South Atlantic Coastal Study

Final Planning Aid Report:
Biological Resources and Habitats Vulnerable to Sea Level Rise and Storm Activity in the Southeastern United States, including Puerto Rico and the U.S. Virgin Islands.

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April 2020 (revised)

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Introduction

The U.S. Army Corps of Engineers is conducting the South Atlantic Coastal Study (Study) to identify risks and vulnerabilities of areas to increased hurricane and storm damage as a result of sea level rise. The Study covers the coastal areas of six states (North Carolina, South Carolina, Georgia, Florida, Alabama and Mississippi) and two territories (Puerto Rico and the U.S. Virgin Islands). The Study will conduct regional analyses of coastal risk and identify initial measures and costs that can address vulnerabilities with emphasis on regional sediment management as an actionable strategy to sustainably maintain or enhance current levels of coastal storm risk reduction. The Study was authorized by Section 1204 of WRDA 2016. Guidance was issued on Nov. 16, 2017, requiring the study to follow planning guidance for watershed assessments. Public Law 115-123 provided Federal funding in the amount of $16 million to cover 100% of the Study costs. Multiple Federal supplemental studies and construction efforts funded by Public Law 115-123 will inform, and be informed, by the Study.

This planning aid report provides information on coastal ecosystems and certain biological resources in the study area that are likely to be affected by sea level rise and storm activity over the next 50 to 100 years. There are 194 federally listed species found within the Study area. While bald and golden eagles are no longer federally listed species, they are protected under the Bald and Golden Eagle (16 U.S.C. 668(a); 50 CFR 22) and so are included in this report. The report has three parts. Part 1 provides a review of the threats that sea level rise poses for natural ecosystems in the southeastern United States. Part 2 covers the risks to the 63 coastal National Wildlife Refuges. Part 3 has Vulnerable Priority Biological Resources by State.

Part 1. A Review of the Threats that Sea Level Rise Poses for Natural Ecosystems in the Southeastern United States

Introduction to Sea Level Rise and Storm Surge

"*Earth's climate is now changing fast-er than at any point in the history of modern civilization, primarily as a result of human activities. The impacts of global climate change are already being felt in the United States and are projected to intensify in the future—but the severity of future impacts will de-pend largely on actions taken to reduce greenhouse gas (GHG) emissions and to adapt to the changes that will occur."* (NCA 2018). The climate has been changing throughout millennia resulting in fluctuations in temperatures and sea levels. Using historical information back to the late 1880s no longer helps us understand what the future will bring. Even if GHG emissions ended today, there will be a several-hundred-year period lag in response that will allow temperatures to continue to increase, ice to melt, oceans to expand, and sea levels to rise. (Miller and Traxler 2018). Substantial damages to the U.S. economy, environment, and human health and well-being over the coming decades would be unavoidable. (PNAS 2004).

With the arrival of active hurricane periods along the Gulf Coast, Southeast Coast and the Caribbean Islands due to decadal-scale variability (Ross et al. 2009), such as the Atlantic Multi-Decadal Oscillation (AMO), the interaction between higher sea levels and storm surge will soon reach a tipping point with respect to the maintenance of local freshwater ecosystems and human water supplies along coastal lowlands. Acceleration in sea level rise (SLR) and an increase in hurricane intensity due to global warming could bring this tipping point sooner (Church and White 2006). SLR has rendered pine forests on the Florida Keys more vulnerable by reducing the area capable of capturing precipitation and recharging fresh groundwater supplies. In 2017, Hurricane Irma brought 12 ft. of storm surge to Big Pine Key, which flooded the island leaving freshwater resources (groundwater and surface solution holes) for humans, animals, and vegetation contaminated by saltwater.

Sea Level Rise to Date

The rate of global mean sea level (GMSL) rise since 1900 has been faster than during any comparable period over at least the last 2,800 years (Kopp et al., 2016). The emission of greenhouse gases (GHGs) significantly increased with the Industrial Revolution in the early 1890s. These emissions continue to increase today. Warming of the atmosphere in response to the GHGs causes temperatures to rise (NCA 2018, NOAA 2017, and IPCC 2013). In addition, rising temperatures leads to ice melt and thermal expansion of the oceans, which in turn leads to sea level rise. For example, the rate of SLR in the Florida Keys had been an average rate of 0.09 inch/year prior to the last decade (NOAA 2016). In the early 2000s, SLR began to accelerate exponentially and was estimated at 0.30 inch/year in 2016 (Benedict 2018). This is an increase of 0.21 inch/year over the average. This delayed response by the ocean to increasing GHG

emissions and increasing temperatures is called a "lag effect" and began occurring about 75-100 years after GHG emissions began to rapidly increase (Miller and Traxler 2018).

Sea Level Rise Scenarios

SLR scenario planning is a comprehensive exercise that involves the development of scenarios that capture a range of plausible future conditions. That development is then followed by an assessment of the potential effects of those scenarios on a focal resource or decision, and the identification of responses under each scenario, with a focus on those that are robust across scenarios. SLR modeling scenarios are based on GHG emission rates, radiative forcing variables, temperature trends, and geographic location, among other factors.

Due to newer information and analyses in 2017, the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS) scientifically revised SLR projections of the Intergovernmental Panel on Climate Change (IPCC) (2013). Revisions included recent observational and modeling literature related to the potential for rapid ice melt in Greenland and Antarctica along with other regional processes. Regional downscaling methods are used to provide climate information at the smaller scales and there is high confidence that downscaling adds value both in regions with highly variable topography and for various small-scale phenomena (IPCC 2013), such as islands and keys.

The NOAA (2017) report had two primary tasks:

1. Update scenarios for global SLR to include ocean-level increases due to ice sheet melting and mass reductions (likely with 66-100% probability).
2. Integrate regional factors for the U.S. coastline, such as;
    a. Shifts in oceanic circulations (likely with 66-100% probability),
    b. Changes in earth's gravitational field (fluxing of the crust and mantle),
    c. Land subsidence or uplift due to glacial changes,
    d. Sediment compaction, and
    e. Groundwater and fossil fuel withdrawals.

The NOAA (2017) projections are also dependent on future GHG emissions and associated ocean-atmosphere warming. There is very high confidence that the model accurately reproduced the more rapid warming in the second half of the 20th century. NOAA (2017) also adjusted the GMSL to account for the additional regional factors. Each line in the scenario graph was developed with independent data sets. The primary dependent factor is the amount of GHG emissions that are projected to continue, decrease, or increase releases over time. The projections presented in several peer-reviewed publications provide evidence to support a likely global mean sea level rise of 6.6 ft. to 8.9 ft. by 2100 (7.6 ft. to 9.9 ft. by 2100 if tidal influences are considered). Recent results regarding Antarctic ice-sheet instability indicate that such outcomes are more likely (66-100% probability) than previously thought (NOAA 2017). To ensure consistency with these recent updates to the peer-reviewed scientific literature, NOAA

recommends a revised 'extreme' upper-bound scenario, which is 1.5 – 2.5 ft. higher than the upper bound scenario from NOAA (2012) and IPCC (2013).

High Tide and Tidal Flooding

NOAA tide gauges are measuring rapid increases in coastal flood risk along U.S. coastlines due to SLR rise (NOAA 2019). According to NOAA (2019), the most noticeable impacts from SLR is the increasing frequency of high tide flooding (HTF) and that projecting out into the future (i.e. 2030 and 2050) provides vital information for addressing coastal flooding impacts. NOAA (2019) used the 2017 SLR scenarios and indicated that today's national HTF frequency of 5 days (national median) is likely to increase to 7–15 days by 2030 and 25–75 days by 2050 with much higher rates in many coastal locations.

Future Pulse Events

Resiliency of a species or habitat refers to its ability to withstand stochastic disturbance events (pulse events). Thus, resiliency is related to the demographic ability to absorb and bounce back from pulse events and persist at the population or meta-population scale (Smith 2018). SLR will add to the cumulative effect of flooding and pulse events making them worse than in previous years.

Climate change is expected to cause an increased frequency and heavier-than-usual rain events, like the 100-year flood. The term "100-year flood" is used in to simplify the definition of a flood event that statistically has a 1-percent chance of occurring in any given year. Likewise, the term "100-year storm" is used to define a rainfall event that statistically has this same 1-percent chance of occurring (NOAA 2017).

The cumulative effect of a 100-year flood event (rainfall or storm surge) along with SLR will cause higher water levels of 1-2 ft. with the event resulting in increased damage to property and habitats. This information is helpful in understanding the impacts that pulse events can have combined with SLR on coastlines that are only 2 - 4 ft. above sea level.

Ground Surface Inundation versus Root Zone Salinization

One factor necessary for the maintenance of forests and herbaceous freshwater marshes is a persistent supply of fresh groundwater. Past studies have focused primarily on ground surface inundation of ocean water to determine effects to vegetation from SLR and tidal flooding. However, the focus should be more on the initial impacts of salty groundwater on the root zone of flora as impacts will occur before complete ground surface inundation (Miller et al. 2018).

Hardwood species of inland forests and hammocks are deep rooted and use fresh groundwater for hydration (Saha et al. 2011). This water zone used by roots is called the vadose zone. Sternberg and Swart (1987) showed that the hardwood hammock species in the Florida Keys growing next to coastal saline waters had isotopic signatures similar to freshwater, indicating that

the roots of hardwood species extracted freshwater from the soil in the vadose zone at the top of the groundwater table.

Ross et al, (2009) suggests that shrinking of the freshwater table in the coastal uplands of the Everglades is a likely cause of initial vegetation change as a result of SLR. These consequences of SLR in the long term will likely prove detrimental to the upland vegetation communities. Decline in capacity of freshwater resources will likely be made worse with the additive effects of storm surges and unusually high tides.

Future Impacts to Tidal Marshes, Estuaries, Coastal Bays, and Ocean Coasts

SLR causes root zone salinization followed by saltwater inundation on the surface in tidal marshes and estuaries. This results in the conversion of vegetated areas into areas of open water. Wetlands have very specific water elevation tolerances. If the water is not deep enough, it is no longer a wetland. If the water is too deep, the area becomes open water rather than a vegetated wetland. Slowly rising waters on a gentle, continuously rising surface should result in a band of wetlands migrating landward (TAMU 2019). However, the loss of wetlands across the Gulf and Atlantic Coasts will not be uniform. Some areas may lose most, if not all, of their existing coastal wetlands. How quickly wetlands change will depend mostly on the topography of the coastal zone, specifically the conformation of the coastal slope in the shoreline zone. In areas of uniform, gently increasing slope, we can expect that some new wetlands might form as new areas become inundated (TAMU 2019).

Future impacts from SLR are expected to be widespread in coastal areas. Coastal habitats provide breeding areas and migration corridors for many threatened or endangered species (Gieder 2014). Coastal landscape encompasses a variety of environments that will respond differently to SLR according to their geomorphology, geologic setting, ecology and level of development (Church 2014). Elevated water levels due to SLR will exacerbate coastal erosion and flooding (Sweet 2014), particularly along developed coasts that have substantial, fixed, low-elevation infrastructure and real estate. In particular, the combined effects of climate-driven erosion and inundation may reduce habitat area and (or) quality along sandy and (or) wetland shorelines (Kirwan et al., 2013). These changes are expected to have a broad range of effects on natural and built environments, from affecting the breeding, nesting, and feeding behavior of threatened shorebird species.

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Part 2. Risks to Coastal National Wildlife Refuges

Discussions for each National Wildlife Refuge (NWR) are drawn from the relevant Comprehensive Conservation Plans (CCP), as well as other U.S. Fish and Wildlife Service (Service) documents and websites. Threats to the NWRs are included in the refuge-specific descriptions; however, in general, storm surge and sea level rise (SLR) may result in widespread loss or degradation of coastal refuge habitats. SLR, and accompanying saltwater intrusion, will likely change salt marsh and freshwater marsh to open water. A change in hydrology or salinity in forested wetlands may change those habitats to salt marsh or freshwater marsh, as trees die and are replaced by herbaceous vegetation. Upland habitats may change to wetlands over time, as hydroperiods change and soils are inundated for longer portions of the growing season. Barrier island NWRs may break up or disappear entirely in future years, as SLR overwhelms the island's geomorphic processes.

The Service has conducted a Coastal Wetland Elevation Monitoring Program since 2012, to assess how wetland habitats in tidal freshwater and saltwater marshes, peatland pocosins, and forested wetlands on NWRs are changing with SLR along the Atlantic and Gulf Coasts. The program includes a network of 20 monitoring sites on 18 NWRs in the southeast. The overarching objective of the program is to describe potential effects of SLR on priority habitats, determine rates of wetland elevation change, and forecast longevity of these habitats in refuges within the South Atlantic geography. Understanding refuge-specific rates of wetland elevation change and relative SLR is important to help refuge managers answer critical questions and adjust management techniques of wetlands towards future conditions. A regional synthesis report is anticipated in early 2020. Preliminary data indicate that coastal marshes appear to be accreting in response to SLR.

NORTH CAROLINA

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

Eight of the 10 National Wildlife Refuges (NWR) in Eastern North Carolina are vulnerable to threats from coastal storm surge and sea level rise.

Pea Island NWR

An Executive Order established Pea Island NWR on April 8, 1938, as a refuge and breeding ground for migratory birds and other wildlife. The refuge covers approximately 5,000 acres within the coastal barrier island chain known as the Outer Banks. The NWR was named for the beach peas (*Strophostyles helvola*) that once dominated the backsides of the coastal dunes, which mature in October as geese arrive. The beach face and exposed areas of the dunes are nesting habitat for colonial nesting birds, such as oystercatchers. The beaches provide foraging habitat for shorebirds and nesting habitat for sea turtles. Piping plovers nest on unvegetated sand areas with shallow pools of water. Ducks rest and feed in the bodies of water west of the refuge, and marsh birds and wading birds inhabit the marshes. Federally listed species or species proposed for listing known to occur on the NWR include piping plover, red knot, Eastern black rail, American alligator, seabeach amaranth, and loggerhead, green, leatherback, and Kemp's ridley sea turtles. In addition, bald eagles and golden eagles (both protected under the Bald and Golden Eagle Protection Act or BGEPA) are present on the refuge.

Pea Island Refuge is an overlay of a portion of Cape Hatteras National Seashore. Through a Memorandum of Understanding signed in July 1975 and amended in 1987, the National Park Service (NPS) and the Service work together to manage the refuge and the national seashore. The NPS is responsible for interpreting historical and cultural assets, maintaining all parking lots and the restroom facility adjacent to the Visitor Center, and assisting with law enforcement patrols along the beach. The Service is responsible for all wildlife and habitat management activities, operation of the Visitor Center, recreational access, and uses on the refuge. Pea Island Refuge remained a stand-alone refuge until 1984 when the Service started administering it as part of a two-refuge complex with the newly created Alligator River NWR. This NWR is located in the Lower Coastal Plain, where daily tidal cycles flood beaches and marshes, maintaining the hydrology that kept the area's flora and fauna vigorous. Coastal breezes blow salt spray over the barrier islands trimming the woody vegetation behind the low broad dunes and depositing fresh sand on the herbaceous dune vegetation (USFWS 2006a).

Threats from Sea Level Rise and Storm Surge

The expected increase in the rate of SLR and storm activity is virtually certain to affect Pea Island NWR. Periodic storm events cut inlets through the barrier islands, bringing tidal fluctuations to the sounds. Periodic storm events also overwash the barrier islands. Ocean overwash can deposit fresh layers of sand across the islands that sometimes extend new layers of sand to the sounds. Within a period of SLR where ocean overwash occurs, the elevation of the island can be raised and the whole island effectively moves toward the mainland to the west. However, the maintained highway along the eastern shoreline of the NWR represents a form of shoreline hardening (albeit usually behind man-made dunes), which prevents the islands movement toward the mainland. The acceleration in SLR and associated storm surge could reach a point where Pea Island would not be able to adjust quickly enough, and the shoreline would begin to experience more frequent cross-island overwash or even permanent inundation.

Alligator River NWR

Alligator River NWR is located in mainland Dare and Hyde Counties, North Carolina. The refuge is named for the Alligator River, which constitutes the refuge's western Boundary. The Service established Alligator River NWR in March 1984 to protect and conserve migratory birds and other wildlife resources through the protection of wetlands. The refuge covers approximately 152,260 acres and lies at the eastern end of a broad, flat, and swampy peninsula. The refuge surrounds the 46,000-acre Dare County Bombing Range, used by the Navy and Air Force for target practice with inert ordnance. Within the bombing range, the North Carolina Wildlife Resources Commission manages 41,200 acres as a game land (USFWS 2008a).

Federally listed species and proposed species known to occur on the NWR include red wolf, northern long-eared bat, Eastern black rail, red-cockaded woodpecker, and American alligator. The refuge provides habitat for 42 species of mammals, 61 species of reptiles and amphibians, and 250 species of birds, including the bald eagle and golden eagle. The refuge supports wildlife species that are important from both a regional and a national standpoint (Noffsinger et al. 1984). Its large size and dense vegetation makes it a haven for species that avoid man, such as the black bear. Also, the refuge harbors many species adapted to living in forested habitat as opposed to

disturbed areas such as field edges. The refuge lies at or near the northern limit of ranges for several vertebrate species (Noffsinger et al. 1984).

The Alligator River NWR has a great variety of habitat types, including mixed hardwood and pine-dominated upland forest, Atlantic white cedar forest, cypress gum forest, low and high pocosin, tidally influenced and freshwater canals and streams, freshwater marsh, brackish estuarine marsh, and estuarine open water. Managed wetlands (moist soil management units) provide an optimal environment to produce waterfowl food such as milo or millet. Cooperative farmers assist in the management of these cropland areas, which provide food for migratory and resident wildlife, including mammalian game species, migratory waterfowl, endangered species, neotropical migratory birds, and resident game birds.

Threats from Sea Level Rise and Storm Surge

Flooding or inundation resulting from SLR and storm surge would alter the refuge habitats, changing saltwater and freshwater marshes into open water areas, and upland, forested areas into marshes or even open water. As the habitat changes, the wildlife will also change. The effects of SLR and storm surge include inundation and intrusion of saltwater into marsh and forested habitat. The duration of inundation by SLR will make a difference: habitat that is perpetually flooded has no tree regeneration. Thus, SLR could result in loss of habitat over time at locations where inundation becomes perpetual.

Mackay Island NWR

Mackay Island NWR is in Currituck County, North Carolina and Virginia Beach, Virginia. The Service named the refuge for Mackay Island where it is located, which is named for John Mackie, a previous owner. Congress established Mackay Island NWR on December 30, 1960, to protect and conserve migratory birds through the protection of wetlands. The Service established the original acquisition boundary of 7,835 acres in 1961 and expanded the boundary to 9,503 acres in 1991. The Secretary of the Interior issued a proclamation on August 21, 1963, prohibiting waterfowl hunting on 4,621 acres of the refuge and 1,098 acres of water south and west of the refuge.

Mackay Island NWR is a typical southeastern United States coastal wetland system that has formed brackish marshes and forested swamps in the Coastal Plain region. The National Wetlands Inventory described the refuge as an estuarine emergent herbaceous or palustrine, forested wetland with deciduous or broad-leaved deciduous vegetation and a water regime ranging from temporarily flooded to semipermanently flooded (Cowardin et al. 1979). Schafale and Weakley (1990) classify the three natural communities within the refuge boundary as: tidal freshwater marsh, estuarine fringe loblolly pine forest, and mesic pine flatwoods. Other habitats have been altered or created by man. During the growing season, the marshes appear alive with neotropical songbirds, raptors, wading birds, marsh birds, mink, otter, and other wildlife species. The forests of loblolly pine, red maple, black gum, sweetgum, green ash, and wax myrtle echo the sounds of songbirds, wood ducks, and deer. At least 187 species of birds utilize the refuge, including bald and golden eagles. Federally listed and proposed species include red-cockaded woodpecker and West Indian manatee, and the proposed species Eastern black rail.

The North Carolina Natural Heritage Program has designated most of the refuge, with the exception of cropland, managed moist-soil areas, and the shop area, as a Significant Natural Heritage Area. The Nature Conservancy ranks certain vegetative communities as imperiled or rare. The North Carolina Division of Water Quality has designated several water bodies in the vicinity of the Mackay Island Refuge as outstanding resource waters or high-quality waters. The North Carolina Division of Marine Fisheries has designated several streams and water bodies around the refuge as anadromous fish spawning habitats.

Threats from Sea Level Rise and Storm Surge

Flooding resulting from SLR and storm surge would alter the refuge habitats, changing marshes into open water areas, and upland, forested areas into marshes or even open water. Due to the size and location of the NWR, there are no upslope forested areas that may replace lost trees for wildlife habitat. As the habitat changes, the wildlife will also change. The effects of SLR and storm surge include inundation and intrusion of saltwater into forested habitat. The duration of inundation by SLR will make a difference: habitat that is perpetually flooded has no tree regeneration. Thus, SLR could result in complete loss of habitat over time at locations where inundation becomes perpetual.

Currituck NWR

Currituck NWR is located in Currituck County in the northeastern corner of North Carolina. The refuge is named for the county where it is located. The refuge covers a total of 4,570 acres in fee title ownership and 3,931 acres in conservation easements. It is bounded by Currituck Sound on the west; the Atlantic Ocean on the east; the city of Virginia Beach on the north; and Dare County, North Carolina, on the south. The refuge was established on August 2, 1983, to protect and conserve migratory birds and other wildlife resources through the protection of wetlands.

The North Carolina Natural Heritage Program has designated most of the refuge, with the exception of the moist soil management area, as a Significant Natural Heritage Area. The North Carolina Division of Water Quality has designated several water bodies in the vicinity of Currituck NWR as outstanding resource waters or high-quality waters. The North Carolina Division of Marine Fisheries has designated several streams and water bodies within and off the borders of the refuge as anadromous fish spawning habitats.

Currituck NWR is a typical southeastern U.S. coastal barrier island system that has formed dunes, brackish marshes and forested swamps in the Coastal Plain region. Federally listed or proposed species known to occur on the NWR include sea turtles, red knot, piping plover, West Indian manatee, Eastern black rail, and seabeach amaranth, though many of these species have not been documented on the refuge beaches in years. Disturbance from unrestricted vehicular traffic on the beach destroys seabeach amaranth seeds and plants before they can take hold. Piping plover no longer nests on the refuge, likely because of disturbance from vehicles and a lack of available optimal habitat, such as washover habitat or other unvegetated dry sand between or behind the dunes.

The National Wetlands Inventory describes the refuge as an estuarine emergent herbaceous or palustrine, forested wetland with deciduous or broad-leaved deciduous vegetation and a water regime ranging from temporarily flooded to semi-permanently flooded (Cowardin et al. 1979). Schafale and Weakley (1990) identify five natural communities within the refuge boundary: dune grass, maritime dry grassland, maritime shrub, brackish marsh, and maritime swamp forest (USFWS 2006b).

Threats from Sea Level Rise and Storm Surge

The expected increase in the rate of SLR and storm activity is virtually certain to affect Currituck NWR. Periodic storm events cut inlets through the barrier islands, bringing tidal fluctuations to the sounds. Periodic storm events also overwash the barrier islands. Ocean overwash can deposit fresh layers of sand across the islands that sometimes extend new layers of sand to the sounds. Within a period of SLR where ocean overwash occurs, the elevation of the island can be raised and the whole island effectively moves toward the mainland to the west. The acceleration in SLR and associated storm surge could reach a point where the Northern Outer Banks would not be able to adjust quickly enough, and the shoreline would begin to experience more frequent cross-island overwash or even permanent inundation.

Flooding resulting from SLR and storm surge would alter the sound-side habitats, changing marshes into open water areas, and upland, forested areas into marshes or even open water. Due to the size and location of the NWR, there are no upslope forested areas that may replace lost trees for wildlife habitat. As the habitat changes, the wildlife will also change. The effects of SLR and storm surge include inundation and intrusion of saltwater into forested habitat. The duration of inundation by SLR will make a difference: habitat that is perpetually flooded has no tree regeneration. Thus, SLR could result in complete loss of habitat over time at locations where inundation becomes perpetual.

Roanoke River NWR

Roanoke River NWR was established in 1985 to protect and conserve migratory birds and other wildlife resources through the protection of wetlands. Specifically, primary purpose of the NWR was to preserve wintering habitat for mallards, American black ducks, wood ducks, and production habitat for wood ducks (USFWS 1988). The approval memorandum identified three objectives for which the area would be managed: to preserve an area that has traditional high use for wintering waterfowl; to provide additional waterfowl habitat through refuge management; and to establish a waterfowl sanctuary. The refuge is situated in the floodplain of the Roanoke River, and consists almost entirely of wetlands and streams, including cypress-gum swamp, coastal plain bottomland hardwood forest, coastal plain levee forest, coastal plain semi-permanent impoundment, and mesic mixed hardwood forest. Throughout eastern North Carolina, the refuge staff administers 20,978 acres of fee title land in Bertie County; two satellite fee title tracts acquired by the U.S. Department of Agriculture, Farm Services Agency (174 acres in two counties); and 98 conservation easements acquired by the Farm Services Agency (2,870 acres in 19 counties). The refuge covers a total of 20,978 acres, and its southeastern end is at the outlet of the Roanoke River into Albemarle Sound. At the time of its establishment in 1985, this wetland area of national significance was considered as the largest intact, and least disturbed, bottomland forest ecosystem remaining in the mid-Atlantic region.

The flows of the Roanoke River are managed for flood control by the U.S. Army Corps of Engineers (Corps), and for hydroelectric power generation by a private power company. The Service has negotiated flow regimes with the Corps, in order to improve the hydrology of the refuge wetlands in the lower Roanoke River.

Federally listed species known to be present within the refuge include shortnose sturgeon, Atlantic sturgeon, northern long-eared bat, and American alligator. In addition, bald eagles nest on and migrate through the NWR. Although the Refuge was designated specifically as wintering habitat for waterfowl, the NWR also provides forested habitat for neotropical migrants.

