing season burns. For all fire compartments, a strategy of initially conducting dormant-season burns (after many years of fire suppression) to reduce dangerous fuels followed by growing season burns for habitat enhancement would be appropriate. The primary variable between habitat types is fire frequency, which ranges from an estimated 3-10 years for slash pine flatwoods and oak hammocks to 20 years or greater for sand pine scrub.

An important component of this strategy would be to include significant acreage in control areas that will not be burned in order to effectively monitor the results of the prescribed fire program. Fire compartments that have been designated as controls were chosen for their similarity in habitat to areas that will be burned and for their locations with respect to public safety (see Appendices A, B, and C for recommended prescribed burn cycles for each fire compartment).

Objective 4: Reduce distribution of invasive cogongrass on the refuge by 80% over a 10-year period by 2016.

Strategy 1 (**preferred**): Inventory cogongrass distribution and apply herbicides according to research conducted by the U.S. Department of Agriculture, state agencies, non-government organizations, and other agencies.

Rationale: Treatment of cogongrass on the Refuge has been most effective in early fall, just before the plant becomes dormant. Prescribed fire or mechanical treatment (e.g. mowing) may reduce the amount of herbicide necessary to treat cogongrass. However, mowing may not be practical at some sites that are in wet or remote areas. Prescribed burning has logistical and seasonal limitations that preclude its frequent use as a prerequisite to herbicide treatment. Effective control measures for cogongrass are currently being investigated by several states and universities. As new information becomes available, currently recommended techniques should be revised as necessary.

Strategy 2: Use prescribed fire or mechanical treatment in conjunction with herbicide application to control the spread of cogongrass.

Objective 5: Reduce distribution of invasive Chinese tallowtree on the refuge by 80% by 2016.

Strategy 1: (**preferred**) Inventory Chinese tallowtree distribution and apply herbicides for control using acceptable methods and timing.

Rationale: In 2005, the Refuge completed the first year of mapping and treatment as part of the Chinese tallowtree control program. Treated areas will be monitored each year to measure the effectiveness of Arsenal applications. The Refuge will continue to apply knowledge learned from monitoring to develop the most efficient methods for control of Chinese tallowtree.

Strategy 2: Use prescribed fire to control Chinese tallowtrees.

Goal 4

Conduct research to aid in the implementation of the Refuge habitat management program.

Objective 1: Initiate research project with state universities to determine impacts of prescribed fire on migrating birds and their habitat by 2008.

Strategy 1 (**preferred**): Conduct research comparing migratory bird populations in burned versus unburned fire compartments.

Rationale: Bon Secour Refuge provides some of the best remaining stopover habitat on the Gulf coast. Based on descriptions of fire-adapted vegetation and observations of wildfires that we have from researchers and residents during the early part of the 20th century (see Section 2.4, History of Refuge Lands), it is clear that fire plays a prominent role in the dynamics of coastal maritime forests. However, a clear understanding of optimum fire frequency and timing in these habitats would allow the Refuge to refine its prescribed fire program to achieve optimum results for migratory birds. Research proposals for studies that would examine the effects of fire on migratory birds are currently being developed by the Refuge staff in coordination with state universities.

Objective 2: Develop a study to determine changes in plant and avifaunal communities in the black needlerush marsh following treatments of prescribed fire by 2015.

Strategy 1 (**preferred**): Conduct secretive marsh bird surveys to develop a baseline inventory of species that use tidal marshes of the Sand Bayou and Little Point Clear Units by 2008.

Rationale: Populations of secretive marsh birds, which include rails, seaside sparrows (*Ammodramus maritimus*), and Nelson's sharp-tailed sparrows, have not been described on the Refuge. The western half of the Little Point Clear Unit contains extensive finger sloughs that extend northwest to southeast along Mobile Bay. These brackish sloughs include potentially optimum habitat for these vocal, but seldom-seen species. In addition,

the Sand Bayou Unit contains expansive marshes along the margins of Bon Secour and Oyster Bays. These marshes provide a unique opportunity to establish a "before" picture of these elusive birds and their remote habitats, which have not been exposed to prescribed fires. Due to the logistical challenges associated with burning marshes on a regular basis, research into the effects of fire in this plant community may be restricted to opportunistic investigations following wildfires in the area. In the meantime, establishing baseline inventories of these species would be an important first step in understanding the role of fire in this habitat. The Alabama Department of Conservation and Natural Resources has initiated a secretive marshbird survey for the coast so a partnership between ADCNR and the Refuge could result in the development of sound management strategies for these species.

Strategy 2: Compare marshbird habitat use between burned and unburned tidal marshes of the Sand Bayou and Little Point Clear Units by 2010.

6.0 Management Strategy Resources and Constraints

6.1 Necessary Resources

Implementation of Refuge goals, objectives, and their recommended strategies for successful accomplishment are dependent upon fiscal resources in the form of equipment, personnel, and contracts with universities or private sector resource professionals (Table 5).

Table 4. Estimated costs for achieving habitat management objectives.