The downstream end of Roanoke River NWR is at sea level. Seasonally flooded bald cypress and swamp tupelo trees cover the majority of the refuge. SLR will change the types of vegetative cover on the refuge. The grass-dominated freshwater marshes that occupy the fringe of the riverbanks will expand into areas currently covered by bald cypress and swamp tupelo trees. Bald cypress and swamp tupelo forests will expand into areas currently occupied by bottomland hardwood forests. As the habitats change, the wildlife species that inhabit those habitats will also change. Colonial nesting birds such as herons and egrets that currently utilize tall trees along the river will lose their roost sites as trees die and fall. New candidate roost trees further upslope will be separated from open water by freshwater marshes. Cavity-nesting waterfowl, songbirds, and mammals will lose their cavities as the trees they currently use fall, but over time, other trees further upslope will replace them as cavity trees. The freshwater marshes that will expand over time into the former bald cypress-swamp tupelo forests will provide habitat for species of songbirds and waterfowl not currently inhabiting the forested swamps (USFWS 2005a).

Threats from Sea Level Rise and Storm Surge

The downstream end of Roanoke River NWR is at sea level. Seasonally flooded bald cypress and swamp tupelo trees cover the majority of the refuge. SLR will change the types of vegetative cover on the refuge. The grass-dominated freshwater marshes that occupy the fringe of the riverbanks will expand into areas currently covered by bald cypress and swamp tupelo trees. Bald cypress and swamp tupelo forests will expand into areas currently occupied by bottomland hardwood forests. As the habitats change, the wildlife species that inhabit those habitats will also change. Colonial nesting birds such as herons and egrets that currently utilize tall trees along the river will lose their roost sites as trees die and fall. New candidate roost trees further upslope will be separated from open water by freshwater marshes. Cavity-nesting waterfowl, songbirds, and mammals will lose their cavities as the trees they currently use fall, but over time, other trees further upslope will replace them as cavity trees. The freshwater marshes that will expand over time into the former bald cypress - swamp tupelo forests will provide habitat for species of songbirds and waterfowl not currently inhabiting the forested swamps.

Mattamuskeet NWR

Mattamuskeet NWR sits at the southern end of a broad, flat, and swampy peninsula in northeastern North Carolina. It protects and manages 50,180 acres of wildlife habitat in Hyde County. The Service named the refuge after North Carolina's largest natural lake, the 40,000-acre Lake Mattamuskeet, which comprises almost 80 percent of the refuge's area. The lake averages only two feet in depth but is 18 miles long and five to six miles wide. In addition to the lake, the refuge's other main habitats are wet pine flatwoods, moist soil units, natural lake shoreline, and cypress-gum swamp. The refuge is surrounded by cropland, marsh, and timber.

Pamlico Sound, which separates the mainland of North Carolina from the Outer Banks to the east, lies seven miles south of the refuge.

Mattamuskeet NWR was established in 1934 to protect and conserve migratory birds and other wildlife resources through the protection of wetlands. The Service constructed impoundments to provide feeding and resting habitat for migrating and wintering wildlife. Following the refuge's establishment, the numbers of puddle ducks and geese drawn to Lake Mattamuskeet appeared endless and peaked in 1960, when more than 100,000 Canada geese and 200,000 ducks wintered there. A drastic decline in their numbers began soon after and continued until the mid-1980s. In the mid-1960s, the refuge initiated a long-term habitat enhancement project to optimize wintering waterfowl habitat. The project's focus was on refuge areas historically used by Canada geese and puddle ducks. Between 1967 and 1981, over 2,500 acres of low quality marsh were impounded and restored to conditions that favored the production of waterfowl foods, in what are called moist soil units. Currently, manipulation of water levels and mechanical vegetation control in the moist soil units produce impressive stands of natural waterfowl foods, such as wild millet, panic grasses and spike rushes. In addition, dense beds of submerged vegetation desired by swans, diving ducks, and some puddle ducks, are produced naturally in Lake Mattamuskeet. Federally listed species known to occur on the NWR include red wolf, American alligator, and sensitive joint-vetch (*Aeschynomene virginica*). In addition, bald eagles and golden eagles, both protected by BGEPA, are found on the refuge. Golden eagles are winter visitors, while bald eagles may nest or overwinter on the refuge or migrate through.

The refuge actively manages or maintains some of the habitats, including open water habitat, freshwater marsh along the lakeshore, moist soil units, forested habitats, and cropland. Lake Mattamuskeet's submerged aquatic vegetation (principally wild celery, redhead grass, and musk grass) are an important part of the open water habitat. Lake Mattamuskeet is filling in with silt and becoming shallower over time with the accumulation of sediments and organic matter. Consistent removal of silt from canals, particularly the canals which drain the lake, will slow down this process. However, over the long term, the open water habitat of the lake will be replaced by marsh habitat.

It is difficult to exaggerate the true importance of the lake and its surrounding impoundments and wetlands to regional wintering waterfowl. This refuge attracts a majority of the current swans and pintails inventoried along the entire Atlantic Coast. Literally tens of thousands of tundra swans, geese, wading birds, shore birds, and hundreds of thousands of ducks utilize this nucleus during fall, winter, and spring migrations (USFWS 2008b).

Threats from Sea Level Rise and Storm Surge

Flooding resulting from SLR and storm surge would alter refuge habitats, changing marshes into open water areas, and upland, forested areas into marshes or even open water. As the habitat changes, the wildlife will also change. The effects of SLR and storm surge include inundation and intrusion of saltwater into refuge habitats. The duration of inundation by SLR will make a difference: forested habitat that is perpetually flooded has no tree regeneration. Thus, SLR could result in loss of habitat over time at locations where inundation becomes perpetual.

Lake Mattamuskeet and the adjacent freshwater impoundments are managed for wildlife habitat. To fulfill the purposes of the refuge, it is crucial to maintain the water quality of Lake Mattamuskeet. Managing the lake's salinity is important to maintaining its submerged aquatic

vegetation and fish populations. In the short term, flooding and saltwater intrusion from SLR and storm surge could potentially be adequately prevented by the existing management practices. However, as SLR accelerates, the water management systems may be overwhelmed, leading to permanent conversion of the freshwater marsh and open water areas to brackish or saltwater.

Swanquarter NWR

Swanquarter NWR is located on the Pamlico Sound in Hyde County, North Carolina. The refuge is located at the southern end of a broad, flat and swampy peninsula in northeastern North Carolina, and is surrounded by brackish marsh and cropland. The Service named the refuge for the nearby village of Swan Quarter. The refuge was established in 1932 to protect and conserve migratory birds and other wildlife resources. Hunting is allowed on specific tracts of the refuge. Approximately 8,800 acres of the refuge have been designated a Wilderness Area under the National Wilderness Preservation System. Most of the Wilderness Area is brackish marsh. The North Carolina Natural Heritage Program has designated most of the refuge, with the exception of the roads, as a Significant Natural Heritage Area. The North Carolina Division of Water Quality has designated several water bodies in the vicinity of Swanquarter NWR as outstanding resource waters or high-quality waters.

Swanquarter NWR provides habitat for a wide variety of birds. Because of the refuge's large size and plant community diversity, habitat is provided for forest dwelling species as well as marsh dwelling species. This somewhat unique complex of various wetland habitat types results in the presence of some unique avian forms, such the Wayne's black-throated green warbler, a distinct form of prairie warbler, and an unusually dense population of worm-eating warblers (Watts and Paxton 2002). There are approximately 250 species of birds that visit regularly, with about 40 to 50 additional species considered accidental visitors. The area is roughly at midpoint in the Atlantic Flyway and is a much used and valuable feeding and resting area for numerous species of wintering waterfowl. Tundra swans, snow geese, coots, and more than twenty-five species of ducks winter either on the refuge or in the sounds and rivers adjacent to the refuge. Populations of migratory waterfowl peak during the months of November through February. In addition to waterfowl, large numbers of hawks, owls, and many species of passerine birds may be seen. Avian species composition changes throughout the year since most are migratory. Pamlico Sound provides open water for resting, feeding, and escape cover for waterfowl.

The species that breed on the refuge are characteristic of species that inhabit other coastal plain communities. They include warblers, nuthatches, thrashers, and blue-gray gnatcatchers. Wading birds, such as the great blue heron, are common and breeding has been documented in at least one rookery on the refuge. Bald eagles and ospreys have also historically nested on the refuge, and golden eagles have been recorded. Federally-listed or proposed species known to occur on the NWR include Eastern black rail, red wolf, and red knot (USFWS 2008c).

Most of the refuge lies within a few feet of sea level, and marshes cover the majority of the refuge. Other habitats on the refuge include mixed pine hardwood forest, high pocosin, estuarine fringe loblolly pine forest, non riverine swamp forest, pond pine pocosin, and open water.

Threats from Sea Level Rise and Storm Surge

Flooding resulting from SLR and storm surge could be a long-term problem for the Swanquarter NWR. Over the last 100 years the sea level has risen approximately one foot. A further rise in sea level would alter the habitat, changing marshes into open water areas, and upland areas into marshes. As the habitat changes, the wildlife will also change. SLR could result in loss of habitat over time at locations where inundation becomes perpetual. The fresh groundwater aquifer would be even more susceptible to saltwater intrusion because of the expected SLR.

Cedar Island NWR

Cedar Island NWR is a 14,480-acre refuge in Carteret County, North Carolina. The Service named the refuge for the island on which it is located. The Cedar Island NWR was established in 1964 to protect and conserve migratory birds, and other wildlife resources through the protection of wetlands. There are 253 species of birds, mammals, reptiles, amphibians, and fish

The North Carolina Natural Heritage Program has designated most of the refuge, with the exception of the headquarters area, as a Significant Natural Heritage Area. The North Carolina Division of Water Quality has designated several water bodies in the vicinity of Cedar Island NWR as outstanding resource waters or high-quality waters. The North Carolina Division of Marine Fisheries has designated several streams and water bodies within and off the borders of the refuge as fish nurseries and anadromous fish spawning habitats.

The National Wetlands Inventory described the refuge as an estuarine emergent herbaceous or palustrine, forested wetland with deciduous or broad-leaved deciduous vegetation, and a water regime ranging from temporarily flooded to semi-permanently flooded (Cowardin et al. 1979). Schafale and Weakley (1990) identify nine natural communities within the refuge boundary: brackish marsh, maritime shrub, maritime dry grassland, coastal fringe sandhills, coastal fringe evergreen forest, cypress gum swamp, bay forest, pine savanna, and wet pine flatwoods. The Cedar Island NWR includes is part of an extensive complex of brackish marshes along the Pamlico and Core Sounds. The marshes adjacent to the refuge are largely undisturbed and are protected by government ownership of Cape Lookout National Seashore and Piney Island. Federally-listed or proposed species known to occur on the NWR include piping plover, red knot, and Eastern black rail, along with bald and golden eagles (USFWS 2008d).

Threats from Sea Level Rise and Storm Surge

Flooding resulting from SLR and storm surge would alter refuge habitats, changing marshes into open water areas, and upland, forested areas into marshes or even open water. As the habitat changes, the wildlife will also change. The effects of SLR and storm surge include inundation and intrusion of saltwater into refuge habitats. The duration of inundation by SLR will make a difference: forested habitat that is perpetually flooded has no tree regeneration. Thus, SLR could result in loss of habitat over time at locations where inundation becomes perpetual.

SOUTH CAROLINA

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

Waccamaw NWR

Waccamaw NWR is located in South Carolina's "Lowcountry," about 60 miles north of Charleston, within Georgetown, Horry and Marion counties. Its 54,000-acre acquisition boundary contains portions of the Great and Little Pee Dee rivers and the Waccamaw River. These river systems and associated wetlands comprise a large portion of the Winyah Bay drainage basin and are an important component of the Winyah Bay ecosystem. Waccamaw NWR is one of four refuges in the South Carolina Lowcountry Complex, along with Ace Basin, Cape Romain, and Santee.

As of 2007, Waccamaw NWR has acquired 97 tracts, comprising a total of 10,590 acres within its authorized acquisition boundary. The wetland diversity of this refuge is what sets it apart from most others found along the east coast. Waccamaw NWR's tidal freshwater wetlands are some of the most diverse freshwater wetland systems found in North America today, and offer important habitats for abundant migratory birds, fish, and resident wildlife. More than 400 species of animals are supported by the variety of habitats within the refuge acquisition area, including several endangered species. Birds, such as the swallow-tailed kite, osprey, wood storks, white ibis, and prothonotary warbler, along with many species of waterfowl can be observed on a seasonal basis. Mammals, like the American black bear, frequent Waccamaw NWR's forests year-round. Notably, the refuge acquisition area supports the highest density of nesting swallow-tailed kites in South Carolina and is the northernmost documented nesting area for this raptor within its range. Additionally, Waccamaw NWR's wetlands play a critical role in the filtration and stormwater retention of the primary drinking water resource for the greater Grand Strand region.

Waccamaw NWR habitats are dominated by blackwater and alluvial forested wetlands, also described as semi-permanently flooded tidal deciduous forested wetlands and seasonally flooded tidal deciduous forested wetlands, respectively. These habitats form dense stands of vegetation throughout the floodplains of the Great Pee Dee, Little Pee Dee, and Waccamaw rivers and support diverse fauna, among them neotropical migratory birds, waterfowl, black bear, and threatened and endangered species (USFWS 2008e).

Adaptation for Resilience

The Refuge is the first in the country to successfully use minor boundary modification as an approach to conserve land and build climate and storm surge resilience. "The minor boundary modification will remove 6,849 acres of land from the Refuge which is either unlikely to be protected by the Refuge or no longer provides quality wildlife habitat due to local activities that have permanently changed the landscape. The current boundary will be changed so that 6,638 new acres will be added to the Refuge through the purchase of properties from willing landowners. These additional lands harbor critical riverside habitat that will help local wildlife withstand the effects of climate change, improve public access to the Waccamaw River, enhance recreational opportunities, support clean drinking water and reduce flood risks in surround communities (American Rivers 2020)

Santee NWR

The Santee NWR is not within the SACS coastal boundary but is vulnerable to storm surge and SLR and contains areas of cultural and local significance. Santee NWR was established in 1942, and is in Clarendon County, South Carolina. The 15,000-acre refuge lies within the Atlantic Coastal Plain and consists of mixed hardwoods, mixed pine hardwoods, pine plantations, marsh, croplands, old fields, ponds, impoundments, and open water. This tremendous diversity of habitats supports many kinds of wildlife.

A myriad of wildlife species inhabit the varied landscape of Santee NWR. Santee NWR is home to an incredible diversity of wildlife species, including 313 birds, 96 mammals, 120 fish, 72 reptiles, and 66 amphibians. During the winter months, the bald eagle and occasionally the peregrine falcon can be seen. From November through February, migrating waterfowl, such as mallards, pintails, teal, and wood ducks, along with Canada geese, are a major attraction. Throughout the year, red-tailed and red-shouldered hawks can be viewed soaring overhead, as can a variety of songbirds in the trees, and wild turkey.

Santee NWR also contains areas of cultural and local significance. The 420-acre Dingle Pond unit consists primarily of a Carolina Bay and is a designated public use natural area. A historic site on the refuge that is listed on the National Register of Historic Places is the Santee Indian Mound/Fort Watson area. The mound itself is more than 3,000 years old and artifacts of the Santee NWR have been dated to 3,500 years ago. During the Revolutionary War, the British kept a garrison of about 100 soldiers at the mound. This gave them strategic control over the Santee River and a major road connecting Charleston to Camden. The garrison was eventually captured by American revolutionary forces under General Francis Marion (USFWS 2008f).

Cape Romain NWR

Established in 1932 as a migratory bird refuge, Cape Romain NWR encompasses a 22-mile segment of the southeast Atlantic coast. The refuge consists of 66,287 acres which include barrier islands, salt marshes, intricate coastal waterways, long sandy beaches, fresh and brackish water impoundments, and maritime forest. Points of interest include Bulls Island, Cape Island, and Lighthouse Island where two lighthouses, no longer operational, still stand (USFWS 2010a).

Adaptation for Resilience

Climate change, sea level rise and worsening storm surge are concerns within the Winyah-Sewee Conservation and Resiliency Planning Project area, which includes Cape Romain NWR and is led by The Nature Conservancy of South Carolina. Some parts of the project area may lose approximately half of their beach habitat, and saltwater intrusion will shift some freshwater habitats to brackish or tidal communities. Project recommendations include the expansion and connection of protected areas, allowing for the creation of habitat corridors across the topography of the ecosystem allowing vegetation communities to shift their ranges as climate and storm surge conditions continue to change (Land Trust Alliance 2020)

Ernest F. Hollings ACE Basin NWR

ACE Basin NWR is located within the 350,000-acre Ashepoo–Combahee–Edisto (ACE) Basin

Project. The ACE Basin Project is widely recognized as a unique and critical environment marked by a wide diversity of wildlife and plants and represents the largest estuarine resource in South Carolina. The refuge is composed of two units, together comprising approximately 11,815 acres. The Edisto Unit consists of 7,203 acres and is located approximately 20 miles southwest of the city of Charleston, South Carolina in Charleston County. The Combahee Unit consists of 4,612 acres in Beaufort, Colleton, and Hampton Counties and is located approximately 20-25 miles northwest of the city of Beaufort, South Carolina. The refuge's two units are drained by two significant river systems: the Combahee–Salkahatchie, which flows through the Combahee Unit; and the South Edisto, which flows adjacent to the Edisto Unit. Many broad, low-gradient interior drains are present as either extension of tidal streams and rivers or flooded bays and swales. Within this diverse drainage system, the refuge contains exceptionally diverse wildlife habitat including high-quality forested wetlands, forested uplands, brackish natural marshes, freshwater natural marshes, managed marshes or wetland management units, marsh islands, and pristine estuarine rivers (USFWS 2009a).

Savannah, Pinckney Island, and Blackbeard Island NWR

A chain of seven national wildlife refuges form the Savannah Coastal Refuges Complex that extends from Pinckney Island NWR near Hilton Head Island, South Carolina, to Wolf Island NWR near Darien, Georgia. Between these two refuges lie five additional national wildlife refuges: Savannah (the largest unit in the Complex), Wassaw, Tybee, Harris Neck, and Blackbeard Island NWRs. These seven refuges total 56,949 acres, spanning about 100 miles of the Atlantic Ocean coastline, and are administered from their headquarters at the Savannah NWR Visitor Center (USFWS 2011a).

These refuges are located in an ecosystem characterized by coastal marsh and barrier islands and locally referred to as "Lowcountry," bordered on the west by sandhill ridges and on the east by the Atlantic Ocean, and extending from Georgetown, South Carolina, to St. Mary's, Georgia.

The variety of birdlife within the Lowcountry is enhanced by its location on the Atlantic Flyway. During the winter months, thousands of mallards, pintails, teal, and many other species of ducks migrate into the area, joining resident wood ducks on the coastal refuges. In the spring and fall, transient songbirds and shorebirds stop briefly on their journeys to and from northern nesting grounds. Among these casual visitors are the warblers (e.g., magnolia, prairie, blackpoll, American redstarts, blackthroated blue), and sandpipers (e.g., buff-breasted, white-rumped, pectoral, whimbrels, semipalmated sandpipers, short-billed dowitchers). Many migratory songbirds and shorebirds terminate their southern journeys and spend the winter. The hermit thrush, ruby crowned kinglet, yellow-rumped warbler, black-bellied plover, and sanderling are a few of the winter residents.

The barrier islands provide ideal habitat for a wide variety of plants and animals, including species of concern such as the American alligator, piping plover, wood stork, loggerhead sea turtle, and southern bald eagle. The saltwater marshes that lie behind the barrier islands are nurseries for countless marine organisms, including shrimp, oysters, crabs, striped bass, and

other commercial and sport species that are particularly important to the coastal economy. Such an abundance of life in the salt marsh invites other animals to rest, feed, or nest -- promoting the diversity of flora and fauna found in the Lowcountry coastal plain and the barrier island habitats.

Savannah NWR

Saltwater intrusion due to past dredging projects has resulted in a loss of tidal freshwater marshes on the refuge from 6,000 acres in 1927 to less than 2,800 acres today. A study to assess the changes in plant communities and the corresponding interstitial salinity gradient (a follow-up to studies conducted in 1986-87 and 1993-94) is ongoing with plans to continue indefinitely until the freshwater marsh fully recovers. Also, scientists from the National Wetlands Research Center and the University of New Orleans are investigating forest dieback in the tidal freshwater swamps and the influence of saltwater intrusion within the refuge (USFWS 2011a).

Pinckney NWR

Despite the many small ponds on the refuge, freshwater supplies are limited because of large domestic, commercial, and industrial demands on the regional groundwater aquifer and the resultant water table drawn down and saltwater intrusion into the aquifer. This limits the ability of refuge personnel to develop freshwater wetlands for migratory songbirds, reptiles, and amphibians. Saltwater intrusion has moved under the Port Royal sound and been detected in Moss Creek. The refuge's freshwater ponds are permanently closed to public fishing. Limited freshwater supplies are further exacerbated by recent drought conditions (USFWS 2011a).

Tybee NWR

Tybee NWR is considered a sanctuary for migratory birds. The refuge is located in Jasper County, South Carolina, at the mouth of the Savannah River. Originally only a 1-acre oyster shoal until 1998, it is now used as a spoil site for material dredged from the Savannah River by the Corps of Engineers and presently encompasses an area of about 400 acres of scrub/shrub habitat, sand beaches, and marsh. Impacts of Savannah River dredging and harbor deepening activities threaten aquatic habitats (USFWS 2011a). Limited freshwater supplies are further exacerbated by recent drought conditions (and by the future anticipated effects of climate change).

<u>Threats from Sea Level Rise and Storm Surge along Coastal South Carolina</u>

The IPCC has concluded that warming of the climate is undeniable and could cause changes in our stewardship of our lands. Examples of potential changes are altered fire regimes, rain and snowfall patterns, access to water resources, hydrology in rivers and wetlands, frequency of extreme weather events, higher storm surge, and rising sea levels at coastal refuges.

Coastal refuges are particularly vulnerable to SLR associated with global warming. Tidal marshes are among the most susceptible ecosystems to climate change, especially accelerated SLR. Rising sea level may result in tidal marsh submergence and habitat migration as salt marshes transgress landward and replace tidal freshwater and brackish marsh (Ehman 2008). Marsh and swamp habitats, which are exquisitely sensitive to salinity and flooding patterns, will

also shift upward and inland. The first to adapt or be eradicated from the refuges would be reptiles, amphibians, and fish.

Changes in coastal wetlands due to sea-level rise were modeled for coastal South Carolina using the Sea Level Affecting Marshes (SLAMM) model. This model simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea-level rise projected for coastal marshes and other near-shore habitats. SLR of approximately 52 cm (Scenario – SRES A1B mean) is predicted for this area (Craft et. al 2008). Salt marshes throughout the refuges would likely convert to open water, and barrier islands shrink in size. In addition to the rising seas, the effects of climate change and global warming will be higher storm surge and tidal flooding.

"National Wildlife Refuges along the east coast of the U.S. protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges" (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

GEORGIA

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

Savannah, Wassaw, Harris Neck, and Blackbeard Island NWR

A chain of seven national wildlife refuges form the Savannah Coastal Refuges Complex that extends from Pinckney Island NWR near Hilton Head Island, South Carolina, to Wolf Island NWR near Darien, Georgia. Between these two refuges lie five additional national wildlife refuges: Savannah (the largest unit in the Complex), Wassaw, Tybee, Harris Neck, and Blackbeard Island NWRs. These seven refuges total 56,949 acres, spanning about 100 miles of the Atlantic Ocean coastline, and are administered from their headquarters at the Savannah NWR Visitor Center.

These refuges are located in an ecosystem characterized by coastal marsh and barrier islands and locally referred to as "Lowcountry," bordered on the west by sandhill ridges and on the east by the Atlantic Ocean, and extending from Georgetown, South Carolina, to St. Mary's, Georgia.

The variety of birdlife within the Lowcountry is enhanced by its location on the Atlantic Flyway. During the winter months, thousands of mallards, pintails, teal, and many other species of ducks migrate into the area, joining resident wood ducks on the coastal refuges. In the spring and fall, transient songbirds and shorebirds stop briefly on their journeys to and from northern nesting grounds. Among these casual visitors are the warblers (e.g., magnolia, prairie, blackpoll,

American redstarts, blackthroated blue), and sandpipers (e.g., buff-breasted, white-rumped, pectoral, whimbrels, semipalmated sandpipers, short-billed dowitchers). Many migratory songbirds and shorebirds terminate their southern journeys and spend the winter. The hermit thrush, ruby crowned kinglet, yellow-rumped warbler, black-bellied plover, and sanderling are a few of the winter residents.

The barrier islands provide ideal habitat for a wide variety of plants and animals, including species of concern such as the American alligator, piping plover, wood stork, loggerhead sea turtle, and southern bald eagle. The saltwater marshes that lie behind the barrier islands are nurseries for countless marine organisms, including shrimp, oysters, crabs, striped bass, and other commercial and sport species that are particularly important to the coastal economy. Such an abundance of life in the salt marsh invites other animals to rest, feed, or nest -- promoting the diversity of flora and fauna found in the Lowcountry coastal plain and the barrier island habitats (USFWS 2011a).

Savannah NWR

Saltwater intrusion due to past dredging projects has resulted in a loss of tidal freshwater marshes on the refuge from 6,000 acres in 1927 to less than 2,800 acres today. A study to assess the changes in plant communities and the corresponding interstitial salinity gradient (a follow-up to studies conducted in 1986-87 and 1993-94) is ongoing with plans to continue indefinitely until the freshwater marsh fully recovers. Also, scientists from the National Wetlands Research Center and the University of New Orleans are investigating forest dieback in the tidal freshwater swamps and the influence of saltwater intrusion within the refuge (USFWS 2011a).

Wassaw NWR

Wassaw NWR is located in Chatham County between the Wilmington and Vernon Rivers in coastal Georgia, approximately 14 miles south of Savannah. Unlike many of Georgia's barrier islands, Wassaw NWR has experienced little in the way of human influences. Minimizing disturbance to wintering and nesting birds on beaches is the primary management opportunity. The highlight of the refuge is its 7 miles of undeveloped, spectacular beaches. However, the refuge's oceanfront beach is characterized by an eroding shoreline along its northern and southern ends. Sand is potentially being lost by dredging operations in the Savannah River, creating a deficit in the overall sand which historically replenished barrier islands, including Wassaw NWR (USFWS 2011a).

Harris Neck NWR

Harris Neck NWR is located on the South Newport River in coastal Georgia. This area represents some of the most important estuarine river systems in the southeastern United States. It is characterized by extensive salt marshes and freshwater marshes which support one of the most biologically productive systems in the world (USFWS 2011a).

Blackbeard Island NWR

Blackbeard Island NWR is located on Sapelo Sound in coastal Georgia and represents some of the most important estuarine habitat in the southeastern United States. It is characterized by extensive salt marshes and freshwater marshes which support one of the most biologically productive systems in the world. The primary threat to this region is urban development, which will contribute to increased stormwater runoff, pollution, groundwater depletion and sedimentation of offshore habitats.

Blackbeard Island NWR consistently has one, if not the highest density of nests in Georgia, and is considered a most important loggerhead beach. The Blackbeard Island NWR sea turtle project began in 1966 and represents one of the longest sea turtle nest study/protection programs in Georgia (USFWS 2011a).

SLR model simulations from the SLAMM modeling predict a rise of approximately 58 cm (Scenario – SRES A1B mean) for Blackbeard Island NWR by the year 2100 (Craft et. al 2008).

Wolf Island NWR

Wolf Island NWR is a barrier island located off the Georgia coast, 12 miles east of Darien (by boat) in McIntosh County. The refuge was established by Executive Order No. 5316 on April 3, 1930, as a migratory bird sanctuary. It includes Egg Island and Little Egg Island and encompasses a total of 5,126 acres.

This three-island wildlife refuge at the mouth of the Altamaha River consists mainly of salt marsh and provides critical sanctuary for rare migrating birds and nursery habitat for sea turtles. Wolf Island, the largest island in the refuge, covers 4,519 acres. Its boundaries are defined by the South River to the north; Little Mud River to the west; Altamaha Sound to the south; and the Atlantic Ocean to the east. The island has only 300 acres of dune and beach along its narrow, four-mile-long eastern shoreline. It fronts the sea in the Altamaha River Delta and forms a physical barrier between Doboy Sound to the north and Altamaha Sound to the south. Tucked into the mouth of Altamaha Sound and directly south of Wolf Island are Egg and Little Egg islands. They are 593 and 14 acres in size, respectively, and support extensive salt marsh with only 70 acres of upland (USFWS 2008g).

<u>Threats from Sea Level Rise and Storm Surge along Coastal Georgia</u>

Changes in coastal wetlands due to sea-level rise were modeled for coastal Georgia using the SLAMM model. SLR of approximately 58 cm (Scenario – SRES A1B mean) is predicted for this area (Craft et. al 2008). Salt marshes throughout the refuges would likely convert to open water, and barrier islands shrink in size. Tidal marshes will become submerged and transgress into salt marsh (Ehman 2008). Swamp habitats, which are exquisitely sensitive to salinity and flooding patterns, will shift upward and inland. The first species to adapt or be eradicated from coastal refuges in Georgia will likely be reptiles, amphibians, and fish. In addition to the rising seas, the effects of climate change and global warming will be higher storm surge and tidal flooding.

"National Wildlife Refuges along the east coast of the U.S. protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal

communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges" (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

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FLORIDA

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

Lake Woodruff NWR

Lake Woodruff NWR consists of ~21,574 acres in central Florida along the St. Johns River, Florida's largest river. The St. Johns River is a series of interconnected lakes that stretches 310 miles from its southern formation in Indian River County's swamps north to Jacksonville in Duval County near the Florida-Georgia border. The geographical position of the refuge, straddling the zone of overlap between the temperate and subtropical biotic provinces, contributes to the vast species richness of the area. The refuge is uniquely situated to support a wide variety of resident and migratory species. The refuge derives its name from Lake Woodruff, a 2,200-acre waterbody formed during the Pleistocene [100,000 years before present (BP)] when the St. Johns River basin was a large coastal lagoon complex. The eastern boundary of the refuge is part of an ancient dune system known as the Atlantic Coastal Ridge (Schnable and Goodell 1968) which formed when sea levels fell sharply during glaciation. The resulting differences in elevation present on the refuge, from prehistoric dunes to shallow lakes, have created a variety of habitats, including freshwater marshes, hardwood swamps, and a variety of upland habitats. These diverse refuge habitats support numerous plant species and are utilized by many fish and wildlife species, including seven regularly occurring Federal listed threatened and endangered species, as well as numerous State protected species. Although the refuge is important to a

variety of species, it is especially important to swallow-tailed kites. The refuge supports the second largest pre-migration roost of swallow-tailed kites in the United States (USFWS 2008h).

St. Johns NWR

Established on August 16, 1971, to provide habitat for threatened and endangered species, especially the now extinct dusky seaside sparrow, St. Johns NWR is in Brevard County in east central Florida. Lying in the Upper St. Johns River Basin, the 6,257-acre refuge is managed as a satellite of the Merritt Island NWR Complex. While St. Johns NWR itself is not staffed, staff from the Merritt Island NWR Complex conducts management activities on this refuge (USFWS 2011b). It is divided into two main management units: the SR 50 Unit (4,210 acres plus 31 acres at the Fox Lake Tract) and the Bee Line Unit (2,016 acres).

Merritt Island NWR

Merritt Island NWR, located along Florida's east central coast about 60 miles east of the city of Orlando in Brevard and Volusia Counties, was established by agreement as an overlay of the National Aeronautics and Space Administration's John F. Kennedy Space Center. The refuge covers a total of more than 140,000 acres and lies within one of the most productive estuaries in the country, the Indian River Lagoon, which has more species of plants and animals than any other estuary in North America (South Florida Water Management District 2005). The refuge faces the Atlantic Ocean and includes three major water bodies that are all part of the Indian River lagoon system: the Indian River Lagoon itself, Mosquito Lagoon, and the Banana River. A growing human population, along with ongoing development and other human activities, currently threatens the fragile but highly productive waters of the Indian River Lagoon system and the refuge.

The refuge derives its name from Merritt Island, which, along with Cape Canaveral, is a barrier island complex that formed during the Pleistocene and Holocene periods. The complex is one of the last extensive undeveloped barrier islands on the eastern coast of Florida. The lagoon's location, combined with its large size and other physical characteristics, make it one of the most diverse estuaries in North America. As a result, a wide array of habitats exist on the refuge, including the beach and dune system; estuarine waters; forested and non-forested wetlands; impounded wetlands; and upland shrublands and forests. These diverse habitats support more than 1,000 species of plants and more than 500 species of fish and wildlife, including a variety of waterfowl, shorebirds, and neotropical migratory birds, as well as 93 federal- and state-listed species. Ten federally listed threatened and endangered species regularly occur on the refuge. Merritt Island NWR was established on August 28, 1963, as the 286th refuge of the National Wildlife Refuge System. According to the agreement with NASA, the lands and waters of the Kennedy Space Center are primarily to serve the space program and secondarily to serve as a wildlife refuge or park (USFWS 2008i).

Threats from Sea Level Rise and Storm Surge

Due to elevation, topographic relief, and proximity of the refuge to the ocean, impacts on the refuge stemming from global warming and climate change may manifest themselves through rising sea levels, more intense tropical cyclones, higher storm surge, and increased tidal flooding.

The extent and nature of the refuge's impoundments and marshes could be altered and affect the flora and fauna that presently use these habitats.

Currently, the refuge beach and dune systems transition quickly into coastal scrub. Rapid changes in SLR may outpace the natural changes in beach and dune habitat succession. Beach and dune changes would likely negatively impact sea turtle nesting habitat and nesting success. Additionally, this would lower the beach dune profile that protects (shades) nesting and hatchling sea turtles from the disorienting effects of nighttime artificial lights from nearby NASA and Air Force launch pads. The West Indian manatee will likely be affected due to deterioration of water quality and clarity affecting seagrass beds that the manatee are dependent on for food within the Indian River Lagoon.

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Adaptation for Resilience

Recognizing the increasing maintenance and replacement costs for coastal roads in Florida due to more frequent flooding and storm surge, the Federal Highway Administration (FHWA) – Eastern Federal Lands Highway Division (EFL), assisted Merritt Island NWR replace a road that is frequently washed out. EFL replaced the road with innovative construction materials and techniques that would be cost-effective over the lifecycle of the road, compared to traditional roadway designs, and would help minimize impacts to the environment and wildlife in the event of a washout.

Black Point Wildlife Drive is an unpaved road approximately five miles long with swamps on both sides. Because it is a loop road, it also experiences storms from all angles. For this road, EFL and USFWS selected a four-inch thick cellular confinement system (CCS) base filled with limestone and covered with two inches of limestone. A cost analysis indicated that construction of the CCS filled with limestone was comparable or slightly cheaper than a traditional road base paved with asphalt. The new road has lasted for over seven years with no damage (Adaptation Clearinghouse 2020)

Archie Carr NWR

Archie Carr NWR is a fragmented, linear refuge located along a 20.5-mile (33-km) stretch of barrier island in southeast Florida. It includes beaches and dunes, maritime hammock, coastal scrub, mangrove swamps, and borders the most diverse estuary in the U.S. as well as rare, nearshore sabellariid reefs. The refuge partnership contains 45 archaeological sites (including 39

Ais Indian shell middens, four burial mounds, and two historic sites). There are also 12 submerged shipwreck sites in the nearshore waters of the Atlantic Ocean adjacent to the refuge.

While sea turtles are threatened with extinction throughout the world, the Archie Carr NWR hosts the largest nesting population of loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles in the U.S., with a quarter of all loggerhead sea turtle nests and a third of all green sea turtle nests. Loggerheads at the refuge annually produce between 8,000 to 21,000 nests (averaging 400-1,000 nests per mile/1.6 km). Green sea turtles at the refuge annually produce between 100 to 4,000 nests and leatherback sea turtles (*Dermochelys coriacea*) annually produce between 1 to 70 nests. Peak nesting totals for green sea turtles have increased over 600% since 1990. Peak nesting totals for leatherbacks have increased over 900% since 1990. Both greens and leatherbacks reached all-time highs in 2007, with over 4,460 green turtle nests and 74 leatherback nests. After 1990, loggerhead nesting totals increased until 1998, but have since decreased, reaching an all-time low in 2007 with 7,905 nests. Overall, loggerhead nesting totals have decreased by 50%. The Archie Carr NWR rivals the beaches of Masirah Island at the Sultanate of Oman as the most important loggerhead nesting beach in the world. About 90% of the world's loggerhead population nests in Florida and Oman. Further, the refuge provides connectivity to the Indian River Lagoon and Pelican Island NWR, which provide very important foraging habitat for juvenile sea turtles (USFWS 2008j).

Threats from Sea Level Rise and Storm Surge

The effects of climate change on Florida barrier islands include SLR, more intense tropical cyclones, higher storm surge, and increased tidal flooding (Church and Gregory 2001; Emanuel 1987; Emanuel 2005; Webster et al. 2005; Mann and Emanuel 2006; Holland and Webster 2007; IPCC 2007), all of which are likely to further erode refuge beaches and dunes. Beach and dune erosion are likely to reduce the amount of habitat available for Southeastern beach mice as well as sea turtle and shore bird nesting, especially in areas where shorelines are developed.

Mangrove swamps are predicted to migrate inland (Doyle 1998), replacing habitats further inland. The availability of fresh water and nutrients influences the location, size, structure, and productivity of mangrove communities on the refuge. Mangrove distribution can be limited if; 1) the rate of SLR exceeds the rate of mangrove forest growth and substrate accretion, 2) the landward slopes provide no suitable habitat for forest retreat (Wanless 1998), and 3) areas with seawalls behind mangrove habitat prevent such shoreline adjustment.

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Pelican Island NWR

On October 23, 1970 under Public Law 91-504, the 5.5-acre Pelican Island became one of the smallest wilderness areas in the National Wilderness Preservation System. All management activities occurring within the original 5.5-acre wilderness boundary must meet the standards and criteria set forth in the Wilderness Act. Currently, about 3.3 acres of the wilderness area are submerged due to the erosion of Pelican Island proper. Currently over 5,400 acres, Pelican Island NWR was established in 1903 on 5.5 acres "as a preserve and breeding ground for native birds" through an unnumbered Executive Order and expanded in 1909 by Executive Order 1014.

Part of the South Florida Ecosystem, Pelican Island NWR is located within the southern Indian River Lagoon. The Indian River Lagoon is located along a transition zone between the warm-temperate climate to the north and a more subtropical climate to the south. The Lagoon's location, combined with its large size and other physical characteristics, make it the most diverse estuary in North America.

Nathaniel P. Reed Hobe Sound NWR

The Hobe Sound NWR sits as an oasis of pre-contact Florida ecology bisecting the burgeoning urban growth centers to the north and south of the cities of Jacksonville and Miami, respectively. Part of the refuge is situated atop ancient sand dunes that reflect the cycles of deposition and erosion in response to sea-level changes during the last 65 million years. These dunes and their associated lagoons served as important ecological environments that provided subsistence to tribal groups living here prior to European colonization and American settlement. Early in the 20th century, the rush to develop Florida resulted in a great loss of native habitats. However, this refuge's very existence was borne out of the vision of conservation-minded residents who conveyed lands to the Service in an effort to preserve and protect such rare and threatened species as mermaid-like manatees; chattering scrub jays; and lumbering, gargantuan leatherback sea turtles. In an effort to protect the ecosystems at Hobe Sound, one of those settlers, Joseph V. Reed, established the Reed Wilderness Seashore Sanctuary in 1967, a registered national landmark. This sanctuary is located at the north end of what is now Hobe Sound NWR. The refuge is located not far from Pelican Island, the birthplace of the National Wildlife Refuge System, where 100 years ago, President Theodore Roosevelt in essence made a promise to the American people to set aside a network of lands and waters for wildlife (USFWS 2007a).

<u>Threats from Sea Level Rise and Storm Surge</u>

The refuge contains a significant acreage of coastal strand and tidal swamp habitats. These habitats will be, and probably already are, affected by ongoing sea-level rise. Predicted rises, based on the research of the Intergovernmental Panel on Climate Change in 2007, suggest that a 5 cm sea-level rise in 50 years would exact consequences for the resources, purposes, and objectives of this refuge that would elevate issues, such as boat wakes, to an even greater significance.

Significant land acquisition should be considered within the context of sea-level rise. Land prices in this area are significant and will continue to increase. From the standpoint of strategic growth, this highlights the need to consider the threat posed by sea-level rise to the long-term sustainability of the refuge and its purposes.

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Crocodile Lake NWR

Crocodile Lake NWR is on upper Key Largo in Monroe County, Florida. The refuge was established in April 1980 under the authorities of the Endangered Species Act (ESA) of 1973 (as amended), and the Land and Water Conservation Fund Act of 1965 (as amended in 1976). It currently covers 6,700 acres, including 650 acres of open water. It contains a mosaic of habitat types, including tropical hardwood hammock, mangrove forest, and salt marsh. These habitats are vital for hundreds of plants and animals, including six federally listed species.

Crocodile Lake Refuge is unusual in that not all of the critical habitat areas are in a pristine, undisturbed condition. A large portion of the refuge was slated to become a residential development, complete with canals for boating access. The organic peat dredge-spoil from the canal system was piled up in berms on the banks of the canals and became an important nesting area for the federally listed American crocodile. In the U.S., crocodiles are only found in South Florida and the Florida Keys.

The refuge protects one of the largest remaining tracts of tropical hardwood hammock, which is a globally threatened habitat type. These diverse forests are home to hundreds of plants and animals, including the federally listed Key Largo woodrat, Key Largo cotton mouse, Schaus swallowtail butterfly, Stock Island tree snail, and eastern indigo snake. These species require hammocks in order to survive. Unfortunately, most of the hammocks in Key Largo have been eliminated by development, which has led to considerable population declines in these already imperiled species (USFWS 2006d).

<u>Threats from Sea Level Rise and Storm Surge</u>

Sea levels have fluctuated over time and the landmass of south Florida has been both exposed and submerged by water. Approximately 120,000 years ago, sea levels dropped close to the present level exposing the coral and allowing for formation of the islands of the Florida Keys. The ancient coral reefs were very large as evidenced by Key Largo limestone, which is up to 145 feet thick in some areas of the upper Keys. Some natural erosion has been exacerbated by human use and boat wakes, particularly on backcountry islands. SLR and increased tropical cyclone intensity will eventually affect wetlands and mangrove forests with higher storm surge and increased tidal flooding.

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Adaptation for Resilience

The Refuge has enlisted numerous volunteers to help with eroding crocodile nesting habitat due to coastal SLR and storm surge. Volunteers assisted with replenishing the nesting habitat from a barge using canoes (Tampa Bay Times 2019). Volunteers are one of the most important adaptation management measures that a refuge has.

National Key Deer NWR

National Key Deer NWR was established on August 22, 1957 to protect and conserve Key deer and other wildlife resources. It comprises 84,834 acres with nearly 8,983 acres of land on several islands within the approved acquisition boundary, as well as additional parcels located outside the boundary administered by the refuge. These lands host diverse habitats, most notably globally endangered tropical hardwood hammocks and pine rocklands. The refuge provides habitat for hundreds of endemic and migratory species, including 21 federally listed species, such as Key deer, Lower Keys marsh rabbit, and silver rice rat. It contains a variety of plants endemic to the Florida Keys.

When the refuge was established, the Key deer was nearing extinction. Less than 50 deer remained as a result of uncontrolled hunting. Establishment of the refuge, along with habitat acquisition and law enforcement efforts, has allowed the deer population to increase and stabilize. Today, there are about 600 Key deer located on Big Pine and No Name Keys, with around 100 more located on surrounding islands. Key deer continue to be classified as endangered because the population is isolated and confined to a small geographic area, which could allow a disease outbreak or hurricane to wipe out the entire species.

The refuge is an important stopping point for thousands of migrating birds each year and an important wintering ground for many North American bird species. Notable species include the piping plover and the peregrine falcon. The mosaic of upland and wetland habitats found in the Florida Keys is critical breeding and feeding ground for birds, and refuge land acquisition efforts strive to add to the lands already protected.

Loggerhead, green, and hawksbill turtles forage in the waters surrounding National Key Deer NWR, but nesting is limited to refuge lands on Ohio Key, where a small number of loggerhead turtle nests occur annually. Data are lacking on the frequency of Kemp's ridley turtles in this refuge, but this rare species is likely a sporadic visitor (USFWS 2009b).

Threats from Sea Level Rise and Storm Surge

Low-lying islands, such as the Florida Keys, will face the most direct and dramatic impacts of climate change, particularly from rising seas, intensity of tropical cyclones, higher storm surge, and increased tidal flooding. Effects have already been experienced in the Keys refuges. For example, widespread mortality of slash pine trees resulted from saltwater inundation due to Hurricane Wilma's storm surge in 2005. Also, there have been shifts in plant community composition along the coastal fringe due to higher spring tides and from an incremental SLR over the past hundred years. Salt intrusion into the subsurface freshwater lens from this historic SLR has reduced the extent of pine rockland and freshwater wetlands on Sugarloaf Key, resulting in more salt-tolerant plant communities (Ross et al. 1994). Storm events also cause considerable physical damage to beach berms and native vegetation along vulnerable shorelines, impacting nesting habitat for sea turtles and shorebirds. Rising sea levels will continue to decrease the availability and abundance of prey for wading birds that forage in shallow waters on the expansive tidal flats of the backcountry. Climate change is expected to amplify and hasten these effects, potentially at rates that exceed the normal resiliency of plant communities to recover, shift, or adapt accordingly (Stanton and Ackerman 2007, Clough 2008a).

Due to newer information and analyses in 2017, National Oceanic and Atmospheric Administration (NOAA) and U.S. Geological Services (USGS) scientifically revised SLR projections from 2013 by IPCC (IPCC 2013). Revisions included recent observational and modeling literature related to the potential for rapid ice melt in Greenland and Antarctica along with other regional processes (NOAA 2017). Regional downscaling methods are used to provide climate information at the smaller scales and there is high confidence that downscaling adds value both in regions with highly variable topography and for various small-scale phenomena (IPCC 2013), such as islands and keys.

The latest NOAA report (NOAA 2019) discusses the impacts from tidal flooding and increasing high tides, which are a high risk factor for habitat and freshwater pools on the Florida Keys. Combining a tide and/or tidal flooding elevation with SLR projections causes impacts to root zones, the freshwater lens, and upland vegetation communities much earlier in time. Inundation and pre-inundation impacts to the Florida Keys actually happens 10-20 years sooner depending on the scenario (Miller 2019).

The South Florida Ecological Services Office (SFESO) requested SLAMM be run by Stetson University in February 2018 to visualize and compare impacts of the various SLR scenarios on habitat and land use within the Lower Keys. Modeling results provide projected land cover conditions with 1 ft., 2 ft., 3 ft., and 4 ft. of SLR (SLAMM 2018). With 3 ft. of SLR by years 2050-2070, Big Pine Key has 601 acres (7%) of undeveloped dry land remaining while mangroves increase to 3,859 acres or 43% of the island.

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endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

Great White Heron NWR

Great White Heron NWR was established in 1938, by Executive Order 7993 signed by President Roosevelt, as a haven for great white herons, migratory birds, and other wildlife. The refuge encompasses 117,720 acres of land and water with 6,300 acres of land, of which 1,900 acres of land were designated Wilderness in 1975 under Public Law 93-632. While the islands are primarily mangroves, some of the larger islands contain pine rockland and tropical hardwood hammock habitats. This vast area, known locally as the "backcountry," provides critical nesting, feeding, and resting areas for more than 250 species of birds. As noted above, the Service co-manages the open water and submerged lands owned by the State of Florida through a Management Agreement.

Great white heron nesting is restricted to extreme south Florida, including the Florida Keys. The refuge was created to protect great white herons from extinction since the population was decimated by the demand for feathered hats. Protection of great white herons was successful, and these magnificent birds can be observed feeding on tidal flats throughout the refuge. The refuge islands are also used for nesting by 10 wading bird species, including the reddish egret and many neotropical migratory bird species.

Three species of sea turtles rely on the backcountry for feeding and nesting. Green and loggerhead sea turtles successfully nest in the refuge. Hawksbill sea turtles are known to feed in seagrass beds throughout the refuge, but nesting has not been observed. Data are lacking on the frequency of Kemp's ridley turtles in the Great White Heron NWR, but this rare species is likely a sporadic visitor (USFWS 2009b).

Key West NWR

Key West NWR is among the first refuges established in the United States. President Theodore Roosevelt created the refuge in 1908 as a preserve and breeding ground for colonial nesting birds and other wildlife, during the period when widespread plume hunting was devastating bird populations throughout Florida. Key West NWR is west of Key West, Florida, and accessible only by boat. Key West NWR consists of the Marquesas Keys and 13 other keys distributed across over 375 square miles of open water. The refuge encompasses 208,308 acres of land and water, with only 1 percent (2,019 acres) being land. Most islands are dominated by mangrove plant communities. Exceptions are the hardwood hammock in the Marquesas Keys and the beaches and dunes there and on Boca Grande and Woman Keys. All islands lack freshwater and native, terrestrial mammals are absent.

Key West NWR provides habitat and protection for federally listed species, including piping plover and roseate terns. The refuge harbors the largest wintering population of piping plovers and the largest colony of white-crowned pigeons in the Florida Keys. It is a haven for over 250 species of birds, including 10 wading bird species that nest in the refuge. Other notable imperiled

species include the Miami blue butterfly and sea turtles. Waters within the refuge's administrative boundaries are important developmental habitat for green, loggerhead, and hawksbill turtles. More loggerhead and green sea turtle nests are found each year in Key West NWR than any area of the Florida Keys except for the Dry Tortugas (USFWS 2009b).

Threats from Sea Level Rise and Storm Surge

In an effort to address the potential effects of SLR on Key West NWR, the Service contracted the application of the SLAMM model. SLAMM simulations predict Key West NWR will be severely impacted under all the SLR scenarios tested. Tidal flats compose 17% of Key West NWR. Tidal flats are predicted to be completely inundated by 2100 under every SLR scenario examined. Mangroves are the second-most common land cover type in the refuge and at 1 meter of SLR by 2100, a level that some scientists consider to be the "most likely" scenario", 99% of the refuge mangroves are predicted to be lost. In addition, all of the irregularly flooded marsh appears resilient to the mean scenario but nearly 75% is predicted to be lost by 2100 under the max scenario (0.69 m SLR by 2100). At SLR rates of 1 m, the entire refuge is predicted to convert to open water (Clough 2011).

Coastal National Wildlife Refuges protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

Adaptation for Resilience

In 2017, a group of stakeholders met in the Florida Keys to discuss incorporating climate change considerations into conservation planning and actions for 98 threatened and endangered species and their habitats in the Florida Keys. Participants discussed challenges in carrying out adaptation based upon their agency structures and policies. This discussion revealed that many of the participants felt that their current agency structure doesn't allow for proper implementation of adaptation strategies. The main issues identified by participants were inflexibility in both planning structures, and upper management. Another major issue identified by participants was funding for adaptation. One participant noted that the current funding streams that are available for adaptive management are one-time funds tied directly to specific goals and objectives; however, effective adaptive management requires flexibility to adjust strategies should needs arise. This pointed out the weakness in the request for proposals process and the inability to integrate adaptive management into these processes. This discussion highlighted needed changes to policy and proposed new methodologies (Benedict 2018).

Ten Thousand Islands NWR

The Ten Thousand Islands NWR was established under the provisions of the "Arizona-Florida Land Exchange Act of 1988," authorized by Public Law 100-696. The Act authorized the Department of the Interior to convey 68 acres of the Department of the Interior Indian School property in Phoenix, Arizona, to Collier interests in exchange for 108,000 acres in Collier County, Florida. In addition, the Department received $34.9 million to establish Indian education trust funds. Approximately 35,000 acres were conveyed to Service to establish Ten Thousand Islands NWR.

The refuge provides habitat for a wide range of invertebrates, fishes, amphibians, reptiles, birds, and mammals. The refuge provides important habitat for several notable threatened and endangered species, including the Atlantic loggerhead, Green, Kemp's ridley, and Hawksbill sea turtles, American crocodile, wood stork, bald eagle, and West Indian manatee. More than 189 species of birds, 196 species of fish, 45 species of reptiles and amphibians, and 22 species of mammals use the refuge. The refuge also plays an important role in the restoration of the South Florida Ecosystem. Lands and waters of the ecosystem have been critically altered due to environmental and economic impacts of urbanization, agriculture, and other human activities. Also important are the recreational uses of the refuge. The public uses the mangrove ecosystem and greater area of the refuge in a variety of pursuits, including sportfishing, birdwatching, camping, boating, and enjoying the aesthetics of the area (USFWS 2000a).