Goal	Objective	Frequency Interval	Initial Cost ($)	Annual Cost ($)
1	1	3 yrs.	127,000	30,000
1	2	Annual	5,000	2,000
2	1	5 yrs.	50,000	24,000
2	2	------	0	0
2	3	3 yrs.	50,000	24,000
2	4	Annual	10,000	5,000
3	1	One-time	22,000	0
3	2	15 yrs.	20,000	0
3	3	Annual	10,000	5,000
3	4	Annual	2,000	1,000
3	5	Annual	50,000	10,000
4	1	Annual	150,000	30,000
4	2	Annual	10,000	5,000
Totals			**506,000**	**136,000**

6.2 Management Constraints

The impact of a major hurricane is probably the most important constraint in accomplishing the goals and objectives of this Plan. During the years 2004-2005, Hurricanes Ivan and Katrina substantially affected Refuge operations. As a result, staff resources were largely devoted to responding to the effects of these storms on Refuge habitats and infrastructure. To accomplish post-hurricane debris removal, Refuge management and biological staff prepared damage assessments, grant proposals, press releases, environmental documents (Section 7 evaluations, Environmental Assessments), and reviews of cleanup proposals. Inevitably, some refuge objectives were deferred during this period when habitat restoration and resumption of public use was the top priority following a natural catastrophe. During this era when hurricane frequency is predicted to be high, the associated costs and administrative workload associated with destructive tropical storms should be expected at Bon Secour.

The rapid development of private lands adjacent to the Refuge represents another significant constraint in achieving habitat objectives. As the natural buffer between developed areas and Refuge lands is narrowed or eliminated the constraints on effective habitat management are increased. The application of prescribed fire is made more difficult in areas of urban interface. In any setting, the limited parameters of air temperature, relative humidity, and wind characteristics under which safe operations can occur often result in delays or cancellations of the prescribed burn. These constraints are intensified when the fire compartment is located next to a highly developed area. In these areas, fire prescriptions are often written to authorize burning only when very specific conditions are observed (e.g. NNW wind direction), often because of smoke management concerns near subdivisions or highways. Increased development along refuge boundaries results in fewer prescribed burning opportunities or, in the case of some small refuge tracts, eliminates fire as a habitat management tool altogether. The presence of invasive species on the Refuge will also increase as the surrounding areas become more developed.

6.3 Regulatory Compliance

This document is a step-down Plan from the Refuge Comprehensive Conservation Plan. As a result, the Habitat Management Plan meets the requirements of the National Environmental Policy Act (NEPA) since it is consistent with the goals and objectives of the Refuge CCP and Environmental Assessment. In cases where the Habitat Management Plan differs slightly from the Refuge CCP, the actions proposed are involve *less* disturbance to the human environment than originally those originally called for in the CCP (e.g. leaving some areas of the refuge unburned as research control plots).

A Section 7 Biological Evaluation Form was also completed for the CCP and covers the goals and objectives of this Plan. Proposals for specific research and habitat management projects described in this Plan that may affect endangered species or wetlands will be evaluated in consultation with the Daphne Ecological Services Field Office on a case-by-case basis.

Refuge Compatibility Determinations were prepared and approved for the CCP. If any additional uses are considered that would require a compatibility determination then these activities will be evaluated prior to their implementation on the Refuge.

All appropriate state permits will be obtained for management activities described in this Plan.

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8.0 Acknowledgements

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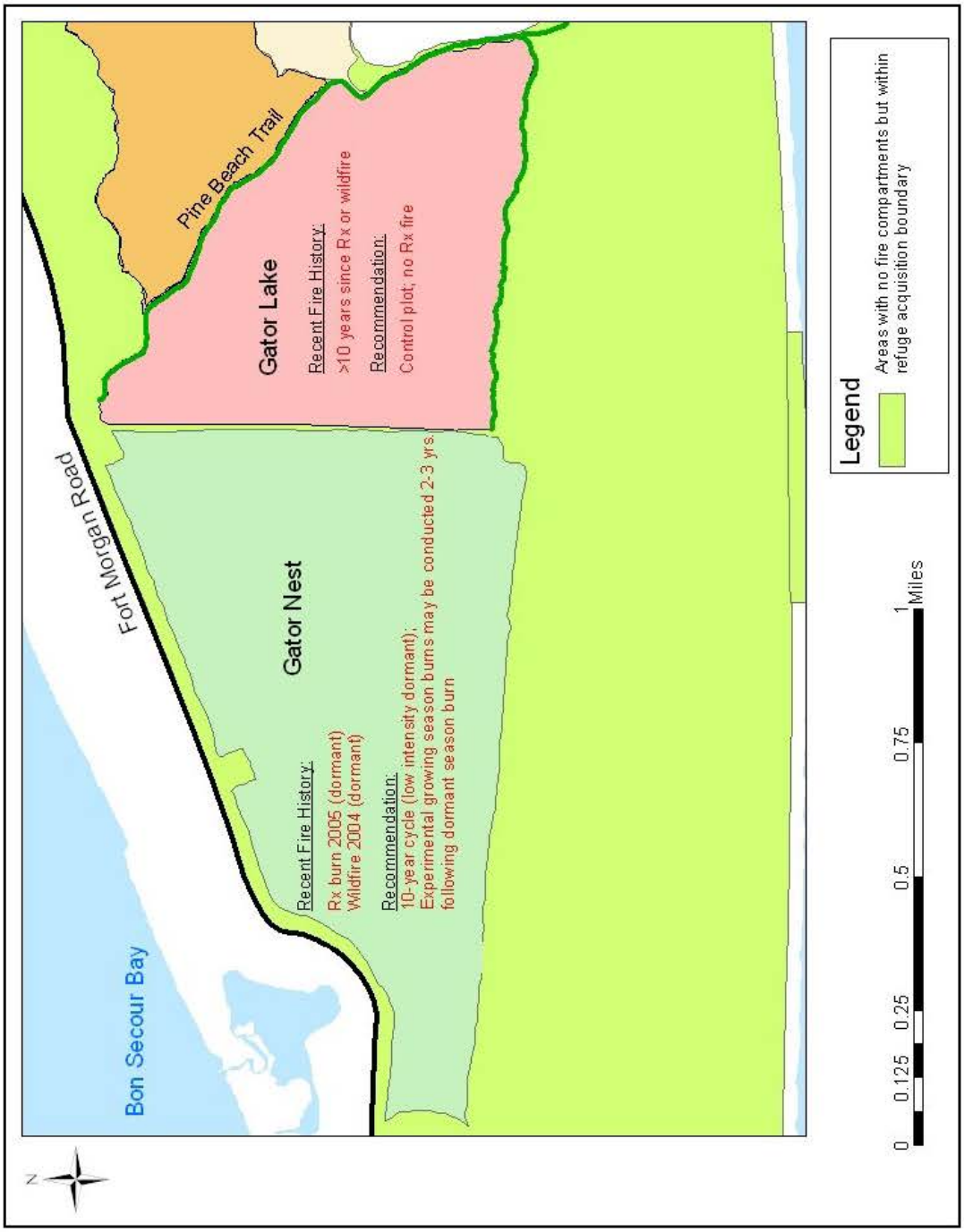
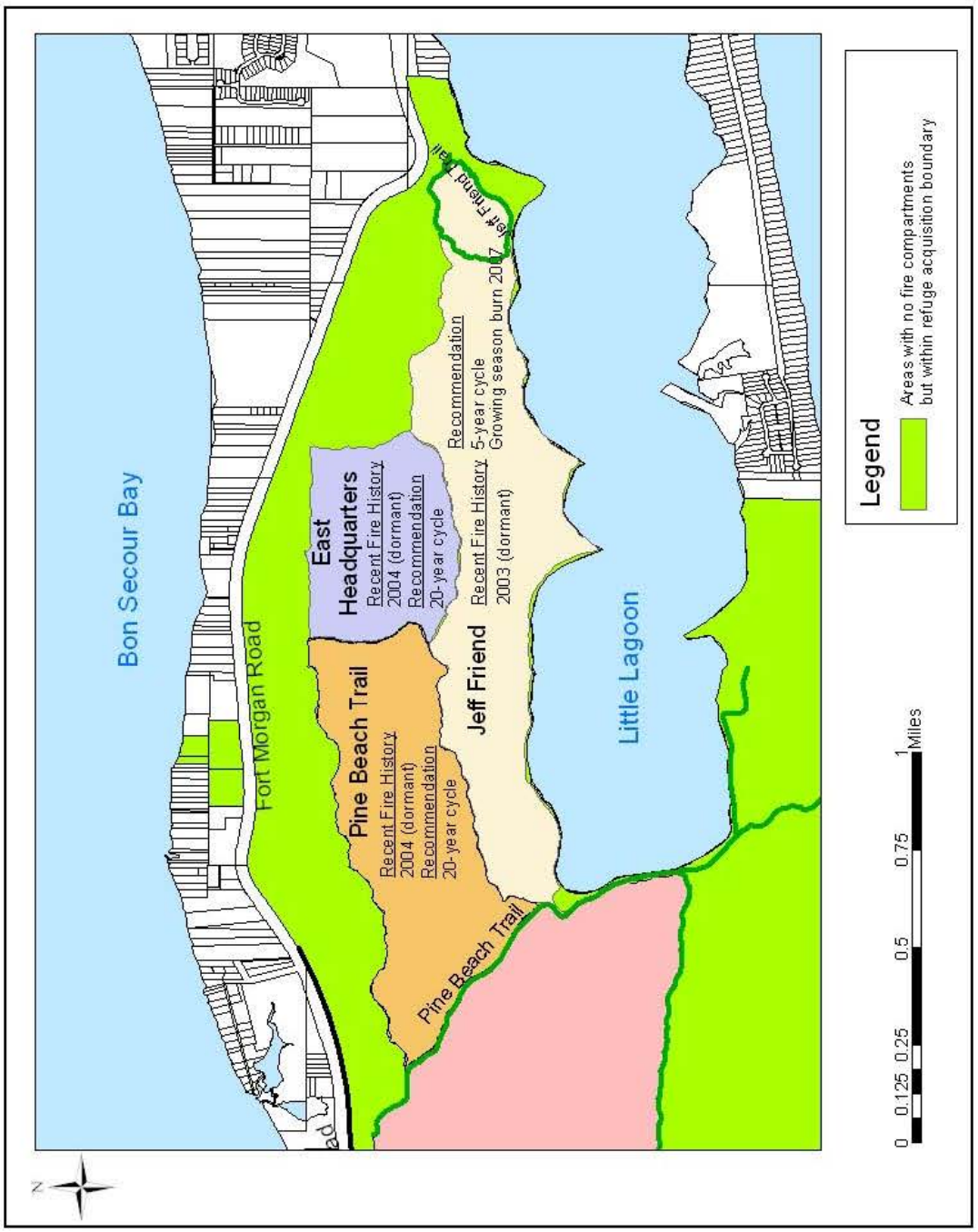
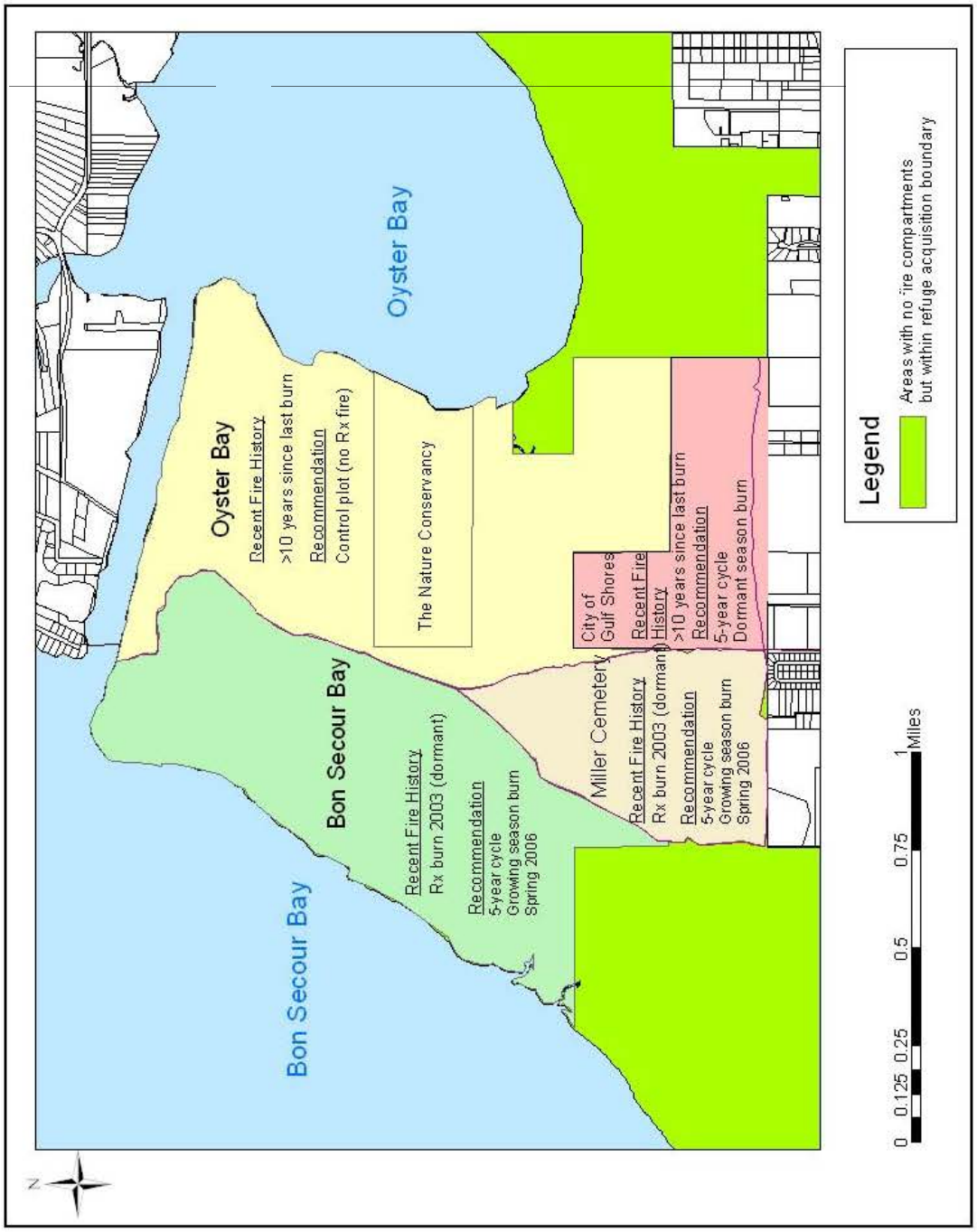
Appendix A. Fire compartments and recommended burn cycles, western Perdue Unit, Bon Secour NWR.