J.N. "Ding" Darling NWR

J.N. "Ding" Darling NWR is located along the southwest coast of Florida in Lee County, approximately 15 miles southwest of Fort Myers, on the subtropical barrier island of Sanibel in the Gulf of Mexico. Currently, most of the island's private lands (ca. 60 percent of the Island) are developed with single- and multiple-level single- and multi-family housing and low-density commercial establishments. The refuge is part of the largest undeveloped mangrove ecosystem in the United States and is world famous for its spectacular wading bird populations.

The refuge's boundary covers approximately 6,406.79 acres (2,592.74 ha) of estuarine habitats, including tropical hardwood forests, beaches, mangrove swamps, impoundments, mixed wetland shrubs and interior wetlands, and open waters and seagrass beds. Approximately 41 percent or 2,619 acres (1,160 ha) of the refuge is designated as a wilderness area (Figure 3). Approximately 272 species of birds (including accidentals), 60 species of reptiles and amphibians (including exotic species), 102 fish species (including exotic species), and 33 species of mammals (including exotic species) have been identified on or within the vicinity of the refuge (USFWS 2010b).

Threats from Sea Level Rise and Storm Surge

In 2006, the SLAMM was run for the refuge. This modeling effort predicted that the refuge would transition to predominantly mangroves and open estuarine waters with limited uplands by 2100 (McMahon 2006). By 2100, total or near losses were modeled for ocean beach, tidal flats, and estuarine beach habitats of the refuge. Substantial losses were modeled for the refuge's inland open water and inland fresh marsh. Losses between 43 percent and 67 percent were modeled for salt marsh, hardwood swamps, and dry land on the refuge (McMahon 2006). Refuge

mangroves are expected to increase by 75 percent and open estuarine waters by 119 percent (McMahon 2006).

Coastal National Wildlife Refuges protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

Adaptation for Resilience

Scientists at the Refuge are conducting research and monitoring of threatened and endangering species, like the rice rats and the mangrove ecosystem to identify changes caused by SLR and whether species are adapting to the changes. Research is in collaboration with the U.S. Geological Survey (USGS). The refuge has installed surface evaluation tables to measure the effect of mangroves on wetland elevation due to SLR. USGS will continue to test the soil and peat under the mangroves to determine carbon storage rates, economic values, ecosystem services, and future distribution and abundance of mangroves (USFWS 2016).

Pine Island NWR

The Pine Island NWR was established by President Theodore Roosevelt through Executive Order 939 in 1908 upon the recommendation of T. Gilbert Pearsonof the National Audubon Society, to protect thousands of herons, egrets, and pelicans that were being hunted to support the plume trade in the early 1900s. The refuge is surrounded by the Pine Island Sound State Aquatic Preserve. The over 600-acre refuge includes 18 islands and consists of densely forested red and black mangroves with little uplands habitat. Several of the islands are important nesting and roosting areas for colonial waterbirds, including the brown pelican, great egret, snowy egret, reddish egrets, great blue heron, little blue heron, tricolored heron, double-crested cormorant and anhinga. Dolphins and manatees can be seen in the surrounding waters as well as loggerhead, green, and kemp's ridley sea turtles.

Island Bay NWR

The Island Bay NWR was established as a ". . . preserve and breeding ground for native birds" on October 23, 1908, through Executive Order 958 signed by President Theodore Roosevelt. Upon the recommendation of T. Gilbert Pearson of the National Audubon Society, Island Bay NWR was protected by Audubon warden Columbus McLeod before he was presumed murdered

in the line of duty, later that same year. On October 23, 1970, President Richard Nixon signed Public Law 91-504 establishing the refuge as a Wilderness Area.

Located in a vast complex of mangrove islands and brackish waters, the refuge consists of six undeveloped, roadless tracts of land totaling 20 acres occupying the higher portions of several islands and their mangrove shorelines. The refuge islands include Gallagher Key, Bull Key, and two unnamed keys located between Bull and Turtle Bays. Two other tracts, the Cash and John Quiet Mounds, are located on the edge of Turtle Bay reaching heights of 10-20 feet above sea level. These sites are dominated by large mounds built by Calusa Indians who inhabited the coastal area of South Florida hundreds of years ago. Today, beaches and shores of the refuge provide loafing and feeding sites for shorebirds, gulls, and terns. The surrounding shallow bays provide valuable feeding areas for wading and water birds. Other vertebrates known to use the refuge or surrounding waters include raccoons, marsh rabbits, manatees, and sea turtles.

Matlacha Pass NWR

Matlacha Pass NWR was established on September 26, 1908 and consists of three small islands. The refuge was established as a "...preserve and breeding ground for native birds" by president Theodore Roosevelt through Executive order 943 upon the recommendation of T Gilbert Pearson of the National Audubon Society.

Since then, the refuge has grown to 31 islands encompassing over 500 acres. The islands contain two basic vegetative zones, upland sand ridges and mangroves. Several islands of the Matlacha Pass NWR are used as roosting and nesting sites for a variety of colonial waterbirds including the brown pelican, great egret, snowy egret, reddish egrets, great blue heron, little blue heron, tricolored heron, double crested cormorant and anhinga. The beaches and shores provide loafing, feeding, and nesting areas for migratory ducks, shorebirds, gulls, and terns. Ospreys and bald eagles can be observed nesting and feeding in Matlacha Pass NWR. Several endangered and threatened species benefit from the habitats described including: wood storks, sea turtles, and manatees.

Caloosahatchee NWR

Caloosahatchee NWR was established by President Woodrow Wilson on July 1, 1920, through Executive Order 3299 as a ". . . preserve and breeding ground for native birds" upon the recommendation of Thomas and Mina Edison. Originally, the Caloosahatchee NWR consisted of several mangrove islands. However, shoreline development, dredging of the river, and construction of the I-75 bridge has changed the physical arrangement and appearance of these islands. Today, the refuge still remains approximately 40 acres of mangrove shorelines and upland island habitats. The refuge is located adjacent to the Florida Power and Light Company's Orange River Power Plant and the Orange River's outflow. The warm water outflow from the power plant is a major wintering area for the endangered West Indian manatee.

Egmont Key NWR

Egmont Key NWR is located at the mouth of Tampa Bay, along the Gulf Coast of Florida in Hillsborough County. In 1974, the 392-acre refuge was established to protect the Key's significant natural, historical, and cultural resources from the impending threats of development. Egmont Key is the only refuge island open to the public in Tampa Bay and has been traditionally visited for many years as a primary recreation destination. The refuge is open only during daylight hours. The island receives about 130,000-170,000 visitors annually that access the island by private or tour boat (USFWS 2004; and Kleen and Hunter 2006).

Specifically, Egmont Key NWR seeks to provide nesting habitat for brown pelicans and other waterbirds, as well as to conserve and protect barrier island habitat and preserve historical structures of national significance. Presently, the island's approximately 244 acres of beach and coastal berm supports more than 110 species of nesting, migrating, and wintering birds. Thousands of laughing gulls and royal terns, hundreds of brown pelicans and sandwich terns, dozens of black skimmers and least terns, and a handful of American oystercatchers, nest annually. Egmont Key provides valuable wildlife habitat in the very populated Tampa Bay area. The island is listed as critical habitat for endangered piping plovers and provides habitat and protection for endangered manatees and sea turtles. Approximately 20-70 endangered Atlantic loggerhead turtles nest annually. Egmont has an unusually high population of gopher tortoises and box turtles (USFWS 2010c). Two wildlife sanctuaries, one on the east side of the island and one at the south end of the island, comprise about 97 acres and are closed to all public use, year-round (Kleen and Hunter, June 2006).

Pinellas NWR

Pinellas NWR is located at the mouth of Tampa Bay, along the Gulf Coast of Florida, in Pinellas County. The refuge was established in 1951 as a breeding ground for colonial bird species. It contains seven mangrove islands encompassing about 394 acres, with only Indian Key within the city limits of St. Petersburg. The refuge is comprised of Little Bird, Mule, Jackass, Listen, and Whale Island Keys and leases Tarpon and Indian Keys from Pinellas County. A Pinellas County seagrass sanctuary is located around Tarpon and Indian Keys and the use of internal combustion engines within this zone is prohibited to protect seagrass beds. Hundreds of brown pelicans and double crested cormorants and dozens of herons, egrets, and roseate spoonbills nest within Tarpon and Little Bird Keys. Pinellas Key provides important mangrove habitat for most long-legged wading species, especially for reddish egrets (USFWS 2010c). All of the mangrove islands of Pinellas NWR are closed to public use year-round to protect migratory birds (Kleen and Hunter, USFWS, June 2006).

Passage Key NWR

Passage Key NWR is located at the entrance to Tampa Bay in Manatee County, along the Gulf Coast of Florida, just north of Bradenton, Florida. When Passage Key was originally designated as a federal bird reservation by President Roosevelt in 1905, it was a 60- acre island with a freshwater lake and lush vegetation. Unfortunately, erosion and hurricanes have virtually destroyed the key. It is now a meandering sand bar, varying is size from 0.5 to 10 acres, depending on weather (USFWS 2004). In 1970, Passage Key NWR was designated a Wilderness

Area, and because of its fragility and small size it is now closed to all public use. The refuge's objectives are to provide habitat for colonial waterbirds. Hundreds of brown pelicans, laughing gulls, black skimmers, and royal terns nested annually until the island was washed away in 2007. Small numbers of herons and egrets also nested on the island. The key once hosted the largest royal tern and sandwich tern nesting colonies in the state of Florida. Passage Key NWR is closed to public use year-round to protect migratory birds that use the island (USFWS 2010c).

Chassahowitzka NWR

Chassahowitzka NWR is in Citrus and Hernando Counties along Florida's north-central west coast. Chassahowitzka NWR was established on December 29, 1941, with the acquisition of 2,742 acres in Hernando County. Presently, the refuge includes 30,842 acres of primarily black needlerush (*Juncus maritima*) salt marsh habitat within a 36,865-acre acquisition boundary. The refuge protects saltwater bays, estuaries, brackish marshes, and hardwood swamps in Homosassa, FL. In 1970, the refuge lands within Citrus County were designated Wilderness. Today, this refuge provides habitat for one federally threatened species, the West Indian manatee (USFWS 2012a).

Crystal River NWR

Established in 1983, Crystal River NWR is the only refuge created specifically for the protection of the threatened Florida Manatee, a subspecies of the West Indian Manatee. This unique refuge preserves the last unspoiled and undeveloped spring habitat in Kings Bay, which forms the headwaters of the Crystal River. The refuge preserves the most important aquifer fed spring havens in Kings Bay (King Spring and Three Sisters Springs), which provide critical habitat for the manatee populations that migrate here each winter (USFWS 2017d).

Lower Suwannee NWR

Located along the southern edge of the Big Bend Region of Florida's west coast, the Lower Suwannee NWR is found in the westernmost part of Levy County and the southern tip of Dixie County. The refuge is approximately 50 miles southwest of Gainesville, Florida.

Lower Suwannee NWR was established on April 10, 1979, under the authority of the Fish and Wildlife Act to protect the lower Suwannee River ecosystem. The initial acquisition in 1979 was 5,300 acres of land at Shired Island. Additional parcels of land were acquired over a 15-year period, until the refuge reached its present size of 52,935 acres. The refuge, which is predominantly wetlands, is bisected by 20 miles of Stephen Foster's famous Suwannee River and includes more than 20 miles of coastal marsh along the Gulf coast. The refuge also encompasses an unusual diversity of floodplain hardwoods; cypress-lined sloughs; cabbage palm and cedar islands; cypress domes; hydric, mesic, and xeric hardwood hammocks; and low pine flatwoods. Each of these diverse vegetative communities contributes to making Lower Suwannee NWR, one of the largest undeveloped river delta-estuarine systems in the United States.

Lower Suwannee NWR was established to protect, maintain, enhance, and where appropriate, restore habitats along the lower reaches of the Suwannee River. The refuge also protects water

quality and quantity through sound land resource management and cooperative relationships with state agencies that have jurisdictional authority over the water and aquatic resources therein. Further, the refuge provides habitat for several threatened and endangered species and species of special concern in the State of Florida (USFWS 2000b).

Cedar Keys NWR

Cedar Keys NWR is located along the western coast of Florida, approximately 90 air miles north-northwest of Tampa and 60 miles southwest of Gainesville. Located in Levy County along the southern edge of the Big Bend Region, the 13 islands that make up the refuge surround the coastal town of Cedar Key, Florida, where State Road 24 terminates at the Gulf of Mexico.

Cedar Keys NWR was established to protect colonial birds during a time when market hunters, desiring feathers for the ladies apparel industry, were slaughtering millions of birds. Today, the threat is much different - coastal islands are being rapidly developed and habitat is lost forever. Seahorse Key has been designated critical habitat for colonial wading birds. Historically, up to 200,000 birds nested on Snake and Seahorse Keys. Recent data show approximately 10,000 white ibis; great, cattle, and snowy egrets; great blue, little blue, black-crowned night, yellow-crowned night, and tri-colored herons; cormorants; and brown pelicans nest on Seahorse Key annually. Snake Key has not been used for nesting since the late 1960s.

Cedar Keys NWR includes important coastal barrier island habitat with maritime forests, salt marsh, and the northern most limit of mangrove swamps. About 50 percent of Florida's salt marsh and more than 3,000 square kilometers of seagrass beds occur in the Big Bend Region, providing habitat for migratory birds, anadromous and interjurisdictional fish, and threatened and endangered species. The blend of these estuary and riverine habitats creates a large, complex system which exhibits how watersheds function.

Adaptation for Resilience

In 2014, the University of Florida (UF) and its Sea Grant program undertook an exercise called “Planning for Coastal Changes in Levy County” that estimated how sea level rise would impact Cedar Key — which areas may stay high and dry and which will face inundation.

The study showed tidal gauge measurements from 1913 to 2016. The mean sea level trend was a rise of about 7 inches from 1914 to 2016. The rise is accelerating — the Cedar Key gauge showed a 5 percent increase from 2006 to 2013. The UF project included many community events to both explain the project and get thoughts, suggestions and perspective from Levy County residents (USA Today 2017).

St. Marks NWR

St. Marks NWR is located in Wakulla, Jefferson, and Taylor Counties along the Gulf Coast of northwest Florida, about 25 miles south of Tallahassee (Figure 2). It currently covers about 69,155 acres with an approved acquisition boundary of 74,469 acres. The refuge staff also manages 947 acres of state land and 334 acres of USDA Forest Service land within the approved acquisition boundary.

On October 31, 1931, during the time of the Great Depression, Executive Order 5740 established the St. Marks Migratory Bird Refuge under the U.S. Department of Agriculture, Bureau of Biological Survey. The first land set aside under the Migratory Bird Conservation Act and the Six Million Dollar Fund was the 53-acre Lighthouse Reservation. This is an area of salt marshes and grass flats at the mouth of the St. Marks River, adjacent to Apalachee Bay. At the time, it was important for migrating Canada geese. On December 24, 1931, President Herbert C. Hoover signed Presidential Proclamation 1982, which established an Executive Closure Area under the authorities of the Migratory Bird Treaty Act of 1918, and the Migratory Bird Conservation Act of 1929. This prohibited hunting of migratory waterfowl in Apalachee Bay between the St. Marks Lighthouse and the Aucilla River, as well as on private lands bordering the coastal marshes. These inland timber lands were primarily purchased from Phillips Turpentine Company in subsequent years and became the nucleus of what is now the St. Marks Unit of the refuge.

The primary purpose of the refuge is wildlife habitat conservation. Unlike many present-day islands of conservation in the Southeast, the refuge is embedded within a matrix of over 1.46 million acres of nearly contiguous public lands on 55 properties (Figure 5 and Table 1). This does not include 106,046 acres of submerged lands within the Apalachicola National Estuarine Research Reserve and 945,412 acres of submerged lands in the Big Bend Seagrasses Aquatic Preserve. As shown in Table 2, much of the remaining privately owned land in the region is intensively managed industrial forest land, possessing both major conservation potential and the threat of future development (USFWS 2006e).

St. Vincent NWR

St. Vincent NWR is in Franklin and Gulf Counties along the Gulf Coast of northwest Florida, approximately 60 miles from Panama City and 80 miles from Tallahassee. The approved acquisition boundary for the refuge is approximately 13,736 acres. The refuge owns, in fee-title, approximately 12,490 acres, which make up its management boundary. The refuge staff also oversees 21 Farm Service Agency (FSA) easements (1,625 acres) in six counties. In 2005, the refuge merged with St. Marks NWR to create the North Florida National Wildlife Refuge Complex. The St. Vincent NWR office/visitor contact station is located in Apalachicola.

The 12,490-acre refuge management boundary includes two islands: St. Vincent Island (12,358 acres), Pig Island (46 acres), and a mainland tract (86 acres). The majority of refuge management activities occurs on St. Vincent Island located in Apalachicola Bay, in Franklin County, and is only accessible by boat. St. Vincent Island consists of 21 different habitat types, ranging from upland slash pine, sand pine, scrub, hardwood hammocks, cabbage palm flatwoods, beach dunes, grasslands, marsh, and open water. There are few developed areas on St. Vincent Island. Pig Island is a small, 46-acre, undeveloped, low-lying coastal island located in Gulf County, Florida. It is situated behind St. Joseph Peninsula, a Gulf-facing spit. A small embayment called Pig Island Bayou separates Pig Island from this peninsula on the south side and adjoins the surrounding St. Joseph Bay, a prolific estuary. The undeveloped island is part of the coastal lowland containing sparse coniferous forest, freshwater marsh, flat sand terrain, bars, and pits. The island and peninsula are part of a dynamic coastal system formed from the deltaic Apalachicola River system. The mainland tract known as the 14 Mile site is located south of County Road 30A in Franklin County. It has a small developed area where a radio tower and three volunteer campsites are located. The habitat types on the 14 Mile site range from pine

upland and oak hammocks, to estuarine marsh. Some refuge management activities occur on the 14 Mile site (USFWS 2012b).

Threats from Sea Level Rise and Storm Surge along Coastal Florida and Florida Keys

The climate, geology and topography, soils, air quality, and hydrology and water quality form the foundation of the physical environment of the coastal Florida refuges. Climate change related stressors such as more intense hurricanes, SLR, higher storm surge, and increased tidal flooding pose challenges for refuges and will likely enhance the negative impacts of other stressors.

Likely changes and stressors include alterations in wildlife populations and ranges, including alteration of the composition of plant community types and increased density and diversity of exotic and invasive species.

Sanibel Island, for example, is a coastal barrier island with gentle, low elevation topography that would be more likely to experience higher rates of coastline erosion. Rises in sea levels could shift marshes and beaches inland (Field et al. 2001), transitioning intertidal marshes into subtidal marshes (Galbraith et al. 2002) or open water. SLR would also increase saltwater intrusion resulting in the alteration of plant communities, particularly freshwater wetlands; and result in declines in mangrove and seagrass communities (Twilley et al. 2001).

With an increase in tropical cyclone intensity, higher storm surge, and increased tidal flooding, there would be temporary increases in sediments and organic material discharged to coastal waters (Twilley et al. 2001). These changes would also present conditions likely to increase the incidence of algal blooms and red tide events and increase the spread of exotic and invasive species (Ogden et al. 2005), and negatively change ecologically important diverse plant species (Browder et al. 2005). This would potentially increase the number of threatened and endangered species and further imperil those already at risk. The potential effects of changing climate on isolated refuges could be substantial because of the limited opportunities for natural species to migrate (Twilley et al. 2001).

Low-lying islands, such as the Florida Keys, will face impacts from rising sea levels, increased tropical cyclone intensities, higher storm surge, and increased tidal flooding. Such effects have already been experienced in the past; however, these events will likely become more frequent and severe based on projections by the Intergovernmental Panel on Climate Change (IPCC) (Intergovernmental Panel on Climate Change 2007).

Salt intrusion into the subsurface freshwater lens under the islands from SLR and saltwater inundation of surface freshwaters, such as solution holes, from storm surge can alter coastal ecosystems and freshwater marshes, resulting in more salt-tolerant aquatic plant communities.

Coastal National Wildlife Refuges protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic

events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

ALABAMA AND MISSISSIPPI

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

Bon Secour NWR

Bon Secour NWR is located on the Gulf Coast, 8 miles west of the city of Gulf Shores, Alabama, in Baldwin and Mobile counties. The planning study area is divided into five separate management units along the Fort Morgan Peninsula and Little Dauphin Island. Although the refuge was established in 1980, to date, only 6,978 acres have been acquired within the 12,570-acre acquisition boundary, including the 575 acres leased from the State of Alabama. The Service has management jurisdiction along the shoreline above mean high tide, except on the Little Dauphin Island Unit, which contains 560 acres of submerged bottoms managed by the Service. The potential wildlife habitat values of beach/dune, maritime forests, and estuarine habitats provided the impetus to purchase the properties for the refuge.

The refuge was established for the protection of neotropical migratory songbird habitat and threatened and endangered species. Bon Secour Refuge represents the best remaining stopover and staging habitat for neotropical migratory songbirds during the fall and spring migration along the Alabama coastline. The refuge also provides crucial habitat for beach nesting birds, such as snowy and Wilson's plovers, American oystercatchers, least terns and black skimmers; secretive marsh birds, such as rails; and migratory and wintering shorebirds on beaches, especially the federally threatened piping plover. A portion of the refuge's Fort Morgan unit and all of Little Dauphine Island are designated as critical habitat for the piping plover. Shorebirds use beaches and washover sites, which support high quality food sources during migration and winter.

The Refuge also protects the last remaining undisturbed beach mouse habitat found in Alabama, consisting of several key plant communities that form a mosaic of micro-habitats. Sea turtles have been documented to nest on the refuge beaches that support nest densities as high or higher (4.5-5.0 nests/mile). Hatching success has increased to 85 percent along the Alabama coast as a result of increased monitoring efforts and public support of conservation measures (USFWS 2005b).

Adaptation for Resilience

The addition of 470 acres to the Bon Secour National Wildlife Refuge along the Alabama Gulf Coast is a perfect example of how protecting habitat can make a difference in face of SLR. The diverse habitats of the refuge provide a home to several threatened and endangered species and serve as a key migratory stopover for more than 370 species of birds. This conservation success was made possible through a partnership between the USFWS, The Conservation Fund and the Alabama Department of Conservation and Natural Resources, and was supported by diverse stakeholders ranging from local, state and federal officials to conservation partners, including the National Wildlife Federation. The project not only laid down a foundation for restoring coastal

habitats but will also support the region's abiding economic development. Before The Conservation Fund purchased the 470 acres as an interim landowner, the land was slated for residential and commercial development. Now, the site is in public ownership and will provide long-term support for those who depend on the land and water economically, while finally securing wildlife habitats that were first identified as needing conservation when Bon Secour National Wildlife Refuge was first created in June 1980.

After the Deepwater Horizon oil spill in April 2010, several separate funding streams were created to restore and protect important habitats, including legal settlement funds used to establish the National Fish and Wildlife Foundation's (NFWF) Gulf Environmental Benefit Fund. This funding was critical to the Bon Secour National Wildlife Refuge conservation effort. A key tenet of the strategy for spending these Deepwater Horizon-related NFWF funds is to "*maintain the ecological functions of landscape-scale coastal habitats, including barrier islands, beaches and coastal marshes, and ensure their viability and resilience against existing and future threats, such as sea level rise".* (NWF 2019)

Grand Bay NWR

Grand Bay NWR is located in the coastal zone of Jackson County, Mississippi, and Mobile County, Alabama, approximately 10 miles east of Pascagoula, Mississippi, and about 20 miles west of Mobile, Alabama. It forms part of the Gulf Coast National Wildlife Refuge Complex, which also includes Mississippi Sandhill Crane NWR to the west and Bon Secour NWR to the east.

Habitats encompassed by the refuge include a riverine area on the west side containing a section of the Escatawpa River and a tributary, Black Creek; an area of coastal savanna in the central part of the refuge; and a large gopher tortoise colony at the northeast corner of the refuge.

Grand Bay NWR's cypress-tupelo swamps provide ideal habitat for wood ducks, other migratory birds, and resident wildlife species, including white-tailed deer and wild turkey. The refuge's salt flats, tidal creeks, and brackish marshes are used extensively by wading birds, shorebirds, and waterfowl; including mottled duck, a species of concern in both Alabama and Mississippi. About 20 percent of the coastal waterfowl in Alabama and Mississippi winter in this area, the most prevalent species being lesser scaup, redhead, ring-necked duck, mallard, and American wigeon.

Other species that use the refuge's estuarine habitats include bald eagles, peregrine falcons, clapper rails, black rails, Gulf salt marsh water snakes, and Mississippi diamondback terrapins. The fishery of the Escatawpa River system and its associated sloughs and lakes contain populations of species such as largemouth bass, bream, crappie, and catfish. Public fishing is popular along the river. More than 80 species of fish have been reported from the estuarine habitats of Grand Bay, including species such as Atlantic croaker, spot, menhaden, spotted sea trout, flounder, red drum, oysters, and several species of shrimp (USFWS 2005c).

Grand Bay NWR provides a wide variety of habitats for migratory species. The northern portion of the refuge is composed of palustrine forested habitat, with mixed hardwoods and slash/loblolly pine as the most prevalent species types. This habitat supports a broad variety of neotropical migratory birds, as well as several species of waterfowl.

Further south within the refuge, a palustrine emergent ecosystem becomes more common, with increasing shrubs and bottomland hardwood stands. At the true coastal interface, the habitat

transitions into a broad floodplain swamp ecosystem. The southernmost portions open to marine intertidal, estuarine subtidal, and estuarine intertidal emergents, and finally to palustrine unconsolidated shore. This portion supports various species of sandpipers, terns, and kites. Threatened and endangered species that occur at or may visit this refuge include the threatened gopher tortoise, the endangered red-cockaded woodpecker, and the endangered brown pelican.