Appendix B. Fire compartments and recommended burn cycles, eastern Perdue Unit, Bon Secour NWR.



Appendix C. Fire compartments and recommended burn cycles, Sand Bayou Unit, Bon Secour NWR.



Appendix D. Mammals* reported by Howell (1921) for coastal Baldwin County, Alabama, with comments on distribution and status in the early 20th century.

*** specimens were collected in 1908 and from 1911-1916 unless otherwise noted by year of observation; taxonomy follows Wilson and Reeder (1993).**

Florida Opossum	(*Didelphis virginiana pigra*)—Bon Secour
Howell Mole	(*Scalopus aquaticus howelli*)—Orange Beach
Red Bat	(*Vespertilio borealis*)—rare on the coast—Point Clear
Mahogany Bat	(*Atalapha borealis seminola*)—Orange Beach
Hoary Bat	(*Vespertilio cinereus*)—Point Clear, "rare migrant"
Evening Bat	(*Vespertilio humeralis*)—abundant and generally distributed throughout the state
LeConte free-tailed Bat	(*Nyct[icea] cynocephala*)—Orange Beach (January 24 & 28, 1912, two specimens shot by local hunters)
Florida Black Bear	(*Ursus floridanus*)—Bon Secour (1905), only one for many years
Red fox	(*Canis fulvus*)—small numbers near Bon Secour, "numerous reports from residents indicate foxes from other states have been imported and liberated"
Gray fox	(*Canis cinereo-argenteus*)—reported from all sections of the state and is common; decline attributed to the "favorite sport" of fox hunting with hounds (Orange Beach)
Raccoon	*Procyon lotor lotor*)—numerous tracks along the shores of the bays (Orange Beach)
Mink	(*Mulstela mink*)—occurs rarely at Orange Beach
Alleghenian Spotted Skunk	(*Spilogale ringens*)—Bon Secour "seems to be unknown at Orange Beach"
Florida Skunk	(*Mephitis mephitica elongata)*—Perdido Bay, Bon Secour, Dauphin Island
Otter	(*Mustela lutra canadensis)*--Orange Beach, Bon Secour, occurs sparingly throughout state
Bobcat, Florida Wildcat	(*Lynx floridanus*)--Orange Beach, moderate numbers throughout state
White-fronted beach mouse	(*Peromyscus polionotus albifrons*)--from Little Lagoon eastward to the mouth of Perdido Bay these mice occur in abundance;
Cotton mouse	(*Peromyscus gossypinus gossypinus)*- Orange Beach; abundant statewide
Swamp rice rat	(*Oryzomys palustris palustris*)--numerous about Little Lagoon; "fisherman who ply their trade at night on the Lagoon state that these rats are common there and that at night they often come around the tents on the shore of the lagoon to feed on scraps of fish and other food thrown out by the men"

Cotton Rat	(*Sigmodon hispidus hispidus*)--Bon Secour, abundant
Florida Wood Rat	(*Neotoma floridana floridana*)--Orange Beach; abundant
Norway Rat	(*Rattus norvegicus*)--widely distributed
House Mouse	(*Mus musculus*)--widely distributed
Alabama pocket gopher	(*Geomys tuza mobilensis*)--local, Orange Beach
Bachman fox squirrel	(*Sciurus texianus*)--Orange Beach
Southeastern flying squirrel	(*Glaucomys volans saturatus*)--common statewide
Carolina Beaver	(*Castor canadensis*)--vague reports in southern part of state
Eastern Cottontail	(*Sylvilagus floridanus mallurus*)--Orange Beach, Bon Secour, abundant
Marsh Rabbit	(*Sylvilagus palustris*)--Orange Beach; abundant in salt marshes
Virginia Deer	(*Odocoileus virginianus*)--occasionally seen near Orange Beach; numerous between Foley and Perdido Bay in 1915

Appendix E. Birds reported by Howell (1924) for coastal Baldwin County, Alabama, with selected locations of records and comments on status in the early 20th century.*

*English and scientific names follow the 7th edition of the American Ornithologists' Union Check-list of North American Birds and the 42nd –46th Supplements to the Check-list.

Snow Goose (*Chen caerulescens*)--uncommon
Wood Duck (*Aix sponsa*)--greatly reduced in numbers, rare on the coast
Gadwall (*Anas strepera)*--common winter resident
American Wigeon (*Anas americana*)--uncommon migrant and winter visitor
American Black Duck (*Anas rubripes*)--common winter resident
Mallard (*Anas platyrhynchos)*--common migrant and winter
Blue-winged Teal (*Anas discors)*--common migrant
Northern Shoveler (*Anas clypeata)*--common migrant and winter visitor
Northern Pintail (*Anas acuta*)--abundant migrant
Green-winged Teal (*Anas crecca)*--uncommon winter visitor
Canvasback (*Aythya valisineria)*--uncommon winter
Redhead (*Aythya americana)*--common winter resident
Ring-necked Duck (*Aythya collaris*)--common winter resident
Greater Scaup (*Aythya marila*)--moderate numbers on the coast
Lesser Scaup (*Aythya affinis*)--common winter resident
Surf Scoter (*Melanitta perspicillata*)--rare
Long-tailed Duck—(*Clangula hyemalis)*--rare
Bufflehead (*Bucephala albeola)*--uncommon winter resident
Common Goldeneye (*Bucephala clangula*) uncommon winter resident
Hooded Merganser (*Lophodytes cucullatus*)--common year-round
Red-breasted Merganser (*Mergus serrator*)--common winter
Ruddy Duck (*Oxyura jamaicensis)*--rare
Wild Turkey (*Meleagris gallopavo*)—"exterminated" in the swamps and hammocks near Orange Beach in the 1910s
Northern Bobwhite (*Colinus virginianus*)—abundant; Bon Secour, Orange Beach
Common Loon (*Gavia immer*)--common winter
Pied-billed Grebe (*Podilymbus podiceps*)--Little Lagoon (Oct. 24, 1908), moderate in winter, numerous during migration
Horned Grebe (*Podiceps auritus*) common winter
American White Pelican (*Pelecanus erythrorhynchos*)--regular in migration and winter
Brown Pelican (*Pelecanus occidentalis*)--common year-round
Double-crested Cormorant (*Phalacrocorax auritus*)--common year-round
Magnificent Frigatebird (*Fregata magnificens*)--uncommon year-round
American Bittern (*Botaurus lentiginosus*)--uncommon winter and migrant
Least Bittern (*Ixobrychus exilis*)--abundant summer resident
Great Blue Heron (*Ardea herodias*)--common
Great Egret (*Ardea alba*)--almost extirpated from the state
Snowy Egret (*Egretta thula*)--thought to be completely extirpated from the state