Mississippi Sandhill Crane NWR

The sandhill crane (*Grus canadensis*) is a long-necked, grayish-brown bird that stands about four feet tall. It broadly resembles the great blue heron in size and shape but has a distinctive reddish crown and vocalizations often described as "loud and clattering" (USFWS 1991). Most of North America's sandhill cranes are also noted for their long migrations. The Mississippi sandhill crane (*Grus canadensis pulla*) is an endangered, nonmigratory subspecies of the sandhill crane.

Mississippi Sandhill Crane NWR was established in 1975 in Jackson County in southeastern Mississippi for the protection and recovery of this critically endangered bird and the restoration of its unique habitat, wet pine savanna (e.g., pitcher plant bogs). An estimated 95–97 percent of wet pine savanna habitat has been altered and the refuge plays a critical role as a representative remnant of this ecosystem. The Mississippi Sandhill Crane Refuge consists of three separate units totaling approximately 19,300 acres: Gautier, Ocean Springs, and Fontainebleau units. Each unit lies within the limited nesting range of the endangered Mississippi sandhill crane (GORP n.d.).

Resident sandhill cranes formed a continuous population in Georgia and Florida and discontinuous populations along the Gulf Coastal Plain of Texas, Louisiana, Mississippi, and Alabama. Mississippi sandhill cranes originally occurred in small separate colonies along the Gulf Coast of Louisiana, Mississippi, Alabama, and Florida. Nesting sandhill cranes were so abundant in the marshes and wet prairies of southwestern Louisiana that they were considered a serious pest (USFWS 1991). Now, in contrast, nonmigratory sandhill cranes nest only in Mississippi and Florida (USFWS 2007b).

Bogue Chitto NWR

On June 30, 1980, President Jimmy Carter signed Public Law 96-288 authorizing the 40,000-acre Bogue Chitto NWR in Washington and St. Tammany Parishes, Louisiana, and Pearl River County, Mississippi. Since that time, the Service has been acquiring bottomland hardwood habitat in the Pearl River Basin. On December 13, 1989, Congress authorized a boundary expansion for Bogue Chitto NWR that included an additional 8,400 acres of bottomland hardwoods in St. Tammany Parish. To date, 36,597 acres have been placed under refuge management. The refuge is still in an acquisition phase.

Established in 1980, Bogue Chitto NWR is one of eight refuges managed as part of the Southeast Louisiana National Wildlife Refuge Complex (Complex). The refuge headquarters is located about 9 miles northeast of Slidell, Louisiana. The 36,597-acre refuge is bisected by the Pearl River, with portions of the refuge located in St. Tammany and Washington Parishes in Louisiana and Pearl River County in Mississippi. On the Mississippi side of the river, the refuge is bounded by Old River Wildlife Management Area (15,400 acres) to the north and by the State of Louisiana's Pearl River Wildlife Management Area (35,031) to the south, thereby forming an

87,000-acre block of protected forested wetlands and adjacent uplands within the Pearl River Basin (USFWS 2011c).

Threats from Sea Level Rise and Storm Surge along Coastal Alabama and Mississippi

Tidal marshes are among the most susceptible ecosystems to climate change, especially accelerated SLR (SLR). The International Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) suggested that global sea level will increase by approximately 30 cm to 100 cm by 2100 (IPCC 2001). Rahmstorf (2007) suggests that this range may be too conservative and that the feasible range by 2100 could be 50 to 140 cm. Pfeffer et al. (2008) suggests that 200 cm by 2100 is at the upper end of plausible scenarios due to physical limitations on glaciological conditions. Rising sea level may result in tidal marsh submergence (Moorhead and Brinson 1995) and habitat migration as salt marshes transgress landward and replace tidal freshwater and irregularly flooded marsh (Park et al. 1993). In an effort to address the potential effects of SLR on the refuge, the Service contracted the application of SLAMM modeling.

Swamp lands are predicted by the model to be somewhat resilient at the refuges. Even under a scenario of one meter of SLR by 2100, only 33% of swamplands are predicted to be lost. The 1.5 meter scenario is more severe, though, resulting in a loss of 58%. The reason for this resiliency appears to be a combination of initial elevation and a lower historical rate of SLR than some other sites (Louisiana, for example). Dry land loss rates range from 11% (under 0.39 meters of SLR) to 35% (under 1.5 meters of SLR). (Clough 2009).

Brackish marsh is predicted to be more vulnerable than swamps. Under the lowest scenario of SLR, the loss of brackish marsh is only predicted to be 14%. However, increasing the SLR scenario to 1 meter by 2100 increases the predicted loss to 65%. Once SLR exceeds accretion rates for this category it is predicted to be completely lost. (Clough 2009).

Coastal National Wildlife Refuges protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

PUERTO RICO

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

The Caribbean Islands National Wildlife Refuge Complex supports and protects wildlife and ecosystems found nowhere else in the United States. Many of these species are endemic to the Commonwealth of Puerto Rico, the U.S. Virgin Islands, and Navassa. Presently encompassing nine existing national wildlife refuges, the Complex collectively supports significant recovery opportunities for a large number of federally listed threatened and endangered species. Particularly notable, the Complex presently supports, or could in the near future, as much potential to recover more threatened and endangered species than any other national wildlife refuge in the Southeast Region. Many migratory birds depend on habitat found within the Complex, including a large number of Service Birds of Conservation Concern. Particularly notable are (1) endemic species, (2) species spending part of the year in the Neotropics, and (3) species that have unique breeding site requirements, making them extremely vulnerable to decline (e.g., colonially nesting seabirds, waterfowl, marsh birds, and shorebirds). The Complex supports present and future opportunities to restore and manage several ecosystems that are highly endangered today, including: (1) Subtropical dry forest, (2) coral reefs, and (3) seagrass beds and adjacent beaches used by nesting threatened and endangered sea turtles. Within the U.S. Caribbean, the most important habitats for migrating shorebirds, and an increasing number of sites supporting emergent wetlands and mangroves, as well as nesting seabirds, are now under management and protection of national wildlife refuges.

Desecheo NWR

Desecheo NWR is an island of approximately 360 acres (146 hectares) in the Mona Passage off the west coast of Puerto Rico, approximately 13 miles (21 kilometers) west of Punta Higüero. Although it is a relatively small island, the terrain is mountainous and rugged. The highest point on the Island is 683 feet (208 meters) above sea level. The habitat on the island is predominantly semi-deciduous dry forest with areas of grassland. Because of the porosity of the soils and the steep topography, there is no permanent freshwater on Desecheo NWR. The introduction of nonnative species such as goats, monkeys, and rats, and human uses of the island have had a substantial impact on the habitat and wildlife of Desecheo NWR. Future management will focus on the restoration, protection, and conservation of the habitat and wildlife resources, including seabirds, other migratory birds, and endemic species and plant communities.

The significance of the seabird nesting on the island led to its designation as a preserve and breeding ground for these birds by President Taft in 1912. Although it was given the “preserve” status at that time, Desecheo was subsequently subjected to several human uses and disturbances that adversely affected both its habitat and wildlife.

In 1937, President Franklin D. Roosevelt transferred Desecheo to Puerto Rico to be managed as a forest and bird preserve. When the United States entered World War II, the island was transferred back to the United States Government for use as a bombing and gunnery range. It continued to be used as an aerial bombing and training ground until 1952. Between 1952 and 1964, Desecheo was used for survival training by the U.S. Air Force. In 1965, the island was

declared as surplus property by the U.S. military. In July 1966, management jurisdiction over Desecheo was acquired by the Department of Health, Education, and Welfare, and the island became a facility for raising a colony of rhesus macaques for research purposes. In December 1976, administration of Desecheo was transferred to the Service and it received the designation of a national wildlife refuge.

The official purpose of Desecheo NWR is derived from land acquisition documents, the authorities for national wildlife refuges, and the original designation of the island as a refuge and breeding ground for native birds. The act authorizing the transfer of real property for wildlife management or other purposes identifies lands that are of particular value in carrying out the national migratory bird management program, and Culebra was determined to be appropriate for transfer to the Service under that purpose (16 U.S.C. 667b). Among other mandates, the National Wildlife Refuge System Administration Act [16 U.S.C. 668dd(a)(2)] directs the Refuge System to conserve, manage, and restore fish, wildlife, and plant resources and their habitats for the benefit of present and future generations of Americans (USFWS 2012c).

Cabo Rojo NWR

Cabo Rojo NWR was established in 1974 when 587 acres of upland habitat were obtained from the Central Intelligence Agency (CIA). Actual protection and restoration of the area began in 1978, with the hiring of the first manager. In 1999, 1,269 acres of salt flats, mangrove fringes, and uplands were purchased from the Carrera family, bringing the total to 1,856 acres.

Cabo Rojo NWR, on the southwestern side of Puerto Rico, was established in 1974, when 587 acres of land were obtained from the CIA as an upland buffer for the Cabo Rojo Salt Flats (a potential Western Hemisphere Shorebird reserve) and as potential habitat for migratory birds. The 1,249-acre Cabo Rojo Salt Flats, previously under private ownership, were purchased and added to the refuge in1999 for a total of 1,836 acres. The salt flats are now managed under a special use permit with a private operator, who continues to manage water levels as part of a commercial salt-harvesting operation and in accordance with the needs of shorebirds (USFWS 2011d).

Laguna Cartagena NWR

In 1984, the U.S. Congress directed the Service to acquire and manage lands at Laguna Cartagena in order to rehabilitate the lagoon for resident and migratory water birds, and to provide for increased wildlife-dependent public use. After several years of negotiations, 773 acres were acquired by the Puerto Rico Land Administration, and on August 8, 1989, the Service signed a 50-year lease agreement, renewable for another 50 years, but with no fee title ownership. In 1996, an additional 270 acres were acquired with fee title transfer to the Service from the USDA Farm Service Agency. The refuge was established "…for the development, advancement, management, conservation, and protection of fish and wildlife resources…" 16 U.S.C. 742f (a) (4) and "…for the benefit of the Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant or condition of servitude…" 16 U.S.C. 742f (b) (1) (Fish and Wildlife Act of 1956).

The refuge is a freshwater, depressional wetland fed mainly by precipitation runoff (Graves 1991). Because the wetland is shaped like a shallow bowl, when pool levels are high more area is

covered by water and the excess flows over the lip of the bowl. When pool levels recede, the area the water occupies decreases, and water ceases flowing out of the bowl. The water that remains trapped occupies a surface area (the dead area) and a volume (the dead volume). The dead area at Laguna Cartagena NWR measures approximately 75-125 acres. It is part of what once was a much larger wetland system in the Lajas Valley that included Laguna de Guánica and the Anegado to the east. The distinct seasonality and variability of precipitation naturally resulted in a wide range of water levels throughout the year. Floodwaters could flow out relatively quickly, reducing the size of the pool from over 400 acres to its dead area in less than a month. This variability encouraged a mosaic of habitats, including open water in the center of the wetland, a fringe of patchy cattails, and a diverse assemblage of plant species requiring slightly drier soils occupying higher elevations. Subtropical dry forest historically surrounded the wetland (USFWS 2011e).

Culebra NWR

In 1909, portions of the Culebra Archipelago were designated as a wildlife reserve in accordance with an Executive Order signed by President Theodore Roosevelt. Administration of the Culebra lands was the responsibility of the U.S. Navy and the wildlife reserve designation was subject to naval and lighthouse purposes. Several of the small islands of the archipelago, as well as the Flamenco Peninsula, were used for gunnery and bombing practice by the U.S. Navy and Marine Corps until their departure in 1976. The following year, portions of the Navy-administered lands were transferred to the Commonwealth of Puerto Rico and jurisdiction over other portions was transferred to the Service. Onsite administration of the refuge was established in 1983. Approximately one-quarter of the Culebra archipelago's total land mass is now included within Culebra NWR, which currently encompasses approximately 1,510 acres.

The original purpose for the refuge designation was established by Executive Order 1042, dated February 27, 1909. This document stated that the designated area provides "… a refuge and breeding ground for native birds." Additional purposes were identified when administration of the land was transferred to the Service because of its "... particular value in carrying out the national migratory bird management program." The National Wildlife Refuge System Administration Act provides further guidance for the management of all national wildlife refuges by identifying "... conservation, management, and ... restoration of the fish, wildlife, and plant resources and their habitats ... for the benefit of present and future generations of Americans ..." as refuge purposes (USFWS 2012d).

Vieques NWR

The Vieques NWR was established on May 1, 2001 when 3,100 acres from the western side of Vieques were transferred by the U.S. Navy to be managed by the Service. On May 1, 2003, the U.S. Navy transferred an additional 14,671 acres located on the eastern side of the island to the Service, bringing the total Vieques NWR acreage to 17,771 acres.

Excellent examples of subtropical dry forest are found on the refuge. The refuge and its adjoining waters are home to at least four endangered plant species and 10 endangered animal species. Hot sands along its undeveloped beaches make The Vieques NWR an ideal nesting site for leatherback, hawksbill and green sea turtles. The seagrass beds along the coast serve as a

refuge and feeding ground for hawksbill and green sea turtles and Antillean manatees. In addition to its ecological value, the refuge contains important archeological and historic resources, including artifacts of the aboriginal Taino culture and the island's sugar cane plantation era (USFWS 2008k).

U.S. VIRGIN ISLANDS

National Wildlife Refuges Vulnerable to Sea Level Rise and Storm Surge

Sandy Point NWR

The refuge was established in 1984 when 340 acres were purchased from the West Indies Investment Company. The land was purchased specifically to protect nesting habitat of endangered leatherback sea turtles (*Dermochelys coriacea*). An additional 43 acres have been acquired since that time to protect the Aklis prehistoric archaeological site and a stand of the endangered Vahl's boxwood tree (*Buxus vahlii*).

Sandy Point NWR provides crucial nesting habitat for three species of federally threatened and endangered sea turtles. The leatherback sea turtle and hawksbill sea turtle (*Eretmochelys imbricata*) are federally listed as endangered, and the green sea turtle (*Chelonia mydas*) is federally listed as threatened. These three sea turtle species are also protected under Territory of the U.S. Virgin Islands regulations.

The federally endangered leatherback sea turtle is the largest sea turtle species in the world, and the largest nesting population within U.S. jurisdiction occurs at Sandy Point NWR. The leatherback sea turtle recovery program began on Sandy Point with tagging efforts in 1977, and has since developed into one of the most unique, long-term sea turtle research and recovery efforts in the world. The program is the result of cooperative efforts between partnering agencies, researchers, nongovernmental organizations, and volunteers. This work resulted in the establishment of the refuge, which has enabled the nesting leatherback sea turtle population to recover and grow consistently over the last 27 years, and a scientific database that has documented this population growth. This unique database is critical for leatherback sea turtle population recovery world-wide (USFWS 2017a).

Green Cay NWR

Green Cay NWR, St. Croix, was established in 1977 to protect the endangered St. Croix ground lizard (*Ameiva polops*). The refuge consists of the entire 14-acre island of Green Cay. The refuge's establishing purpose was to conserve "fish or wildlife which are listed as endangered species or threatened species." The refuge extends only to sea level and does not include any of the submerged marine habitat, including coral reefs which surround the island.

Outcrops of lava, tuffs, and breccias are prominent terrestrial geological features. Prehistoric archaeological conch shell middens (discarded conch shells) once occurred on the shoreline. Estimated to contain as many as 33,000 shells, these middens demonstrated 1,000 years of human use or occupancy, dating back to as early as 1020 A.D.

This island refuge provides critical habitat for the largest remaining natural population of the federally endangered St. Croix ground lizard. Its extirpation from the main island of St. Croix, just several hundred yards away, is generally attributed to the modification and loss of shoreline habitat resulting from human activities, and the introduction of predators, such as mongoose, rats, cats, and dogs. The introduction of the exotic Indian mongoose likely completed the elimination of the species from St. Croix. As a result, this species is one of the rarest reptiles in the world and is unique to St. Croix island ecosystems (2017b).

Threats from Sea Level Rise and Storm Surge on Green Cay

In an effort to address the potential effects of SLR on Green Kay NWR, the Service contracted the application of the SLAMM model. Results for Green Cay indicate that there are no effects for this site until there is at least one meter of SLR at which point 4% of dry land is lost to open water or ocean beach. When 1.5 meters of eustatic SLR occurs, 7% of dry land is predicted to be lost. (Clough 2008b)

Buck Island NWR

Buck Island NWR, St. Thomas, was established in 1969. The refuge consists of the entire 45-acre island. The refuge extends to sea level and does not include submerged or marine habitat. Initially, the Service obtained approximately 35 acres of the island from the U.S. Navy in 1969. An additional 9 acres were obtained from the U.S. Coast Guard in 1981. The final 0.92-acre parcel, which included the historic iron lighthouse, was obtained from the U.S. Coast Guard in 2004. The purpose for establishment of the refuge was its "… particular value in carrying out the national migratory bird management program" (USFWS 2017c).

Threats from Sea Level Rise and Storm Surge to the Caribbean Islands

Potential impacts to the Caribbean island NWRs from increased average temperatures, SLR, more intense tropical cyclones, higher storm surge, and increasing tidal flooding will likely occur as a result of climate change. The types of species and populations most likely to be affected by climate change on the Caribbean refuges include (1) habitat specialists, (2) populations on the edges of their geographical, ecological, or geophysical ranges, (3) those species that occupy fragmented or restricted ranges, and, especially, (4) those species that are poor colonizers or dispersers. Many threatened or endangered species share one or more of these traits. In addition, the Culebra mangroves are subjected to relatively frequent hurricane force winds and likely impacts from SLR.

Coastal National Wildlife Refuges protect critical habitats for a host of fish and wildlife species, but also contribute to essential services that benefit coastal communities. Storm-surge protection, increased water quality, nurseries for commercially important shellfish, and recreational opportunities are only some of the societal benefits contributed by coastal wildlife refuges (USGS 2019). Storm Surge, due to hurricanes and tropical storms, impacts the coastal refuges by covering the low-lying ground with saltwater. This damages vegetation communities and critical habitat for species, including threatened and endangered species. After touring St. Vincent and St. Marks wildlife refuges after Hurricane Michael, it was determined that the refuge animals mostly survived the hurricane (USFWS 2018). These one-time, or sporadic events have historically occurred along the southeast coast and have a role in forming coastal

habitat. Animals tend to survive stochastic events like hurricanes without typically having a big impact on long-term population levels.

Adaptation for Resilience

The U.S. Virgin Islands (USVI) refuges are among the most vulnerable places to the impacts of climate change, particularly SLR. These islands often lack the resources and capacity to plan for and adapt to the inevitable challenges. Data visualization tools are critical to understanding the processes associated with SLR. Responding and adapting to such changes requires an understanding of the risks; weighing options for adapting to changing conditions; and instituting a suite of strategies to implement, measure, and fund response actions having the most benefits to the ecosystems and communities that depend on those services. With support from National Oceanic and Atmospheric Administration's (NOAA) Coral Reef Conservation Program, The Nature Conservancy's (TNC) Caribbean Program directed a project with the objective of developing decision-support tools and conservation strategies that will advance the implementation of ecosystem-based adaptation (EBA) to climate change within the USVI.

In June 2013, TNC convened a USVI Climate Change Ecosystem-based Adaptation workshop for community leaders, researchers, resources managers and climate change adaptation practitioners to:

2. Document the broad array of adaptation to climate change initiatives in the territory which are completed or underway and to identify projects necessary for near-term planning and preparation.
3. Demonstrate methods on the use of geographic information systems (GIS) to identify optimal areas for implementing ecosystem-based adaptation based on ecological and socioeconomic criteria.
4. To develop nature-based solutions to address changes to the coastal and marine environment in the US Virgin Islands.

At this workshop, the participants developed a vision for continuing the work of EBA planning for SLR.

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Part 3. Vulnerable Priority Biological Resources by State

North Carolina

Federally Listed Threatened and Endangered Species

Birds

Piping plover (*Charadrius melodus*)

Three separate breeding populations have been identified, each with its own recovery criteria: the Northern Great Plains (threatened), the Great Lakes (endangered), and the Atlantic Coast (threatened). Piping plovers that breed on the Atlantic Coast of the U.S. and Canada belong to the subspecies *C. m. melodus*. The second subspecies, *C. m. circumcinctus*, is comprised of two populations. One population breeds on the Northern Great Plains of the U.S. and Canada, while the other breeds on the Great Lakes. Piping plovers in North Carolina include individuals from all three breeding populations. Piping plovers from the federally endangered Great Lakes breeding population, as well birds from the threatened Atlantic Coast and Northern Great Plains breeding populations overwinter on North Carolina beaches.

North Carolina is the only state where the piping plover's breeding and wintering ranges overlap and the birds are present year-round. Piping plovers from the Atlantic Coast breeding population nest above the high tide line on coastal beaches; on sand flats at the ends of sand spits and barrier islands; on gently sloping foredunes; in blowout areas and overwashes behind or between dunes; and in sparsely vegetated dunes. The species requires broad, open, sand flats for feeding, and undisturbed flats with low dunes and sparse dune grasses for nesting.

Breeding and wintering plovers feed on exposed wet sand in swash zones; intertidal ocean beach; wrack lines; washover passes; mud, sand, and algal flats; and shorelines of streams, ephemeral ponds, lagoons, and salt marshes by probing for invertebrates at or just below the surface (Coutu et al. 1990; USFWS 1996a). They use beaches adjacent to foraging areas for roosting and preening. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging and roosting (Nicholls and Baldassarre 1990a; 1990b; Drake 1999a; 1999b, Maddock et al. 2009).

<u>Breeding piping plovers</u>
In North Carolina, most nesting pairs are recorded on Cape Hatteras and Cape Lookout National Seashores (Seashores) each year. Other sites where one or two breeding pairs have been recorded in the last ten years include Rich Inlet on the north end of Figure Eight Island, and New Topsail

Inlet and New River Inlet on Topsail Island. The nests on Figure Eight Island are the southernmost piping plover nests in recent years for the Atlantic Coast breeding population. Overall, the numbers of breeding pairs in North Carolina has grown since the Atlantic Coast breeding population was listed. However, the annual number of breeding pairs estimated from 2011 to 2016 in the state is only about 27% higher than the annual number in the 1990s. Annual productivity in North Carolina has varied over the past 20 years and does not show any trends in growth or decline. Productivity has been as low as 0.07 in 1991, when only three chicks fledged from 40 statewide pairs, to 0.96 in 2013, when 56 breeding pairs fledged 54 chicks (Schweitzer, pers. comm. 2017).

Nonbreeding piping plovers

Surveys by multiple groups have documented many banded and unbanded piping plovers during migration and winter in North Carolina. The migrant population is larger than the winter population or nesting population. Piping plovers that winter at sites (meaning they spend the majority of their nonbreeding season at one location) can arrive at their winter site as early as August and depart as late as April (Maddock et al. 2009).

Researchers from Virginia Tech (Virginia Tech Shorebird Program 2016) and others counted as many as 200 banded and unbanded piping plovers (on one date) on the south tip of Ocracoke Island between July 3 and August 26, 2017. The vast majority of the unbanded birds are expected to be from the Atlantic Coast population. Using models associated with Capture-Mark-Resighting (CMR) methods, Virginia Tech estimates that a total of approximately 533 (estimated range of 431—675) individual birds from the Atlantic Coast breeding population utilized the site as a migration stopover during this period, for an average length of at least 28 days. This represents approximately 20% of the entire Atlantic Breeding population of piping plover at this one site (Virginia Tech Shorebird Program 2016). Previous daily counts at this site were as high as 104 (NCWRC 2019).

Other North Carolina sites where greater than 10 piping plovers have been observed regularly since 2006, include other portions of the Seashores (Bodie Island, Cape Point, Bird Shoal, Clam Shoal, and Hatteras Inlet, Core Banks, New Drum Inlet, and Shackleford Banks), Hammocks Beach State, Onslow Beach, New River Inlet, New Topsail Inlet, Lea-Hutaff Island, Rich Inlet, Mason Inlet, and Masonboro Inlet. Developed beaches and inlets that are regularly modified or disturbed are utilized by significantly fewer piping plovers.

Unpublished data from NCWRC's PAWS database (NCWRC 2019) provide banded piping plover data for most coastal areas of North Carolina. Banded piping plovers from all three breeding populations have been recorded on the Seashores and south to Masonboro Inlet. This region of North Carolina, from Cape Lookout to Masonboro Inlet, is extremely important to the survival and recovery of the piping plover, particularly the Great Lakes piping plover (which is listed as endangered).

Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick

Wintering Critical Habitat for Piping Plover

Critical habitat has been designated for the breeding population in the Great Lakes region (USFWS 2001), and for the U.S. portion of the Northern Great Plains breeding population (USFWS 2002b). No critical habitat has been proposed or designated for the Atlantic Coast breeding population, but the needs of all three breeding populations were considered in the 2001 critical habitat designation for wintering piping plovers and in subsequent re-designations.

Critical habitat for wintering piping plovers currently comprises 141 units totaling 256,513 acres along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. Designated areas include habitats that support roosting, foraging, and sheltering activities of piping plovers.

The Service uses the term "physical and biological features" (PBFs) to label the key components of critical habitat that provide for the conservation of the piping plover. The PBFs of piping plover critical habitat are (73 FR 62816-62841):

1. Intertidal sand beaches (including sand flats) or mud flats (between annual low tide and annual high tide) with no or very sparse emergent vegetation for feeding.
2. Unvegetated or sparsely vegetated sand, mud, or algal flats above annual high tide for roosting.
3. Surf-cast algae for feeding.
4. Sparsely vegetated backbeach, which is the beach area above mean high tide seaward of the dune line, or in cases where no dunes exist, seaward of a delineating feature such as a vegetation line, structure, or road.
5. Spits, especially sand, running into water for foraging and roosting.
6. Salterns, or bare sand flats in the center of mangrove ecosystems that are found above mean high water and are only irregularly flushed with seawater.
7. Unvegetated washover areas with little or no topographic relief for feeding and roosting.
8. Natural conditions of sparse vegetation and little or no topographic relief mimicked in artificial habitat types (e.g., dredge spoil sites).