Little Blue Heron (*Egretta caerulea*)--moderately common summer resident
Tricolored Heron (*Egretta tricolor*)--moderately common summer resident
Green Heron (*Butorides virescens*)--common summer resident
Black-crowned Night Heron (*Nycticorax nycticorax)*--locally uncommon
Yellow-crowned Night Heron (*Nyctanassa violacea*)--locally common summer resident
Roseate Spoonbill (*Platalea ajaja*)--rare
Turkey Vulture (*Cathartes aura*)—uncommon
Greater Flamingo (*Phoenicopterus ruber*)--reported by Audubon near Orange Beach
Osprey (*Pandion haliaetus*)—common
Bald Eagle (*Haliaeetus leucocephalus*)—fairly common resident on the Baldwin County coast; 3-4 observed at Little Lagoon in October 1908; reportedly breed near Perdido Bay
Northern Harrier (*Circus cyaneus*)—rare
Sharp-shinned Hawk (*Accipiter striatus*)—uncommon
Cooper's Hawk (*Accipiter cooperii*)—common
Red-shouldered Hawk (*Buteo lineatus*)--common
Broad-winged Hawk (*Buteo platypterus*)—uncommon
American Kestrel (*Falco sparverius*)—locally common
Merlin (*Falco columbarius*)—uncommon migrant and winter resident
Peregrine Falcon (*Falco peregrinus*)—rare migrant; one observed September 21, 1892 at Little Lagoon;
Yellow Rail (*Coturnicops noveboracensis*)--rare winter resident, fairly common during migration
Clapper Rail (*Rallus longirostris*)
King Rail (*Rallus elegans*)--locally common summer resident, rare winter resident
Virginia Rail (*Rallus limicola*)--migrant, winter resident, few records
Sora (*Porzana carolina*)--probably regular and common migrant
Purple Gallinule (*Porphyrio martinica*)--rare summer resident
Common Moorhen (*Gallinula chloropus*)--local
American Coot (*Fulilca americana*)--common winter, abundant migrant
Sandhill Crane (*Grus canadensis*)--adult and young Mississippi sandhill cranes (*G.c. pulla*) were observed near the mouth of Perdido Bay, on the Alabama side, August 1911; a few pairs are resident and breed in the pine flats of Baldwin County (now completely extirpated from the state)
Whooping Crane (*Grus americana*)--very rare; formerly common on Dauphin Island in winter;
Black-bellied Plover (*Pluvialis squatarola*)—common migrant and summer resident
Snowy Plover (*Charadrius alexandrinus*)—moderately common winter and summer resident
Wilson's Plover (*Charadrius wilsonia*)—common summer resident
Semipalmated Plover (*Charadrius semipalmatus*)—uncommon migrant
Piping plover (*Charadrius melodus*)—locally common on the Alabama coast but "nearly exterminated" on much of the Atlantic coast
Killdeer (*Charadrius vociferus*)—common winter, rare summer
American Oystercatcher (*Haematopus palliatus*)—yearly growing rarer
Greater Yellowlegs (*Tringa melanoleuca*)—common migrant
Lesser Yellowlegs (*Tringa flavipes*)—common migrant
Solitary Sandpiper (*Tringa solitaria*) ---abundant migrant
Willet—(*Catoptrophorus semipalmatus*)--common summer resident

Spotted Sandpiper (*Actitis macularius*)—summer resident
Long-billed Curlew (*Numenius americanus*)—rare migrant
Hudsonian Godwit (*Limosa haemastica*)—uncommon migrant
Marbled Godwit (*Limosa fedoa*)—rare migrant
Ruddy Turnstone (*Arenaria interpres*)—irregular migrant
Red Knot (*Calidris canutus*)—rare
Sanderling (*Calidris alba*)—common nearly year-round
Semipalmated Sandpiper (*Calidris pusilla*)—common migrant and winter resident
Western Sandpiper (*Calidris mauri*)—migrant and winter resident
Least Sandpiper (*Calidris minutilla*)—abundant migrant and winter resident
Pectoral Sandpiper (*Calidris melanotos*)—common migrant
Dunlin (*Calidris alpina*)—common winter resident and abundant migrant
Long-billed Dowitcher (*Limnodromus scolopaceus*)[Unclear which species Howell was referring to since he lists long-billed dowitcher as *L. griseus*]--rare
Common Snipe (*Gallinago gallinago*)--uncommon winter resident, abundant migrant
Wilson's Phalarope (*Phalaropus tricolor*)--rare
Laughing Gull (*Larus atricilla*)--common year-round
Bonaparte's Gull (*Larus philadelphia*)--probably regular winter visitor, only one state record (mouth of Perdido Bay)
Ring-billed Gull (*Larus delawarensis*)--common winter
Herring Gull (*Larus argentatus*)--common winter
Caspian Tern (*Sterna caspia*)--rare
Royal Tern (*Sterna maxima*)--common year-round
Common Tern (*Sterna hirundo*)--moderately common migrant
Forster's Tern (*Sterna forsteri*)--common in summer but does not breed in AL
Least Tern (*Sterna antillarum*)--common summer resident; rare nester
Black Tern (*Childonias niger*)--abundant migrant
Black Skimmer (*Rynchops niger*)--common year-round
Mourning Dove (*Zenaida macroura*)—abundant
Common Ground-Dove (*Columbina passerina*)—local uncommon
Carolina Parakeet (*Conuropsis carolinensis*)—probably disappeared from the state prior to 1880
Barn Owl (*Tyto alba*)—locally common
Eastern Screech-Owl (*Megascops asio*)—common
Great Horned Owl (*Bubo virginianus*)—common
Common Nighthawk (*Chordeiles minor*)—common summer resident, especially abundant on the barrier islands
Chuck-Will’s-Widow (*Caprimulgus carolinensis*)—common summer resident
Ruby-throated Hummingbird (*Archilochus colubris*)—common summer resident
Belted Kingfisher (*Ceryle alcyon*)—uncommon
Red-headed Woodpecker (*Melanerpes erythrocephalus*)—fairly common in late summer
Red-bellied Woodpecker (*Melanerpes carolinus*)
Yellow-bellied Sapsucker (*Sphyrapicus varius*)—common migrant and winter resident
Downy Woodpecker (*Picoides pubescens*)—uncommon
Hairy Woodpecker (*Dryobates villosus*)—uncommon
Red-cockaded Woodpecker (*Picoides borealis*)—locally common (breeding at Bayou Labatre)
Northern Flicker (*Colaptes auratus*)—abundant winter resident