A designated unit contains one or more of these PBFs. The seaward edge of each unit is the contour of the mean lower low water (MLLW) elevation of each tidal day, as observed over the National Tidal Datum Epoch. The breadth of each unit extends landward from the seaward edge to where PBFs no longer occur, generally to the toe of stable, densely vegetated dunes. The seaward and landward edges may shift over time with the movement of coastal landforms. Unit boundaries generally exclude developed areas, because these areas do not contain the PBFs. Buildings, marinas, paved areas, boat ramps, exposed oil and gas pipelines, and similar structures

that may occur within unit boundaries do not contain the PBFs and are not considered critical habitat.

In North Carolina, there are 18 designated critical habitat units for wintering piping plover, from Oregon Inlet to Mad Inlet.

Using information provided on inlets in Rice (2012a), the Service determined that there are 151 inlets in the non-breeding range of the Great Lakes piping plover population (including inlets from North Carolina to the Florida Gulf of Mexico shoreline). In North Carolina, 16 of the 20 (75%) existing inlets are modified in some manner, most often by dredging (Rice 2016), including most of the inlets within critical habitat units. This is higher than any other state in the non-breeding range of the Great Lakes piping plover population (Rice 2012a).

Counties: Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick

Threats to Piping Plover Wintering Critical Habitat from Storms and Sea Level Rise

Threats to piping plover wintering critical habitat are similar to the threats to the species. Developed beaches are highly vulnerable to further habitat loss because they cannot migrate in response to sea level rise. Threats on the wintering grounds may impact piping plovers' breeding success if they start migration or arrive at the breeding grounds with a poor body condition. This cumulative habitat loss is, by itself, of major threat to piping plovers, as well as the many other shorebird species competing with them for foraging resources and roosting habitats in their nonbreeding range. However, artificial shoreline stabilization also impedes the processes by which coastal habitats adapt to storms and accelerating sea level rise, thus setting the stage for compounding future losses.

Threats to Piping Plover from Storms and Sea Level Rise

The expected increase in the rate of sea level rise and storm activity is virtually certain to affect plover migratory, wintering, and breeding habitat. There may be improved conditions for piping plover in the near term due to increased overwash and formation of intertidal habitats. However, there is concern that the acceleration in sea level rise and associated storm surges could reach a point where some barrier islands would not be able to adjust quickly enough and they would begin to experience frequent cross-island overwash or even inundation. Concern about the effect of barrier island erosion on neighboring human development could also result in increased shoreline and dune stabilization measures that could degrade plover nesting habitat.
The magnitude of threats from sea level rise is closely linked to threats from shoreline development and artificial stabilization. These threats will be perpetuated in places where damaged structures are repaired or replaced, exacerbated where the height and strength of structures are increased, and increased at locations where development and coastal stabilization

is expanded. Sites that are able to adapt to sea level rise are likely to become more important to piping plovers as habitat at developed or stabilized sites degrades.

Inundation of piping plover habitat by rising seas could lead to permanent loss of habitat, especially if those shorelines are armored with hardened structures (Dugan and Hubbard 2006; Fish et al. 2008; Defeo et al. 2009). Overwash and sand migration are impeded on the developed portions of sandy ocean beaches (Smith et al. 2008) in the U.S. nonbreeding range (Rice 2012b). As the sea level rises, the ocean-facing beaches erode and attempt to migrate inland. Buildings and artificial sand dunes then prevent sand from washing back toward the lagoons, and the lagoon side becomes increasingly submerged during extreme high tides (Scavia et al. 2002). Barrier beach shorebird habitat and natural features that protect mainland developments are both diminished as a result.

The potential for barrier island migration with rising sea level is most likely in the portion of plover's nonbreeding range that is currently preserved or otherwise protected from development (Rice 2012b). Although habitat losses in some areas are likely to be offset by gains in other locations, Galbraith et al. (2002) noted that time lags between these losses and the creation of replacement habitat elsewhere may have serious adverse effects on shorebird populations. Furthermore, even if piping plovers are able to move their wintering locations in response to accelerated habitat changes, there could be adverse effects on the birds' survival rates or subsequent productivity.

Rufa Red Knot (*Calidris canutus rufa*)

On December 11, 2014, the Service listed the rufa red knot as threatened throughout its range (79 FR 73706). The red knot is a medium-sized shorebird about 23 to 28 centimeters (cm) in length. The red knot migrates annually between its breeding grounds in the Canadian Arctic and several wintering regions, including the Southeast U.S., the Northeast Gulf of Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America. During both the northbound (spring) and southbound (fall) migrations, red knots use key staging and stopover areas to rest and feed. Although North Carolina is not one of the most significant U.S. staging areas, red knots migrate through and overwinter on North Carolina beaches. The term "winter" is used to refer to the nonbreeding period of the red knot life cycle when the birds are not undertaking migratory movements. Red knots are most common in North Carolina during the migration season (mid-April through May and July to Mid-October), and may be present in the state throughout the year (Fussell 1994; Potter et al. 1980). Red knots may be found along sandy beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks (Cohen et al. 2010; Cohen et al. 2009; Niles et al. 2008; Harrington 2001; Truitt et al. 2001). The supra-tidal (above the high tide) sandy habitats of inlets provide important areas for roosting, especially at higher tides when intertidal habitats are inundated (Harrington 2008; USFWS 2013).

The red knot is a specialized molluscivore, eating hard-shelled mollusks, sometimes supplemented with easily accessed softer invertebrate prey, such as shrimp- and crab-like organisms, marine worms, and horseshoe crab (*Limulus polyphemus*) eggs (Piersma and van Gils 2011; Harrington 2001). The primary prey of the rufa red knot in non-breeding habitats in North Carolina include *Donax* and *Darina* clams, snails (*Littorina spp*.), and other mollusks, with polychaete worms, insect larvae, and crustaceans also eaten in some locations.
Red knots and other shorebirds that are long-distance migrants must take advantage of seasonally abundant food resources at intermediate stopovers to build up fat reserves for the next non-stop, long-distance flight (Clark et al. 1993). Although foraging red knots can be found widely distributed in small numbers within suitable habitats during the migration period, birds tend to concentrate in those areas where abundant food resources are consistently available from year to year (USFWS 2013).

Counties: Currituck, Camden, Pasquotank, Perquimans, Chowan, Bertie, Beaufort, Washington, Tyrrell, Dare, Hyde, Carteret, Pamlico, Craven, Onslow, Pender, New Hanover, Brunswick

Threats to Red Knot from Storms and Sea Level Rise

The biggest threat to the rufa red knot in North Carolina is the loss of foraging and resting habitat associated with the barrier islands. Severe storms, climate change, land subsidence, and sea level rise are all threats to this essential habitat. Due to increasing sea levels, storm-surge-driven floods now qualifying as 100-year events are projected to occur as often as every 10 to 20 years along most of the U.S. Atlantic coast by 2050, with even higher frequencies of such large floods in certain localized areas (Tebaldi et al. 2012). Rising sea level not only increases the likelihood of coastal flooding, but also changes the template for waves and tides to sculpt the coast, which can lead to loss of land orders of magnitude greater than that from direct inundation alone (Ashton et al. 2007).

The expected increase in the rate of sea level rise and storm activity is virtually certain to affect red knot migratory and wintering habitat. There may be improved conditions for red knot in the near term due to increased overwash and formation of intertidal habitats. However, there is concern that the acceleration in sea level rise and associated storm surges could reach a point where some barrier islands would not be able to adjust quickly enough and they would begin to experience frequent cross-island overwash or even permanent inundation. Outside of the breeding grounds, red knots rely entirely on these coastal areas to fulfill their roosting and foraging needs, making the birds vulnerable to the effects of habitat loss from rising sea levels. Because conditions in coastal habitats are also critical for building up nutrient and energy stores for the long migration to the breeding grounds, sea level rise affecting conditions on staging areas also has the potential to impact the red knot's ability to breed successfully in the Arctic (Meltofte et al. 2007).

Concern about the effect of barrier island erosion on neighboring human development could also result in increased shoreline and dune stabilization measures that could degrade red knot foraging habitat. The magnitude of threats from sea level rise is closely linked to threats from shoreline development and artificial stabilization. These threats will be perpetuated in places where damaged structures are repaired or replaced, exacerbated where the height and strength of structures are increased, and increased at locations where development and coastal stabilization is expanded. Sites that can adapt to sea level rise are likely to become more important to red knots as habitat at developed or stabilized sites degrades.

Eastern Black Rail (*Laterallus jamaicensis jamaicensis*)

On October 9, 2018, the Service proposed to list the eastern black rail as threatened. The eastern black rail is a subspecies of black rail that occurs in salt, brackish, and freshwater wetlands in the eastern United States, Mexico, Central America, and the Caribbean. It is the smallest rail in North America, ranging from 10-15 centimeters (cm) in total length with a wingspan of 22-28 cm (Eddleman et al. 1994). Males and females are similar in size and adults are generally pale to blackish gray, with a small blackish bill and bright red eyes.

Eastern black rails are found in a variety of salt, brackish, and freshwater marsh habitats that can be tidally or non-tidally influenced. Within these habitats, the birds occupy relatively high elevations along heavily vegetated wetland gradients, with soils that are moist or flooded to a shallow depth (Eddleman, Knopf, Meanley, Reid, and Zembal 1988; Nadeau and Conway 2015). Eastern black rails require dense vegetative cover that allows movement underneath the canopy. Plant structure is considered more important than plant species composition in predicting habitat suitability for the subspecies (Flores and Eddleman 1995). Occupied habitat tends to be primarily composed of fine-stemmed emergent plants (rushes, grasses, and sedges) with high stem densities and dense canopy cover (Flores and Eddleman 1995; Legare and Eddleman 2001). However, when shrub densities become too high, the habitat becomes less suitable. Soils are moist to saturated (occasionally dry) and interspersed with or adjacent to very shallow water (1 to 6 centimeters) (Legare and Eddleman 2001). Eastern black rails forage on a variety of small (<1 centimeter (cm) (0.39 inches (in) aquatic and terrestrial invertebrates, especially insects, and seeds.

Eastern black rails are present in North Carolina year-round. Overwintering birds may overlap with the breeding population (Watts 2016). Little is known about eastern black rails during migration, including migratory stopover habitat (Eddleman et al. 1994). The eastern black rail is a wetland dependent subspecies. While it can be found in salt, brackish, and freshwater marshes that are tidally or non-tidally influenced, it has a very specific niche habitat. It requires dense herbaceous vegetation to provide shelter and cover and areas for protected nest sites; it is not found in areas with woody vegetation.

The bird requires shallow water or moist soil for its nesting sites. Ideally, the water level is 1 to 6 cm (0.39 to 2.36 in), although less than 3 cm (1.18 in) is ideal for foraging and chick rearing. Water levels must be below the nests during egg laying and incubation for nests to be successful. Eastern black rails require elevated refugia with dense cover to survive high water events, because juvenile and adult black rails prefer to walk and run rather than fly and chicks are unable to fly. Eastern black rails fly little during the breeding and wintering seasons—they prefer to remain on the ground, running quickly through dense vegetation—and are considered secretive because of this behavior. Having higher elevation areas with dense vegetation allows the birds to escape flood events during the flightless molt period and provides shelter from predators. Eastern black rails forage on a variety of small (<1 cm) aquatic and terrestrial invertebrates, especially insects, and seeds (e.g., *Typha, Scirpus, Spartina* spp.) by gleaning or pecking at individual items (Ehrlich et al. 1988; Eddleman et al. 1994).

Counties: Currituck, Dare, Hyde, Pamlico, Craven, Carteret, Onslow

Threats to Eastern Black Rails from Storms and Sea Level Rise

Storms of increased intensity, which will have stronger winds, higher storm surge, and increased flooding, cause significant damage to coastal habitats by destroying vegetation and food sources, as well as resulting in direct mortality. Increases in storm frequency, coupled with sea level rise, may result in increased predation exposure of adults and juveniles if individuals are forced to emerge from dense vegetative cover (Evens and Page, 1986; Takekawa et al. 2006). Because eastern black rails require a narrow range of water levels and appear to tolerate minor variation within those water levels, drying of habitat as a result of extended droughts may result in habitat becoming unsuitable, either on a permanent or temporary basis (Watts 2016). Extreme drought or flooding conditions may also decrease bird fitness or reproductive success by reducing the availability of the invertebrate prey base (Hands et al. 1989; Davidson 1992). Lower rates of successful reproduction and recruitment can lead to overall declines in population abundance and resiliency to withstand stochastic events such as extreme weather events. The vulnerability of the eastern black rail to the effects of climate change depends on the degree to which it is susceptible to, and able to cope with, adverse environmental changes due to long-term weather trends and more extreme weather events.

Sea level rise will reduce the availability of suitable habitat for the eastern black rail and overwhelm habitat persistence. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of coastal or wetland plant species that provide habitat for the eastern black rail (Warren and Niering 1993; Morris et al.2002). Increased high tide flooding from sea level rise, as well as the increase in the intensity and frequency of flooding events, will further impact habitat and directly impact eastern black rails, i.e., through nest destruction and egg loss (Sweet et al. 2017).

Wood Stork (*Myteria americana*)

On July 30, 2014, the Service reclassified the wood stork's status to threatened. The wood stork is the only true species of stork nesting in the United States. Since its original Enangered Species Act (ESA) listing as endangered in 1984 the U.S. breeding population has shown substantial improvement in the numbers of nesting pairs as a whole and the expansion of its breeding range.

Wood storks were first observed nesting in North Carolina in 2005. As of 2015, there were two known colonies occurring on private lands. While the wood storks nest on private lands, the birds are routinely observed foraging on a broad range of wetlands throughout southeastern North Carolina, including coastal wetlands. The number of nesting pairs has steadily increased from 32 in 2005 to 361 in 2015 (https://www.fws.gov/northflorida/WoodStorks/WOST_Data/Wood%20Stork%20Southast%20United%20States%20Nesting%20Data.html, accessed October 10, 2019).

Wood storks use a wide variety of freshwater and estuarine wetlands for nesting, feeding, and roosting throughout their range and thus are dependent upon a mosaic of wetlands for breeding and foraging. For nesting, wood storks generally select patches of medium to tall trees as nesting sites, which are located either in standing water such as swamps, or on islands surrounded by relatively broad expanses of open water (Ogden 1991). Colony sites located in standing water must remain inundated throughout the nesting cycle to protect against predation and nest abandonment. A wood stork tends to use the same colony site over many years, as long as the site remains undisturbed, and sufficient feeding habitat remains in the surrounding wetlands (Frederick and Ogden 1997). Colony turnover is a typical and fairly rapid process for this species (Frederick and Meyer 2008). Wood storks may also abandon traditional wetland sites if changes in water management result in water loss from beneath the colony trees.

Typical foraging sites include a mosaic of shallow water wetlands. Several factors affect the suitability of potential foraging habitat for wood storks. Foraging habitats must provide both a sufficient density and biomass of forage fish and other prey and have vegetation characteristics that allow storks to locate and capture prey. Calm water, about 5 to 40 cm (2 to 16 in) in depth, and free of dense aquatic vegetation, is preferred (Coulter and Bryan 1993). During nesting, these areas must also be sufficiently close to the colony to allow storks to deliver prey to nestlings efficiently. Hydrologic and environmental characteristics have strong effects on fish density, and these factors may be some of the most significant in determining foraging habitat suitability. Important to wood stork productivity is the timing of two different factors of wetland hydrology. The production of prey that support a wood stork colony is directly related to uninterrupted hydro periods of certain durations prior to the nesting season and then prey becoming available due to short-term drawdown of water levels that cue and support wood stork nesting.

The overall distribution of the breeding population of wood storks is in transition. The wood stork appears to have adapted to changes in habitat in south Florida in part expanding its breeding range north into Georgia, South Carolina, and North Carolina (Brooks and Dean 2008). To date, many of the colonies in the more northern range extension are much smaller than historic colonies in south Florida and this may be the factor of a more linear distribution of foraging habitats with wetlands associated with rivers, inter-tidal wetlands, isolated wetlands and marsh impoundments (Murphy and Coker 2008).

Counties: Bladen, Brunswick, Columbus, Sampson

Threats to Wood Storks from storms and Sea Level Rise

The effects of sea level rise include inundation of coastal habitat and intrusion of saltwater into estuaries and more inland areas including freshwater marshes, which can result in changes in vegetation and in the presence and density of various animal species. These and other changes both now and in the future depend on the magnitude of the sea level rise and other factors such as storm surges (SCDNR 2013; Williams 2013).

There is uncertainty about the likely effects of sea level rise on wood stork habitat, and at this point in time we do not have quantitative predictions of how much nesting habitat or foraging habitat might be affected by such impacts. Based on the best scientific information currently available, the effects appear likely to be mixture of both positive and negative influences on habitat. Wood stork colony sites located in standing water must remain inundated throughout the nesting cycle to protect again predation and nest abandonment. Sea level rise could result in more favorable conditions of inundation throughout the nesting cycle in some areas that currently become seasonally too dry to be suitable. Conversely, additional inundation could make render some currently suitable foraging habitat adjacent to nesting colonies too deep to be suitable as foraging habitat.

The duration of inundation by sea level rise also will make a difference: colonies that are perpetually flooded have no tree regeneration and thus sea level rise could result in loss of some colonies over time at locations where inundation becomes perpetual. At the same time, sea level rise could result in development of estuaries and suitable habitat for nesting and foraging at sites relatively more inland than currently suitable habitat and thus support range expansion. Although human development and climate change adaptation measures aimed at protecting human communities and infrastructure could substantially affect the extent and location of new estuaries that might become established in the face of a changing climate (Feagin et al. 2010; Torio and Chmura 2013).

Red-Cockaded Woodpecker (*Picoides [Dryobates] borealis*)

The red-cockaded woodpecker (RCW) is listed as an endangered species. About the size of the common cardinal, the RCW is approximately 7 inches long, with a wingspan of about 15 inches. Its back is barred with black and white horizontal stripes. The RCW's most distinguishing feature is a black cap and nape that encircle large white cheek patches. Rarely visible, except perhaps during the breeding season and periods of territorial defense, the adult male has a small red streak on each side of its black cap called a cockade. RCWs were once considered common throughout the longleaf pine ecosystem, which covered approximately 90 million acres before European settlement. The longleaf pine ecosystem has disappeared from much of its original range because of widespread commercial timber harvesting, turpentine industry, tree farming, urbanization, and agriculture. Much of the current pine forest habitat is also very different in quality from historical pine forests in which RCWs evolved. Today, many southern pine forests are young and an absence of fire has created a dense pine/hardwood forest.

The RCW is a territorial, non-migratory species. The species' social system is more complex than most species of birds; individuals live in groups normally consisting of a breeding pair and zero to four male (rarely female) offspring from previous years. These offspring assist in incubating eggs and brooding and feeding nestlings produced by the breeding pair.
The diet of RCWs consists mostly of insects, including species found in or on pine trees. Fruits and seeds make up a small portion of the overall diet. Methods of foraging include flaking away bark and probing under the bark using their specialized forked tongue to extract insects. Large, older trees are preferred for foraging. In general, males forage on the limbs and upper trunk while females forage on the trunk below the crown.

The red-cockaded woodpecker makes its home in mature pine forests. Longleaf are most commonly preferred, but other species of southern pine, such as loblolly, pond pine, and shortleaf pine, are also acceptable. An open, park-like pine savanna with little hardwood understory is preferred, such as that maintained by fire. Fire during the growing season is recognized as a key factor in sustaining habitat (Southeast Negotiation Network 1990). While other woodpeckers bore out cavities in dead trees where the wood is rotten and soft, the red-cockaded woodpecker is the only one which excavates cavities exclusively in living pine trees. Cavities are excavated in mature pines, generally over 80 years old. The older pines favored by the red-cockaded woodpecker often suffer from a fungus called red heart disease which attacks the center of the trunk, causing the inner wood, the heartwood, to become soft. RCWs are 'primary' cavity nesters, meaning they are responsible for the construction of cavities. In the southern pine ecosystem there are many 'secondary' cavity users that benefit from the RCWs work. At least 27 species of vertebrates have been documented using RCW cavities, either for roosting or nesting. Species include birds, snakes, lizards, squirrels and frogs. Wood ducks, southern flying squirrels, redbellied woodpeckers, redheaded woodpeckers, eastern bluebirds, brown-headed nuthatches, tufted titmice and great crested flycatchers are the species most

commonly seen in RCW cavities. RCW cavities are a valued resource for many species and competition occurs for their use (USFWS 2002a).

In North Carolina, the RCW is found in the sandhills (southern half) of the piedmont and in all portions of the coastal plain. In the more northern parts of the range in the northeastern NC, the species may be found more unusual habitat types such as pond pine woodland, low and high pocosin, and bay forest.

Counties: Currituck, Camden, Gates, Beaufort, Washington, Tyrrell, Dare, Hyde, Carteret, Pamlico, Craven, Jones, Duplin, Onslow, Pender, New Hanover, Brunswick, Columbus

Threats to Red-Cockaded Woodpeckers from Storms and Sea Level Rise

The effects of sea level rise and storm surge include inundation of pine forest habitat and intrusion of saltwater into estuaries and inland areas, including occupied pine forest habitat. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of the mature pine forests that provide habitat for the red-cockaded woodpecker. The duration of inundation by sea level rise will make a difference: habitat that is perpetually flooded have no tree regeneration and thus sea level rise could result in loss of habitat over time at locations where inundation becomes perpetual.

Roseate Tern (*Sterna dougalii*)

The roseate tern is a federally listed endangered coastal marine species that nests typically in the Northeast U.S., and only rarely in North Carolina. The Northeast population currently has breeding sites distributed between Long Island and Nova Scotia, although formerly its breeding range extended to Virginia and North Carolina.

Roseate terns arrive on the breeding grounds in late April or early May. They typically nest with common terns. Roseates are believed to benefit from the common tern's aggressive defense of colony sites against predators. The nest is a shallow scrape that is sometimes lined with pieces of grass and other debris. The nests may occur on a wide variety of substrates including sand, shell, gravel, rock, and vegetation. Roseates usually conceal their nests under some sort of cover such as clumps of vegetation, rocks, or driftwood. Egg laying begins during the third or fourth week of May. Incubation takes 23-24 days and the chicks fledge 25-28 days after hatching. Roseate terns feed on small fish that are captured by plunge-diving. The young remain dependent on the adults for food for several weeks after fledging which reflects the highly specialized fishing technique that the young must learn. In late July the adults and fledglings typically begin moving to staging areas from which they make foraging flights to feeding areas. Usually by mid- to late-September, roseates begin their southward migration to the north coast of South America.

Counties: Dare, Carteret

Threats to Roseate Terns from Storms and Sea Level Rise

Preferred colony sites for Northeast population are located on smaller islands with sandy, gravelly, or rocky substrates, although smaller colonies occur on long barrier islands especially near the ends. Expected increases in sea level rise, erosion, and storminess could adversely affect many colonies. For example, the Gardiners Island/Cartwright Point area on Long Island, which supported about 150 to 250 breeding pairs in the early 2000s, has been largely abandoned due at least in part to erosion and excessive overwash. In addition, the roseate's typical choice of island perimeter habitat for nesting may make the roseate terns' nests more vulnerable to erosion from sea level rise and storm activity. While common terns nest mostly in an island's interior, roseates mostly nest along the perimeter. This perimeter habitat is vulnerable to sea level rise and storm activity.

Bald Eagle (*Haliaeetus leucocephalus*)

Although the bald eagle was officially removed from the List of Endangered and Threatened Species as of August 8, 2007, it continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (BGEPA). Bald eagles nest in North Carolina from December through mid-May in mature trees (e.g., bald cypress, pine, etc.) near fresh to intermediate marshes or open water. Nest sites typically include at least one perch with a clear view of the water or area where the eagles usually forage. Bald eagles are vulnerable to disturbance during courtship, nest building, egg laying, incubation, and brooding. The Service developed the National Bald Eagle Management (NBEM) Guidelines to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute "disturbance," which is prohibited by the BGEPA. A copy of the NBEM Guidelines is available at https://catalog.data.gov/dataset/national-bald-eagle-management- guidelines.

Counties: All

Threats to Bald Eagles from Storms and Sea Level Rise

The effects of sea level rise and storm surge include inundation of forest habitat and intrusion of saltwater into estuaries and inland areas, including occupied habitat and waterbodies used for foraging. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of the forests that provide nesting habitat for the bald eagle. The duration of inundation by sea level rise will make a difference: habitat that is perpetually flooded have no tree regeneration and thus sea level rise could result in loss of habitat over time at locations where inundation becomes perpetual.

Bald eagle nests are threatened by damage or loss during large, intense storms, particularly those that occur during the nesting season. Nests may be destroyed or trees may be toppled by high winds. Eaglets may be killed or injured by being blown from a nest, or when a nest falls during a storm. Also, eaglets are susceptible to hypothermia if the eaglet or nest is soaked with rain or snow during the cooler months of the nesting season. An increase in the number and intensity of storms will exacerbate these threats.

Mammals

West Indian Manatee (*Trichechus manatus latirostris*)

The West Indian manatee was listed in 1967 as endangered throughout its range and received federal protection with the passage of the Endangered Species Act (ESA) in 1973. West Indian manatees also are protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1461 et seq.). The MMPA establishes, as national policy, maintenance of the health and stability of marine ecosystems, and whenever consistent with this primary objective, obtaining and maintaining optimum sustainable populations of marine mammals. It also establishes a moratorium on the taking of marine mammals.

Adult manatees average 10 feet long and weigh about 2,200 pounds, although some individuals have been recorded at lengths greater than 13 feet and weighing as much as 3,500 pounds. Manatees are commonly found in fresh, brackish, or marine water habitats, including shallow coastal bays, lagoons, estuaries, and inland rivers of varying salinity extremes. Manatees spend much of their time underwater or partly submerged, making them difficult to detect even in shallow water.

Manatees are seasonal inhabitants of North Carolina, typically from June through October, although some individuals may remain longer during the fall season before traveling south for the winter. Only a few each year are documented along the North Carolina coast. Those that are documented are typically seen along the shoreline, either feeding or seeking sources of fresh water, so it is possible that the numbers of manatees visiting the state each summer is underestimated.

Counties: Currituck, Camden, Gates, Chowan, Pasquotank, Perquimans, Bertie, Beaufort, Washington, Tyrrell, Dare, Hyde, Carteret, Pamlico, Craven, Onslow, Pender, New Hanover, Brunswick

Threats to West Indian Manatees from Storms and Sea Level Rise

Though the reasons are not fully understood, manatee survival rates are significantly lower during years with extreme storms (Langtimm et al. 2006). Manatees do not typically move considerable distances as major storms approach but may remain in protected areas within their typical range. Storm surges can sweep slow-moving manatees to other locations or even out to sea. When waters recede, manatees may be trapped in isolated ponds, canals, or even upland locations. Debris in turbulent waters may cause injury or death. Langtimm and Beck (2003) postulate that storms may carry a manatee away from warm winter refugia, while stirring up colder waters (particularly late in the storm season), resulting in cold stun injuries or deaths. Manatees that are caught in extreme storms in more northerly portions of the summer range may be more susceptible to cold water effects, because of the potential for colder waters, more rapid cooling of water during and after storms, and the greater distance from warmer waters. An increase in intensity or number of storms in a season would exacerbate these effects to manatees.

Northern Long-Eared Bat (*Myotis septentrionalis*)

The northern long-eared bat (NLEB) is listed as threatened. The NLEB is a medium-sized bat with a body length of 3 to 3.7 inches and a wingspan of 9 to 10 inches. Their fur color can be medium to dark brown on the back and tawny to pale brown on the underside. As its name suggests, this bat is distinguished by its long ears, particularly as compared to other bats in its genus, *Myotis*. In the colder portions of its range, northern long-eared bats spend winter hibernating in caves and mines. During the summer in cooler climates, and year-round in the North Carolina coastal plain, northern long-eared bats roost singly or in colonies underneath bark, in cavities or in crevices of both live trees and snags (dead trees).

In the coastal plain of North Carolina, NLEB roost in trees year-round. NLEB seem to be flexible in selecting roosts, choosing roost trees based on suitability to retain bark or provide cavities or crevices. This bat has also been found rarely roosting in structures elsewhere, like barns and sheds.

Breeding begins in late summer or early fall. After copulation, females store sperm until spring. In spring, they ovulate and the stored sperm fertilizes an egg. This strategy is called delayed fertilization. After fertilization, pregnant females roost in small colonies and give birth to a single pup. Maternity colonies of females and young generally have 30 to 60 bats at the beginning of the summer, although larger maternity colonies have also been seen. Numbers of individuals in roosts typically decreases from pregnancy to post-lactation. Most bats within a maternity colony give birth around the same time, which may occur from late May or early June to late July, depending where the colony is located within the species' range. Young bats start flying by 18 to 21 days after birth. Maximum lifespan for the northern long-eared bat is estimated to be up to 18.5 years.

Like most bats, NLEB emerge at dusk to feed. In the coastal plain, bats do not appear to hibernate, and will emerge and actively feed even during the winter, on relatively warm evenings. They feed on moths, flies, leafhoppers, caddisflies, and beetles, which they catch while in flight using echolocation or by gleaning motionless insects from vegetation.

Counties: Currituck, Dare, Camden, Pasquotank, Gates, Bertie, Martin, Beaufort, Washington, Hyde, Craven, Jones, Carteret, Pender, New Hanover, Bladen, Columbus

Threats to Northern Long-Eared Bat from Storms and Sea Level Rise

The most severe threat to the NLEB is white-nose syndrome, a fungal infection that has spread quickly across the U.S. since it was observed in 2006. However, it appears from preliminary studies that the NC coastal plain population of NLEB has not been exposed to the fungus. Therefore, the coastal plain may act as a refugium for the species and allow repopulation of affected areas in coming years. In the coastal plain, forested habitat is used year-round by the NLEB. The effects of sea level rise and storm surge include inundation of forest habitat and intrusion of saltwater into estuaries and inland areas, including occupied forest habitat. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of the coastal plain forests that provide year-round habitat for the NLEB. Although dead or dying trees may provide increased roosting habitat for bats in the short-term, long-term loss or degradation of forested habitat from increased storm surge, flooding, and salt-water intrusion may adversely affect northern long-eared bat in the southern coastal plain. The duration of inundation by sea level rise will make a difference: habitat that is perpetually flooded have no tree regeneration and thus sea level rise could result in loss of habitat over time at locations where inundation becomes perpetual.

Red Wolf (*Canis rufus*) (Nonessential Experimental Population)

The red wolf is a native North American canid. Adult red wolves can weigh 53-84 pounds and are about four feet from the tip of the nose to the tip of the tail. The red wolf was first classified as “threatened with extinction” in 1967 under the Endangered Species Preservation Act of 1966. It was declared extinct in the wild in 1980. A captive breeding program was started in 1969, and in 1987, red wolves were experimentally released at Alligator River National Wildlife Refuge (NWR), as a nonessential experimental population (NEP). In 2006, the red wolf population in northeastern NC peaked at 120-130 wolves; however, several threats have resulted in a decline to critical levels, and only approximately 35 wild wolves remain (USFWS 2018b). There are at least 200 wolves in captive breeding facilities.

In an effort to adaptively manage to the challenges confronting the red wolf, the Service is currently proposing a rule that would remove management efforts from existing private lands and instead focus continuing management on Alligator River National Wildlife Refuge and the

Dare County Bombing Range (the "NEP area"). The Service's role outside the proposed management area would be limited to providing technical assistance if requested by landowners.

Under this new proposal, there would be no prohibitions on the take of red wolves on non-federal lands outside the NEP area, provided the take occurs in conjunction with an otherwise lawful activity.

At present, in the North Carolina NEP, the birth rate is not sufficient to overcome the losses to mortality (natural and anthropogenic), inbreeding, and hybridization. This situation is further aggravated by introgression, which effectively reduces births of pure red wolves. There are now insufficient unrelated red wolves to replace lost breeders and therefore, the population cannot recover from these losses and overcome mortality, resulting in a steadily declining population (USFWS 2018b). Without substantial intervention, complete loss of the NEP will likely occur within as few as eight years (Faust et al. 2016). The NEP could avoid extirpation and be viable as a population with intervention (Faust et al. 2016.)

Counties: Dare, Beaufort, Tyrrell, Washington, Hyde

Threats to Red Wolves from Storms and Sea Level Rise

There are severe, short-term threats to the survival of the red wolf, including anthropogenic mortality, inbreeding, and introgression. In the long-term, if management and protection of the red wolf is limited to the Dare County peninsula, sea level rise and storm surge impacts could be significant for the NEP.

The effects of sea level rise and storm surge include inundation of upland habitat and intrusion of saltwater into estuaries and inland areas, including occupied upland habitat. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of the forests and other upland habitats. The duration of inundation by sea level rise will make a difference: habitat that is perpetually flooded have no tree regeneration and thus sea level rise could result in loss of habitat over time at locations where inundation becomes perpetual.

Sea Turtles

Five species of sea turtles are present in North Carolina waters and may nest on North Carolina beaches: loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*). All five species have been documented as nesting in the state in the past five years. The Service and National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) share Federal jurisdiction for sea turtles under the ESA. The Service has responsibility for sea turtles on the nesting beach. NMFS has jurisdiction for sea turtles in the marine

environment. This document only addresses threats to nesting sea turtles, their nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea. The threats are similar for all five species.

Loggerhead sea turtle

The loggerhead sea turtle was federally listed worldwide as a threatened species on July 28, 1978 (43 Federal Register (FR) 32800). On September 22, 2011, the loggerhead sea turtles listing under the ESA was revised from a single threatened species to nine distinct population segments (DPS) listed as either threatened or endangered (79 FR 39755). North Carolina is within the Northwest Atlantic Ocean (NWA) DPS, which is listed as threatened.

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and subadults have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders. Hatchlings are a dull brown color (NMFS 2009a). The loggerhead feeds on mollusks, crustaceans, fish, and other marine animals.

The loggerhead may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and shipwrecks are often used as feeding areas. Within the Northwest Atlantic, the majority of nesting activity occurs on sandy beaches from April through September, with a peak in June and July (Williams-Walls et al. 1983; Dodd 1988; Weishampel et al. 2006). Nesting is concentrated in the southeastern U.S. and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand (Sternberg 1981; Ehrhart 1989; Ehrhart et al. 2003; NMFS and USFWS 2008).

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the dune front (Routa 1968; Witherington 1986; Hailman and Elowson 1992). Since 2000, the annual number of loggerhead nests in NC has fluctuated between 333 in 2004 to 2,289 in 2019 (Godfrey, unpublished data; www.seaturtle.org, accessed September 25, 2019).

Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick

Critical Habitat for the NWA Population of Loggerhead Sea Turtle

On July 10, 2014, the Service designated portions North Carolina beaches as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles (79 FR 39756). North Carolina counties which include critical habitat for nesting logerhead sea turtles include Carteret, Onslow, Pender, New Hanover, and Brunswick.

The Service has designated eight critical habitat units in North Carolina, totaling 96.1 miles (154.6 km) of beach. 15.1 miles (24.3 km) are located within state-owned lands, while 81 miles (130.3 km) are on land owned by private parties or others, such as counties and municipalities. Under the Act and its implementing regulations, the Service is required to identify the physical or biological features (PBFs) essential to the conservation of the loggerhead sea turtle in areas occupied at the time of listing. The Service determined that the following PBFs are essential for the loggerhead sea turtle:

PBF 1—Sites For Breeding, Reproduction, or Rearing (or Development) of Offspring.
PBF 2 - Natural Coastal Processes or Activities That Mimic These Natural Processes.

Counties: Carteret, Onslow, Pender, New Hanover, Brunswick

Threats to Loggerhead Nesting Critical Habitat from Storms and Sea Level Rise

Potential impacts include beach erosion from rising sea levels, repeated inundation of nests, and abrupt disruption of ocean currents used for natural dispersal during the complex life cycle (Fish et al. 2005; Hawkes et al. 2009). Natural beach erosion events may influence the quality of nesting habitat. Short-term erosion events (e.g., atmospheric fronts, northeasters, tropical storms, and hurricanes) are common phenomena throughout the NWA loggerhead nesting range and may vary considerably from year to year. Although these erosion events may affect loggerhead hatchling production, the results are generally localized, and they rarely result in whole-scale losses over multiple nesting seasons. The negative effects of hurricanes on low-lying and developed shorelines used for nesting by loggerheads may be longer-lasting and a greater threat overall. Hurricanes and other storm events can result in the direct loss of sea turtle nests, either by erosion or washing away of the nests by wave action and inundation or ‘‘drowning’’ of the eggs or pre-emergent hatchlings within the nest, or indirectly affect sea turtles by causing the loss of nesting habitat. Depending on their frequency, storms can affect sea turtles on either a short- or long-term basis. The manner in which hurricanes affect sea turtle nesting also depends on their characteristics (winds, storm surge, rainfall), the time of year (within or outside of the nesting season), and where the northeast edge of the hurricane crosses land. When combined with the effects of sea level rise (see the threat category for climate change below for additional information), there may be increased cumulative impacts from future storms.

Along developed coastlines, and especially in areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on loggerhead nesting habitat. The loss of habitat as a result of sea level rise could be accelerated due to a combination of other environmental and oceanographic changes, such as an increase in the intensity of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Kennedy et al. 2002; Meehl et al. 2007).

Substantial amounts of sand are deposited along North Carolina beaches to protect coastal properties to prevent erosion and what otherwise would be considered natural processes of overwash and island migration. As sea level rise accelerates, it is anticipated that coastal communities will increase sand nourishment activities in response. Constructed beaches tend to differ from natural beaches in several important ways for sea turtles. They are typically wider, flatter, and more compact, and the sediments are moister than those on natural beaches (Nelson et al. 1987; Ackerman et al. 1991; Ernest and Martin 1999). On severely eroded sections of beach, where little or no suitable nesting habitat previously existed, sand placement can result in increased nesting (Ernest and Martin 1999). However, in most cases, a significantly larger proportion of turtles emerging on engineered beaches abandon their nesting attempts than turtles emerging on natural or pre-nourished beaches, even though more nesting habitat is available (Trindell et al. 1998; Ernest and Martin 1999; Herren 1999). As sources of beach compatible sand becomes more scarce, efforts to protect coastal properties may include placement of material that is less compatible for sea turtle nesting.

Leatherback sea turtle

The leatherback sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). Leatherbacks have the widest distribution of the sea turtles with nonbreeding animals recorded as far north as the British Isles and the Maritime Provinces of Canada and as far south as Argentina and the Cape of Good Hope (Pritchard 1992). Foraging leatherback excursions have been documented into higher-latitude subpolar waters. They have evolved physiological and anatomical adaptations (Frair et al. 1972; Greer et al. 1973) that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving.

The adult leatherback can reach 4 to 8 feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as stripes along the length of the back (NMFS 2009c). Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. This is the largest, deepest diving of all sea turtle species. Adult females require sandy nesting beaches backed with vegetation and sloped sufficiently so the distance to dry sand is limited. Their preferred beaches have proximity to deep water and generally rough seas.

Leatherbacks nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests (NMFS and USFWS 1992). The interval between nesting events within a season is about 9 to 10 days. Clutch size averages 80 to 85 yolked eggs, with the addition of usually a few dozen smaller, yolkless eggs, mostly laid toward the end of the clutch (Pritchard 1992). Nesting migration intervals of 2 to 3 years were observed in leatherbacks nesting on the Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton

1996). Leatherbacks are believed to reach sexual maturity in 13 to 16 years (Dutton et al. 2005; Jones et al. 2011).

Nesting in North Carolina is sporadic. In 2010, two nests were reported in North Carolina, five were reported in 2012, and none were reported in 2013-2015.

Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick, Craven

Green sea turtle

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). On April 6, 2016, the NMFS and Service issued a final rule to list 11 DPSs of the green sea turtle. Three of the DPSs are endangered species (Central South Pacific, Central West Pacific, and Mediterranean Sea), and eight are threatened species (81 FR 20058). In North Carolina, the green sea turtle is part of the North Atlantic Ocean DPS, and is listed as threatened.

The green sea turtle grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown, and black. Hatchlings are black on top and white on the bottom (NMFS 2009b). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae.

Green sea turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. The green turtle is attracted to lagoons and shoals with an abundance of marine grass and algae. Open beaches with a sloping platform and minimal disturbance are required for nesting. In North Carolina, between 4 and 65 green sea turtle nests are laid annually (Godfrey, unpublished data, www.seaturtle.org, accessed September 25, 2019).

Green sea turtles deposit from one to nine clutches within a nesting season, but the overall average is about 3.3 nests. The interval between nesting events within a season varies around a mean of about 13 days (Hirth 1997). Mean clutch size varies widely among populations. Clutch size varies from 75 to 200 eggs with incubation requiring 48 to 70 days, depending on incubation temperatures. Only occasionally do females produce clutches in successive years. Usually two or more years intervene between breeding seasons (NMFS and USFWS 1991). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick, Pamlico, Craven

Hawksbill sea turtle

The hawksbill sea turtle was Federally listed as endangered on June 2, 1970 (35 FR 8491). The hawksbill is found in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. Hawksbills typically weigh around 176 pounds or less; hatchlings average about 1.6 inches straight length and range in weight from 0.5 to 0.7 ounces. The carapace is heart shaped in young turtles, and becomes more elongated or egg-shaped with maturity. The top scutes are often richly patterned with irregularly radiating streaks of brown or black on an amber background. The head is elongated and tapers sharply to a point. The lower jaw is V-shaped (NMFS 2009d).

Within the continental U.S., hawksbill sea turtle nesting is rare, and nests are only known from Florida and North Carolina. Two nests have been recorded in North Carolina, both in 2015. Both nests, located on the Seashore, were originally thought to be loggerhead nests, but discovered to be hawksbill nests after DNA testing of eggshells. Hawksbill tracks are difficult to differentiate from those of loggerheads and may not be recognized by surveyors. Therefore, surveys in the southeastern U.S. likely underestimate actual hawksbill nesting numbers (Meylan et al. 1995). In the U.S. Caribbean, hawksbill nesting occurs on beaches throughout Puerto Rico and the U.S. Virgin Islands (NMFS and USFWS 1993).

Hawksbills nest on average about 4.5 times per season at intervals of approximately 14 days (Corliss et al. 1989). In Florida and the U.S. Caribbean, clutch size is approximately 140 eggs, although several records exist of over 200 eggs per nest (NMFS and USFWS 1993). On the basis of limited information, nesting migration intervals of two to three years appear to predominate. Hawksbills are recruited into the reef environment at about 14 inches in length and are believed to begin breeding about 30 years later. However, the time required to reach 14 inches in length is unknown and growth rates vary geographically. As a result, actual age at sexual maturity is unknown.

Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick

Kemp's ridley sea turtle

The Kemp's ridley sea turtle was federally listed as endangered on December 2, 1970 (35 FR 18320). The range of the Kemp's ridley includes the Gulf coasts of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland.
Adult Kemp's ridleys are among the smallest sea turtles in the world. The weight of an adult Kemp's ridley is generally between 70 to 108 pounds with a carapace measuring approximately 24 to 26 inches in length (Heppell et al. 2005). The carapace is almost as wide as it is long. The species' coloration changes significantly during development from the grey-black dorsum and plastron of hatchlings, a grey-black dorsum with a yellowish-white plastron as post-pelagic

juveniles and then to the lighter grey-olive carapace and cream-white or yellowish plastron of adults. Their diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

The Kemp's ridley has a restricted distribution, and nesting is mostly limited to the beaches of the western Gulf of Mexico (NMFS et al. 2011). Nesting occurs infrequently in North Carolina, and ranges from no nests to 12 nests per year (www.seaturtle.org, accessed September 25, 2019). Nesting occurs primarily from May into July. Clutch size averages 100 eggs and eggs typically take 45 to 58 days to hatch depending on incubation conditions, especially temperatures (Marquez-Millan 1994; Rostal 2007).

Females lay an average of 2.5 clutches within a season (TEWG 1998) and inter-nesting interval generally ranges from 14 to 28 days (Miller 1997; NMFS et al. 2011). The mean remigration interval for adult females is 2 years, although intervals of 1 and 3 years are not uncommon (Marquez et al. 1982; TEWG 1998; 2000). Males may not be reproductively active on an annual basis (Wibbels et al. 1991). Age at sexual maturity is believed to be between 10 to 17 years (Snover et al. 2007).

Counties: Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick, Pamlico

Threats to Sea Turtles from Storms and Sea Level Rise

Hurricanes and large storms generally produce damaging winds, storm tides and surges, and rain, which can result in severe erosion of the beach and dune systems. Overwash and blowouts are common on barrier islands.

Hurricanes and other storms can result in the direct loss of sea turtle nests, either by erosion or washing away of the nests by wave action and inundation or "drowning" of the eggs or pre-emergent hatchlings within the nest, or indirectly by causing the loss of nesting habitat. Depending on their frequency, storms can affect sea turtles on either a short-term basis (nests lost for one season and/or temporary loss of nesting habitat) or long term, if frequent (habitat unable to recover). The manner in which hurricanes affect sea turtle nesting also depends on their characteristics (winds, storm surge, rainfall), the time of year (within or outside of the nesting season), and where the northeast edge of the hurricane crosses land.

Because of the limited remaining nesting habitat in a natural state with no immediate development landward of the sandy beach, frequent or successive severe weather events could threaten the ability of certain sea turtle populations to survive and recover. Sea turtles evolved under natural coastal environmental events such as hurricanes. The extensive amount of predevelopment coastal beach and dune habitat allowed sea turtles to survive even the most severe hurricane events. It is only within the last 20 to 30 years that the combination of habitat

loss to beachfront development and destruction of remaining habitat by hurricanes has increased the threat to sea turtle survival and recovery. On developed beaches, typically little space remains for sandy beaches to become reestablished after periodic storms. While the beach itself moves landward during such storms, reconstruction or persistence of structures at their pre-storm locations can result in a loss of nesting habitat.

Along developed coastlines, and especially in areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on nesting females and their eggs. Erosion control structures can result in the permanent loss of dry nesting beach or deter nesting females from reaching suitable nesting sites (National Research Council 1990). Nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation or washout by waves and tidal action. Based on the present level of available information concerning the effects of global climate change on the status of sea turtles and their designated critical habitat, the Service acknowledges the potential for changes to occur in the Action Area, but presently has no basis to evaluate if or how these changes are affecting sea turtles. Nor does our present knowledge allow the Service to project what the future effects from global climate change may be or the magnitude of these potential effects.

Freshwater Aquatic Species

Neuse River Waterdog (*Necturus lewisi*)

On May 21, 2019, the Service proposed to list the Neuse River waterdog as a threatened species. The Neuse River waterdog is from an ancient lineage of permanently aquatic salamanders in the genus *Necturus*. It can grow up to 11 inches long. It has a reddish-brown body with an irregular pattern of large blue or black spots. The waterdog has a laterally compressed tail the same coloration as the body; however, the belly is typically a dull brown or gray color with spots similar to those seen elsewhere on the body. Three dark-red, bushy gills project from either side of the head and a dark line runs through the eye. The skin is smooth, slimy and a light rusty brown color, with the belly being a paler brown or grayish. The limbs are rather small, and the front and hind feet have four toes each (unlike most salamanders, which have five toes on each back foot). Genders are similar in appearance. Waterdogs breed annually, mating in the fall/winter, seasons and females spawn in the spring. Clutch sizes vary from an average of 25 to 90 eggs. Both parents guard the nest. Longevity of Neuse River waterdog is unknown. However, its close relative, *Necturus maculosus* may live for over 30 years (USFWS 2017a).

The Neuse River waterdog specific habitat characteristics include low to moderate gradient streams and low current velocity. It is a fully aquatic salamander, never leaving the water. It lacks lungs, getting oxygen from the water via external gills and needs clean, flowing water with high dissolved oxygen concentrations. The species dwells in streams wider than 15 meters but

has been found in smaller creeks. The species thrives in cold water, and is much more active in colder seasons and when water is near-freezing. Researchers have documented activity decreasing after the water temperature rises above 18ºC. waterdogs spend about 85% of the time under large granite rocks or in burrows. In early spring they move into leaf beds over mud banks on the low-energy sides of riffles and where leaves were intact or only slightly decomposed and many small critters are in the leaf litter.

Neuse River waterdogs are sight and scent feeders, with prey consisting of aquatic arthropods (primarily ostracods and copepods), hellgrammites, mayflies, caddisflies, crayfish, beetles, caterpillars, snails, spiders, earthworms, centipedes, millipedes, slugs) and some small fish like darters and pirate perch.

The Neuse River waterdog is endemic to the Tar-Pamlico and Neuse River basins in North Carolina. Its historical distribution includes the Piedmont and Coastal Plain regions of North Carolina within all major tributary systems of the Tar and Neuse, including the Trent River Basin. Today, the species is known to occupy the Neuse and the Tar River basins of North Carolina. The species is not known to migrate.

Counties: Person, Granville, Vance, Warren, Orange, Durham, Wake, Harnett, Franklin, Nash, Edgecombe, Halifax, Pitt, Martin, Beaufort, Johnston, Wayne, Wilson, Greene, Lenoir, Jones, Craven, Onslow, Duplin, Sampson

Threats to the Neuse River waterdog from Storms and Sea Level Rise

Clean, non-polluted water is essential to the survival of the Neuse River waterdog. Streams that have non-altered thermal regimes, average pH, low salinity, and negligible chemical pollution provide suitable habitat for the persistence of waterdog populations. Storm surges typically affect water quality parameters such as nutrients, pH, dissolved oxygen, salinity, and turbidity, potentially making it inhospitable for aquatic biota. Benthic critters such as the waterdog have disproportionate rates of imperilment and extirpation because stream bottoms are often the first habitats affected by pollution (Midway et al. 2010). When the hydrology of a stream is altered and water quantities vary widely, the physical habitat of the stream often becomes degraded from channel erosion, ultimately reducing feeding, spawning, and living spaces of the Neuse River waterdog and other aquatic biota living in the streams (Giddings et al. 2009).

Carolina Madtom (*Noturus furiosus*)

On May 21, 2019, the Service proposed to list the Carolina madtom as endangered. The Carolina madtom is a small catfish, reaching a maximum length of nearly five inches. When compared to other madtoms, the Carolina madtom has a short, chunky body and a distinct color pattern. Three dark saddles along its back connect a wide, black stripe along its side extending from its snout to

the base of its tail. The adipose fin has a dark blotch that does not quite reach the fin's edge, giving the impression of a fourth saddle. Yellowish to tan blotches space the saddles, while the rest of the fish is tan. The belly is un-speckled, and the tail has crescent-shaped brown bands near its edge and center. Its pectoral spines have well-defined serrated (saw-like) projections along both margins (USFWS 2017b).

The species occurs in riffles, runs, and pools in medium to large streams and rivers. Ideally, it inhabits fresh waters with continuous, year-round flow and moderate gradient in both the Piedmont and Coastal Plain physiographic regions. Optimal substrate for the Carolina madtom is predominantly silt-free, stable, gravel and cobble bottom habitat, and it must have cover for nest sites, including under rocks, bark, relic mussel shells, and even cans and bottles. The Carolina madtom is a sight feeder most active during the night, with peaks at dawn and dusk. It eats bottom-dwelling invertebrates such as larval midges, mayflies, caddisflies, dragonflies and beetle larvae. The Carolina Madtom is a freshwater fish species endemic to the Tar-Pamlico, and Neuse River (including the Trent) drainages in North Carolina. The Carolina madtom's presence in the Neuse River Basin is greatly reduced from what historical records show.

Counties: Person, Granville, Vance, Warren, Orange, Durham, Wake, Harnett, Franklin, Nash, Edgecombe, Halifax, Pitt, Martin, Johnston, Wayne, Wilson, Greene, Lenoir, Jones, Craven, Onslow, Duplin, Sampson

Threats to the Carolina madtom from Storms and Sea Leve Rise

The Carolina Madtom faces a variety of threats from declines in water quality, loss of stream flow, riparian and instream fragmentation, deterioration of instream habitats, and expansion of the invasive predator flathead catfish. These threats are expected to be exacerbated by urbanization and climate change. Evidence suggests that the range reduction of the species corresponds to habitat degradation resulting from the cumulative impacts of land use change and associated watershed-level effects on water quality, water quantity, habitat connectivity, and instream habitat suitability, as well predation by the flathead catfish. The effects of climate change have begun to be realized in current Carolina madtom range and may have contributed to habitat degradation.