Pileated Woodpecker (*Dryocopus pileatus*)—uncommon
Eastern Wood-Pewee (*Contopus virens*)—common summer resident
Eastern Phoebe (*Sayornis phoebe*)—fairly common
Loggerhead Shrike (*Lanius ludovicianus*)--common summer resident
Yellow-throated Vireo (*Vireo flavifrons*)--rare summer resident
Blue-headed Vireo (*Vireo solitarius*)--uncommon migrant and summer resident
Red-eyed Vireo (*Vireo olivaceus*)--rare migrant
Blue Jay (*Cyanocitta cristata*)—abundant
American Crow (*Corvus brachyrhynchos*)—uncommon
Fish Crow (*Corvus ossifragus*)—fairly common; flock observed at Little Lagoon in October 1908
Purple Martin (*Progne subis*) --common summer resident
Tree Swallow (*Tachycineta bicolor*)--uncommon migrant and winter resident
Bank Swallow (*Riparia riparia*)--uncommon summer resident
Cliff Swallow (*Petrochelidon pyrrhonota*)-common migrant
Barn Swallow (*Hirundo rustica*)--common migrant
Carolina Chickadee (*Poecile carolinensis*)--uncommon common year-round
Tufted Titmouse (*Baeolophus bicolor*)--uncommon year-round
White-breasted Nuthatch (*Sitta carolinensis*)--uncommon year-round
Brown-headed Nuthatch (*Sitta pusilla*)--common year-round
Brown Creeper (*Certhia americana*)--common winter resident
Carolina Wren (*Thryothorus ludovicianus*)--common year-round
Bewick's Wren (*Thryomanes bewickii*)--uncommon winter resident
House Wren (*Troglodytes aedon*)--uncommon migrant and winter resident
Marsh Wren (*Cistothorus palustris*)—Marian's Marsh Wren collected at Little Dauphin Island in 1914. Other subspecies are uncommon migrants or winter residents
Golden-crowned Kinglet (*Regulus satrapa*)--common winter resident
Ruby-crowned Kinglet (*Regulus calendula*)--common winter resident
Blue-gray Gnatcatcher (*Polioptila caerulea*)--common summer resident
Eastern Bluebird (*Sialia sialis*)--common year-round
Hermit Thrush (*Catharus guttatus*)--common winter resident
American Robin (*Turdus migratorius*)--uncommon winter resident
Gray Catbird (*Dumetella carolinensis*)--uncommon winter resident
Northern Mockingbird (*Mimus polyglottos*)--abundant year-round
Brown Thrasher (*Toxostoma rufum*)--uncommon year-round
European Starling (*Sturnus vulgaris*)—only 3 specimens in the state; “in view of this bird’s rapid extension of range it seems probable that it will soon become established in the State.”
American Pipit (*Anthus rubescens*)--locally common winter resident
Orange-crowned Warbler (*Vermivora celata*)--rare migrant and winter visitor
Northern Parula (*Parula americana*)--common summer resident
Chestnut-sided Warbler (*Dendroica pensylvanica*)--common migrant
Yellow-rumped Warbler (*Dendroica coronata*)--extremely abundant in the pine flats, palmetto hammocks, and coastal dunes.
Blackburnian Warbler (*Dendroica fusca*)--uncommon migrant
Pine Warbler (*Dendroica pinus*)--common year-round
Palm Warbler (*Dendroica palmarum*)--common migrant and winter resident

American Redstart (*Setophaga ruticilla*)-common migrant
Louisiana Waterthrush (*Seiurus motacilla*)--rare migrant
Kentucky Warbler (*Oporornis formosus*)--rare summer resident
Common Yellowthroat (*Geothlypis trichas*)--common year round
Hooded Warbler (*Wilsonia citrina*)--common summer resident
Summer Tanager (*Piranga rubra*)--uncommon summer resident
Eastern Towhee (*Pipilo erythrophthalmus*)—locally uncommon
Chipping Sparrow (*Spizella passerina*)—uncommon winter resident
Field Sparrow (*Spizella pusilla*)—common winter resident
Vesper Sparrow (*Pooecetes gramineus*)—uncommon
Savannah Sparrow (*Passerculus sandwichensis*)—common migrant and winter resident
Henslow's Sparrow (*Ammodramus henslowii*)—uncommon winter resident
Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*)—locally common winter resident
Seaside Sparrow (*Ammodramus maritimus*)—locally common year-round
Song Sparrow (*Melospiza melodia*)—uncommon winter resident
Swamp Sparrow (*Melospiza georgiana*)—fairly common
White-throated Sparrow (*Zonotrichia albicollis*)—abundant migrant and winter resident
Blue Grosbeak (*Passerina caerulea*)--rare migrant
Bobolink (*Dolichonyx oryzivorus*)—uncommon migrant
Red-winged Blackbird (*Agelaius phoeniceus*)—locally common
Eastern Meadowlark (*Sturnella magna*)—common summer resident
Common Grackle (*Quiscalus quiscula*)—common, esp. winter
Boat-tailed Grackle (*Quiscalus major*)—locally common
Brown-headed Cowbird (*Molothrus ater*)—common winter resident; not known to breed in the state
American Goldfinch (*Carduelis tristis*)—common migrant and winter resident
House Sparrow (*Passer domesticus*)—first appeared in Alabama in 1880

Appendix F. Nongame species of concern listed by the State of Alabama which are known or suspected to occur at Bon Secour National Wildlife Refuge.

Reptiles

Eastern Coachwhip (*Masticophis flagellum flagellum*)
Gulf Salt Marsh Snake (*Nerodia fasciata clarkii*)
Mississippi Diamondback Terrapin (*Malaclemys terrapin pileata*)
Gopher Tortoise (*Gopherus polyphemus*)

Birds

Common Ground Dove (*Columbina passerina*)
Bald Eagle (*Haliaeetus leucocephalus*)
Golden Eagle (*Aguila chrysaetos*)
Reddish Egret (*Egretta rufescens*)
Peregrine Falcon (*Falco peregrinus*)
Cooper's Hawk (*Accipter cooperi*)
Merlin (*Falco columbarius*)
Osprey (*Pandion haliaetus*)
American Oystercatcher (*Haematopus palliatus*)
American White Pelican (*Pelecanus erthrorhynchos*)
Piping Plover (*Charadrius melodus*)
Snowy Plover (*Charadrius alexandrinus*)
Wilson's Plover (*Charadrius wilsonia*)
Gull-billed Tern (*Sterna nilotica*)
Bewick's Wren (*Thryomanes bewickii*)

Mammals

Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*)
Alabama Beach Mouse (*Peromyscus polionotus ammobates*)

Appendix G. Known occurrences of non-avian vertebrates at Bon Secour National Wildlife Refuge

Mammals

Virginia Opposum (*Didelphis virginiana*)
Eastern Mole (*Scalopus aquaticus*)
Nine-banded Armadillo (*Dasypus novemcinctus*)
Marsh Rabbit (*Sylvilagus palustris*)
Eastern Cottontail (*Sylvilagus floridanus*)
Eastern Gray Squirrel (*Sciurus carolinensis*)
Southern Flying Squirrel (*Glaucomys volans*)
Marsh Rice Rat (*Oryzomys palustris*)
Alabama Beach Mouse (*Peromyscus polionotus*)
Cotton Mouse (*Peromyscus gossypinus*)
Hispid Cotton Rat (*Sigmodon hispidus*)
Florida Woodrat (*Neotoma floridana*)
House Mouse (*Mus musculus*)
Coyote (*Canis latrans*)
Red Fox (*Vulpes vulpes*)
Common Gray Fox (*Urocyon cinereoargenteus*)
Black Bear (*Ursus americanus*)*
Common Raccoon (*Procyon lotor*)
River Otter (*Lutra canadensis*)
Bobcat (*Lynx rufus*)
Feral Pig (*Sus scrofa*)
White-tailed Deer (*Odocoileus virginianus*)*

*Occurred historically but no recent records.

Reptiles

American Alligator (*Alligator mississippiensis*)
Gopher Tortoise (*Gopherus polyphemus*)
Loggerhead Turtle(*Caretta caretta*)
Kemp's Ridley Turtle(*Lepidochelys kempii*)
Green Anole (*Anolis carolinensis*)
Eastern Fence Lizard (*Sceloporus undulatus*)
Six-lined Racerunner (*Cnemidophorus sexlineatus sexlineatus*)
Five-lined Skink (*Eumeces fasciatus*)
Southeastern Five-lined Skink (*Eumeces inexpectatus*)
Eastern Glass Lizard (*Ophisaurus ventralis*)
Black Racer (*Coluber constrictor*)
Eastern Coachwhip (*Masticophis flagellum flagellum*)
Corn Snake (*Elaphe guttata guttata*)
Gray Rat Snake (*Elaphe obsoleta spiloides*)

Speckled Kingsnake (*Lampropeltis getula holbrooki*)
Cottonmouth (*Agkistrodon piscivorus*)
Dusky Pygmy Rattlesnake (*Sistrurus miliarius barbouri*)
Eastern Diamondback Rattlesnake (*Crotalus adamanteus*)

Amphibians

Two-toed Amphiuma (*Amphiuma means*)
Southern Two-lined Salamander (*Eurycea cirrigera*)
Eastern Spadefoot (*Scaphiopus holbrookii holbrookii*)
Southern Toad (*Bufo terrestris*)
Fowler's Toad (*Bufo woodhousii fowleri*)
Oak Toad (*Bufo quercicus*)
Florida Cricket Frog (*Acris gryllus dorsalis*)
Green Treefrog (*Hyla cinerea*)
Barking Treefrog (*Hyla gratiosa*)
Pine Woods Treefrog (*Hyla femoralis*)
Squirrel Treefrog (*Hyla squirella*)
Spring Peeper (*Pseudacris crucifer*)
Eastern Narrowmouth Toad (*Gastrophryne carolinensis*)
Bullfrog (*Rana catesbeiana*)
Bronze Frog (*Rana clamitans clamitans*)
Pig Frog (*Rana grylio*)
Southern Leopard Frog (*Rana utricularia*)