Storm surges typically affect water quality parameters such as nutrients, pH, dissolved oxygen, salinity, and turbidity, potentially making it inhospitable for aquatic biota. Benthic critters such as the Carolina madtom have disproportionate rates of imperilment and extirpation because stream bottoms are often the first habitats affected by pollution (Midway et al. 2010). When the hydrology of a stream is altered and water quantities vary widely, the physical habitat of the stream often becomes degraded from channel erosion, ultimately reducing Carolina madtom habitat.

Magnificent Ramshorn (*Planorbella magnifica*)

The magnificent ramshorn is currently being considered for listing by the Service. On June 20, 2011, the Service published the annual Candidate Notice of Review and announced the magnificent ramshorn as a new candidate species with a Listing Priority Number of 2, indicating that the full species was imminently threatened by a high magnitude of threats (USFWS 2019).

The magnificent ramshorn is an air-breathing snail, approximately 1.5 inches in diameter, historically found in lentic systems in the southeastern coastal plain of North Carolina. It was last documented in the wild in 2004. Historically, it was documented from only four sites in the lower Cape Fear River Basin in North Carolina: 1) Greenfield Lake, a millpond located on a tributary to the Cape Fear River within the present city limits of Wilmington, New Hanover County, 2) Orton Pond (aka Sprunt's Pond), a millpond located on Orton Creek in Brunswick County, 3) Sand Hill Creek Pond (aka Pleasant Oaks Pond or Big Pond), a millpond on Sand Hill Creek in Brunswick County, and 4) McKinzie Pond, a millpond on McKinzie Creek, in Brunswick County. Species-specific surveys of more than 100 potential sites (including most historical locations) over the last few decades have not documented any magnificent ramshorn snails, and the species is currently believed to be extirpated in the wild. Captive populations are being held at three separate locations in North Carolina, with the intent to reestablish it in the wild, on private and state/federal lands.

It is the largest North American snail in the family Planorbidae (Pilsbry 1903). It has a discoidal (i.e., coiling in one plane), relatively thin shell that is quite wide in relation to the diameter, making it easily identifiable at all ages. The shell is tan/brown colored and is thin and fragile. Rather than having gills, the mantle cavity walls are heavily vascularized and form a lung sac (adapted from Baker 1945), giving the snails the ability to draw oxygen out of the air, as well as breathe under water. However, the length of time the species can live out of water is unknown and likely depends on several factors such as air humidity levels and air temperature.

While juvenile magnificent ramshorns have eyes, the eyes gradually disappear as the snails grow and adults of the species are blind (Dall 1907; Bartsch 1908; Adams 1993). Dall (1907) reported that the life span of the magnificent ramshorn is likely about 2 years (Adams 1993). Members of the Planorbidae family are hermaphroditic (Baker 1945). Magnificent ramshorn lays fertilized eggs on the undersides of leaves of aquatic vegetation. Egg laying is likely triggered by water temperature and lengthening daylight hours and may extend from April to October (Adams 1993; Wood 2004; 2010; Levine and Eads 2014).

The magnificent ramshorn is believed to be primarily herbivorous, feeding on submerged aquatic plants, algae, and detritus (Baker 1945; Wood 2004). Although the magnificent ramshorn is considered a large snail, its shell is thin and fragile indicating that it is adapted to lentic (still or slow flowing) aquatic habitats (Bartsch 1908; Adams 1993). Available information indicates that suitable habitat for the species is restricted to relatively shallow, sheltered portions of still or

sluggish, freshwater bodies with an abundance and diversity of submerged aquatic vegetation and a circumneutral pH (Adams 1993).

Although the complete historical range of the magnificent ramshorn is unknown, available information indicates that the species was likely once an inhabitant of beaver ponds on tributaries in the lower Cape Fear River basin; the species may also have once inhabited backwater and other sluggish portions of tributaries and the main channel of lower Cape Fear River (Adams 1993). Beaver pond habitat was eliminated throughout much of the lower Cape Fear River as a result of the extirpation of the beaver due to trapping and hunting during the 19th and early 20th centuries. This, together with draining and destruction of beaver ponds for development, agriculture and other purposes, is believed to have led to a significant decline in the in the snails' habitat and significant reduction in its abundance (Wood 2010). Also, dredging and deepening of the Cape Fear River channel, which began as early as 1822, and opening of the Atlantic Intercoastal Waterway (through Snow's Cut) in 1930 for navigational purposes have caused saltwater intrusion, altered the diversity and abundance of aquatic vegetation, and changed flows and current patterns far up the river channel and its lower tributaries (Adams 1993; Wood 2010). Under these circumstances, the magnificent ramshorn could have survived only in areas of tributary streams not affected by saltwater intrusion and other changes, such as the millponds protected from saltwater intrusion by their dams (Adams 1993).

Counties: New Hanover and Brunswick

Threats to Magnificent Ramshorn from Storms and Sea Level Rise

The Service and its partners intend to reestablish wild populations of magnificent ramshorn on government-held lands and the lands of willing private landowners in Brunswick and New Hanover Counties, NC. Climate change and sea level rise pose a significant long-term threat to the survival of the magnificent ramshorn and reestablishment of wild populations. As previously noted, the magnificent ramshorn is salt intolerant (Wood 2002), and saltwater intrusion into its habitat is one of the primary factors that has contributed to its extirpation in the wild. During the past century, sea level has risen by at least eight inches and available information indicates the rate of sea level rise is increasing (US Global Change Research Program 2009; Kopp et al. 2015). Sea levels are rising at a rate of about an inch per year (5 inches from 2011-15) in some areas along the east coast of NC (Valle-Levinson et al. 2017). While future rates of sea level change are uncertain and dependent upon ice sheet response to climate change, continued sea level rise threatens the southeastern US coastal zone with retreat of shorelines, inundation of coastal wetlands and streams, and increased salinity of estuaries, coastal wetlands, and tidal rivers and creeks, pushing freshwater coastal ecosystems further inland. In addition, in the future the southeastern US is threatened with potential higher average temperatures (resulting increased evaporation rates), less frequent rainfall (resulting in potentially more frequent and longer dry periods), and an increase in intensity of storm events, including hurricanes; all of which are likely to increase the rate and upstream distance of saltwater intrusion into coastal streams.

Changes in climate and weather patterns may affect ecosystem processes and communities by altering the abiotic conditions experienced by biotic assemblages resulting in potential effects on community composition and individual species interactions (DeWan et al. 2010). Impacts from climate change affect sea level changes, alterations in precipitation patterns and subsequent delivery of freshwater, nutrients, and sediment, and changes in the frequency and intensity of coastal storms (Michener et al. 1997; Scavia et al. 2002; Neumann et al. 2015). During the time (1990s-2000s) when magnificent ramshorn became extremely rare in the wild, three of the top five strongest/most intense storms experienced in Wilmington, NC were in 1996, 1998, and 1999, and caused massive flooding and saltwater intrusion into the ponds where the species occurred.

Plants

Seabeach Amaranth (*Amaranthus pumilus*)

Seabeach amaranth is an annual plant that grows on Atlantic barrier islands and ocean beaches currently ranging from South Carolina to New York. It was listed as threatened under the ESA on April 7, 1993 (58 FR 18035) because of its vulnerability to human and natural impacts and the fact that it had been eliminated from two-thirds of its historic range (USFWS 1996b). Seabeach amaranth stems are fleshy and pink-red or reddish, with small rounded leaves that are 0.5 to 1.0 inches in diameter. The green leaves, with indented veins, are clustered toward the tip of the stems, and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous, borne in clusters along the stems. This species is found on the lower foredunes and upper beach strands on the ocean side of the primary sand dunes and overwash flats at accreting spits or ends of barrier islands.

Germination of seabeach amaranth seeds occurs over a relatively long period, generally from April to July. Upon germinating, this plant initially forms a small unbranched sprig, but soon begins to branch profusely into a clump. This clump often reaches one foot in diameter and consists of five to 20 branches. Occasionally, a clump may get as large as three feet or more across, with 100 or more branches. Flowering begins as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant. Weather events, including rainfall, hurricanes, and temperature extremes, and predation by webworms have strong effects on the length of the reproductive season of seabeach amaranth. Because of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July. Under favorable circumstances, however, the reproductive season may extend until January or sometimes later (Radford et al. 1968; Bucher and Weakley 1990; Weakley and Bucher1992). Within North Carolina, seabeach amaranth numbers vary from year to year. Data in North Carolina is available from 1987 to 2013. Recently, the number of plants across the entire state

dwindled from a high of 19,978 in 2005 to 165 in 2013. This trend of decreasing numbers is seen throughout its range (USFWS, unpublished data).

Seabeach amaranth is dependent on natural coastal processes to create and maintain habitat. However, high tides and storm surges from tropical systems can overwash, bury, or inundate seabeach amaranth plants or seeds, and seed dispersal may be affected by strong storm events.

Counties: Currituck, Dare, Hyde, Carteret, Onslow, Pender, New Hanover, Brunswick

Threats to Seabeach Amaranth from Storms and Sea Level Rise

The expected increase in the rate of sea level rise and storm activity is virtually certain to affect seabeach amaranth. There may be improved conditions for the species in the near term due to increased overwash and formation of suitable habitats, and increased distribution of seeds. However, there is concern that the acceleration in sea level rise and associated storm surges could reach a point where some barrier islands would not be able to adjust quickly enough and they would begin to experience frequent cross-island overwash or even permanent inundation. Concern about the effect of barrier island erosion on neighboring human development could also result in increased shoreline and dune stabilization measures that could degrade seabeach amaranth habitat. The predominant threat to seabeach amaranth is the destruction or alteration of suitable habitat, primarily because of beach stabilization efforts and storm-related erosion.

The effects of large storm events can be substantial (Weakley and Bucher 1992). In the Carolinas, populations of amaranth were severely reduced after Hurricane Hugo struck in 1989, followed by several additional severe storms. A 74 percent reduction in amaranth numbers occurred in North Carolina, from 41,851 plants in 1988 to 10,898 in 1990. The influence stochastic events have on long-term population trends of seabeach amaranth has not been assessed.

Waterbird Nesting Colonies

Species included in this category are brown pelican, Anhinga, double-crested cormorant, black skimmer, Caspian tern, common tern, Forster's tern, gull-billed tern, least tern, royal tern, sandwich tern, black-crowned night heron, great blue heron, great egret, green heron, cattle egret, glossy ibis, little blue heron, snowy egret, tricolored heron, white ibis, yellow-crowned night-heron, great black-backed gull, herring gull, and laughing gull. Wood storks are also included in this category, though discussed separately, above.

The size of a waterbird nesting colony may range from a few breeding pairs to thousands of breeding pairs. Colonial waterbird species nest in several different habitats, including barrier island beaches, estuarine islands (including dredge spoil), maritime forests, and freshwater or tidal swamps, depending on the species. Gulls, terns, and skimmers generally nest on bare sand

and shell with little or no vegetation. Pelicans prefer to nest in grasses or low shrubs. Wading birds, like egrets and herons, most often nest in shrubs or trees (NCWRC 2005).

Counties: All

Threats to Waterbird Nesting Colonies from Storms and Sea Level Rise

The effects of sea level rise include inundation of coastal habitat and saltwater intrusion, which can result in changes in vegetation and in the presence and density of various animal species; these and other changes both now and in the future depend on the magnitude of the sea level rise and other factors such as storm surges.

Sea level rise-related perpetual flooding could result in loss of the associated habitat. This includes perpetual inundation of bare sand and shell habitats used by nesting gulls, terns, and skimmers, as well as loss of vegetation used by pelicans and wading bird colonies. Sea level rise could result in development of suitable nesting habitat at sites relatively more inland than current sites, although human development and climate change adaptation measures aimed at protecting human communities and infrastructure could substantially affect the extent and location of habitat that might become established in the face of a changing climate (Feagin et al. 2010; Torio and Chmura 2013). Additionally, dredge spoil islands, currently used as nesting habitat by several species, may be utilized as a sand borrow source (and removed) for beach nourishment in the future, as compatible offshore sand sources dwindle.

Breeding and Wintering Shorebirds

Species include American oystercatcher, short-billed dowitcher, black-bellied plover, semipalmated plover, Wilson's plover, willet, sanderling, killdeer, semipalmated sandpiper, western sandpiper, and marbled godwit. Piping plover and red knot are also included in this category, but are discussed above.

American oystercatcher, willet, Wilson's plover, and piping plover (Atlantic Coast breeding population) may nest on beaches and estuarine islands in North Carolina. The other species listed above are migrants or winter residents. Many of the breeding shorebird species nest as isolated pairs in sandy areas of the beach or dune system. Some species may form loose colonies. Nests are typically a simple scrape in the sand, though some nests may be lined with pebbles, pieces of shell, or grass.

Migrating and wintering shorebirds may be found along estuarine, inlet, and ocean shorelines up to 10 months of each year, where they forage along the shoreline for invertebrate prey and roost in adjacent vegetated or unvegetated habitats. These species typically travel thousands of miles from breeding habitats in the American Midwest or farther north in the sub-arctic or arctic circle to reach the coast of North Carolina.

Counties: All

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South Carolina

Federally Listed Threatened and Endangered Species

South Carolina Beach Ecosystem

South Carolina has approximately 182 miles of coastline and approximately half of the coastline is developed. South Carolina barrier beaches are part of a complex and dynamic coastal system that continually respond to inlets, tides, waves, erosion and deposition, longshore sediment transport and depletion, fluctuations in sea level, and weather events. The location and shape of the coastline perpetually adjusts to these physical forces. Winds move sediment across the dry beach forming dunes and the island interior landscape. The natural communities contain plants and animals that are subject to shoreline erosion and deposition, salt spray, wind, drought conditions, and sandy soils. Vegetative communities include foredunes, primary, and secondary dunes, interdunal swales, sand pine scrub, and maritime forests. However, the protection or persistence of these important natural landforms, processes, and wildlife resources is often in conflict with long-term beach stabilization projects and their indirect effects, i.e., increases in residential development, infrastructure, and public recreational uses.

Shorebirds

In South Carolina, shorebirds are present year round. The breeding season for shorebirds nesting on South Carolina beaches is March through July and the nonbreeding season for migrating and wintering shorebirds is July through May. Threats to shorebirds and their habitat include continued loss and degradation of habitat due to sand placement projects, inlet relocation and stabilization, groins, seawalls and revetments, and recreational disturbance that displaces birds or disrupts feeding and resting behavior. Artificial shoreline stabilization impedes the processes by which coastal habitats adapt to storms and accelerating sea level rise, thus setting the stage for compounding future losses. The magnitude of threats from sea level rise is closely linked to threats from shoreline development and artificial stabilization.

Piping Plover (*Charadrius melodus*)

The piping plover, named for its melodic call, is a small North American shorebird approximately 17 centimeters (7 inches) long with a wingspan of about 38 cm (15 in) and weighing 40-65 grams (1.4-2.3 oz.). On January 10, 1986, the piping plover was federally listed as endangered in the Great Lakes watershed of both the United States (U.S.) and Canada and as threatened in the remainder of its range in the U.S. (Northern Great Plains, Atlantic and Gulf Coasts, Puerto Rico, and Virgin Islands), Canada, Mexico, Bahamas, and the West Indies. There are three separate breeding populations of piping plovers: 1) Atlantic Coast (threatened), 2) Great Lakes (endangered), and 3) Northern Great Plains (NGP) (threatened). The piping plover winters

in coastal areas of the U.S. from North Carolina to Texas, and along the coast of eastern Mexico and on Caribbean islands from Barbados to Cuba and the Bahamas. In South Carolina, piping plovers are present July through May.

Piping plovers prefer wide, flat, sparsely vegetated barrier beaches, spits, sandbars, and soundside flats, which are formed and maintained by natural forces. Piping plovers prefer to feed in intertidal areas that support their preferred prey items such as polychaete worms and amphipods and rest above the high tide line in unvegetated or sparsely vegetated areas with a wrack line.

Red knot (*Calidris canutus rufa*)

The rufa red knot is a medium-sized migratory shorebird that breeds in the Canadian Arctic, winters in parts of the Southeastern U.S., the Caribbean, and South America, and primarily uses well-known spring and fall stopover areas on the Atlantic coast of the U.S., although some follow a midcontinental migratory route. On December 11, 2014, the rufa red knot was federally listed as a threatened subspecies. The rufa red knot migrates annually between its breeding grounds in the central Canadian Arctic and several wintering regions, including the Southeast United States, the Northeast Gulf of Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America. During both the northbound (spring) and southbound (fall) migrations, red knots use key staging and stopover areas to rest and feed. In South Carolina, red knots can be present July through May. The largest flocks are present in April and May.

Red knots prefer muddy or sandy shorelines along the mouths of sounds and estuaries, tidal flats, and unstabilized tidal inlets. Rufa red knots prefer to forage in flocks intertidal areas that support their preferred prey items such as surf clams, mussels, and horseshoe crab eggs (when available). They roost above the high tide line in unvegetated or sparsely vegetated, undisturbed areas.

Sea Turtles

In South Carolina, sea turtle nesting season is May through October. The nest laying portion of the nesting season is May through early August and the hatching portion of the nesting season is July through October. Sea turtles nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the primary dune line. Threats to sea turtles include: beach erosion, armoring and renourishment; artificial lighting; predation; increased human presence; and recreational beach equipment. Along developed coastlines, and especially in areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on sea turtle nesting habitat.

Loggerhead sea turtle (*Caretta caretta*)

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and juvenilles have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders. Hatchlings are dark gray in color. Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. On September 22, 2011, the loggerhead sea turtle's 1978 listing was revised from a single threatened species to nine distinct population segments (DPS) listed as either threatened or endangered. The nine DPSs are: 1) Northwest Atlantic Ocean DPS; 2) Northeast Atlantic Ocean; 3) Mediterranean Sea DPS; 4) South Atlantic Ocean DPS; 5) North Pacific Ocean DPS; 6) South Pacific Ocean DPS; 7) North Indian Ocean DPS; 8) Southwest Indian Ocean DPS; and 9) Southeast Indo-Pacific Ocean DPS. In the Northwest Atlantic, nesting occurs along the coasts of North America, Central America, northern South America, the Antilles, Bahamas, and Bermuda, but is concentrated in the southeastern U.S. and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand. Five recovery units have been identified in the Northwest Atlantic and are as follows: 1) Northern Recovery Unit (NRU); 2) Peninsula Florida Recovery Unit (PFRU); 3) Dry Tortugas Recovery Unit (DTRU); 4) Northern Gulf of Mexico Recovery Unit (NGMRU); and 5) Greater Caribbean Recovery Unit (GCRU). South Carolina is part of the NRU.

Green Sea Turtle (*Chelonia mydas*)

The green sea turtle grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown and black. Hatchlings are black on top and white on the bottom. The green sea turtle has a worldwide distribution in tropical and subtropical waters. On April 6, 2016, the green sea turtle's 1978 listing was revised from a single threatened species to eleven distinct population segments (DPS) listed as either threatened or endangered. The eleven DPSs are: 1) North Atlantic DPS; 2) Mediterranean DPS; 3) South Atlantic DPS; 4) Southwest Indian DPS; 5) North Indian DPS; 6) East Indian-West Pacific DPS; 7) Central West Pacific DPS; 8) Southwest Pacific DPS; 9) Central South Pacific DPS; 10) Central North Pacific DPS; 11) East Pacific DPS. In the North Atlantic, the majority of nesting occurs in Costa Rica, Mexico, the Florida coast of the U.S., and Cuba. In South Carolina, green turtle nesting is possible, but rare.

Leatherback Sea Turtle (*Dermochelys coriacea*)

The leatherback sea turtle is the largest, deepest diving, and most migratory and wide ranging of all sea turtle species. The adult leatherback can reach 4 to 8 feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as

stripes along the length of the back. Nesting beaches are distributed worldwide along the shores of the Atlantic, Pacific and Indian Oceans. The leatherback sea turtle was federally listed as endangered on June 2, 1970. The leatherback regularly nests in Puerto Rico, the U.S. Virgin Islands, and along the Atlantic coast of Florida. They have been recorded nesting as far north as North Carolina, but only on rare occasions.

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

The Kemp's ridley sea turtle is one of the smallest sea turtles, with adults reaching about 2 feet in length and weighing up to about 100 pounds. The adult Kemp's ridley has an oval carapace that is almost as wide as it is long and is usually olive-gray in color. Hatchlings are black on both sides. Nesting occurs predominantly on Mexico and Texas beaches and rarely on other U.S. beaches. The Kemp's ridley sea turtle was federally listed as endangered on December 2, 1970. In South Carolina, green turtle nesting is possible, but rare.

Counties: Beaufort, Colleton, Charleston, Georgetown, Horry

Seabeach amaranth (*Amaranthus pumilus*)

Seabeach amaranth occurs along the barrier island beaches of the Atlantic Coast. It's range correlates with a zone of low tidal amplitude (USFWS 1996, pp. 4-6). This species appears to need extensive areas of barrier islands and inlets that function in a natural dynamic manner. For instance, many of the remaining extant populations occur on protected barrier islands with functioning inlets (no dams) where there has been little development or hard structure stabilization. Further, seabeach amaranth is often found in the same areas selected for nesting birds such as plovers, terns, and skimmers (USFWS, p. 4).

In South Carolina, the status of seabeach amaranth has fluctuated from eight populations in 1991 to two populations in 2019 (one natural extant population and one reintroduced in Georgetown County). The threats identified in the 1996 Recovery Plan, 2008 and 2018 5-Year Review, including damming of large brown-water rivers, hard structure stabilization (e.g., seawalls, jetties, and groins), and beach stabilization by "soft" structures (sand fences), have negatively impacted this species in South Carolina. Hard stabilization forward of the natural dune line ensures a narrow beach, thereby reducing suitable habitat for seabeach amaranth. Eighteen percent of South Carolina's coast has 90 to 100% sea wall construction. In comparison, North Carolina has discouraged sea wall construction and as a result, only 3 percent of the State developed shoreline is stabilized with hard structures. It is perhaps not surprising that the majority of seabeach amaranth populations occur in North Carolina. The damming of the Santee river greatly reduced the amount of suitable habitat for seabeach amaranth in South Carolina. The Santee River Dam reduced suitable habitat on Cape Romain National Refuge by reducing the amount of Coastal sediment coming to the island thereby reducing natural accretion. Overall, in South Carolina, the remaining extant (natural, not reintroduced) seabeach amaranth population

occurs on a protected barrier island- North Island in Georgetown County. On North Island, seabeach amaranth occurs on an inlet flat where the natural processes are still intact.

Sea level rise due to climate change is noted a threat in the 2018 five-year review (USFWS 2018, p. 42). Further, climate change models predict an increase in storm frequency and intensity. Sea level rise (SLR) will likely reduce the amount of suitable habitat for seabeach amaranth, especially in areas with hard structure stabilization. Studies conducted on piping plover and SLR (Seavey et al. 2011, p. 393), demonstrate that if plover habitat cannot migrate, SLR will likely reduce breeding habitat. Since seabeach amaranth often occurs where piping plovers nest, the results apply to this species as well. To minimize the future impacts from SLR on seabeach amaranth, management should focus on maintaining natural overwash areas, reducing hard and soft stabilization structures to allow natural migration of barrier islands.

Counties: Charleston, Georgetown, Horry

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Eastern Black Rail (*Laterallus jamaicensis jamaicensis*)

The eastern black rail (*Laterallus jamaicensis jamaicensis*) is a subspecies of black rail, the smallest secretive marsh bird and rail species found in North America (Eddleman et al. 1994). The eastern black rail was proposed for listing as threatened under the Endangered Species Act on October 9, 2018. A final listing determination is forthcoming. The eastern black rail is broadly distributed, but occurs in disjunct, localized populations across coastal and interior areas of the United States (east of the Rocky Mountains), and in the Caribbean, Central America, and Brazil. The eastern black rail is wetland-dependent and found in a variety of salt, brackish, and freshwater habitats that can be tidally or non-tidally influenced. Adults are typically 10-15 centimeters (cm) in length with a wingspan of 22-28 cm, and weigh an average 35 grams (Eddleman et al. 1994). Males and females are similar in size, and adults are generally pale to blackish gray, with a small blackish bill and bright red eyes. Average clutch size is seven eggs (Legare and Eddleman 2001), which are laid in a nest bowl constructed of live and dead fine-stemmed plants, often with a canopy and a ramp (Davidson 1992). Nests are typically well hidden in a dense clump of vegetation over moist soil or shallow water (Legare and Eddleman 2001). Adults undergo a complete post-breeding molt each year (Pyle 2008) and are temporarily

unable to fly for approximately three weeks at the end of the breeding season (Eddleman et al. 1994).

Eastern black rails are primarily associated with herbaceous, persistent, emergent wetland plants. The subspecies requires dense overhead cover and soils that are moist to saturated (occasionally dry) and interspersed with or adjacent to very shallow water (typically ≤ 3 cm) to support its resource needs (Eddleman et al. 1994). Shallow pools that are 1-3 cm deep may be the most optimal for foraging and for chick-rearing (Hand 2017, pers. comm.). Eastern black rails occur across an elevational gradient that lies between the lower and wetter portions of estuarine and palustrine marshes and the higher and drier adjacent uplands. Location of individuals across this gradient varies depending on hydrologic conditions. These habitat gradients have gentle slopes such that wetlands are capable of having large areas of shallow inundation (sheet water). These wetlands are able to shrink and expand based on hydrologic conditions and thus provide dependable foraging habitat across the wetted areas and wetland-upland transition zone for the subspecies. Flooding is a frequent cause of nest failure for eastern black rails; therefore, water levels must be lower than nests during egg-laying and incubation in order for nests to be successful. Transition areas also provide critical refugia during flooding events and minimize the risk of predation to black rails when well vegetated (Evens and Page 1986). Eastern black rails fly little during the breeding and wintering seasons, and instead, remain on the ground, running quickly through dense vegetation likely using the runways of rodents and rabbits (e.g., *Microtus* spp.) (Eddleman et al. 1994). Because birds require dense vegetative cover that allows movement underneath the canopy and are found in a variety of marsh habitats with a large salinity range, plant structure is considered more important than plant species composition in predicting habitat suitability (Flores and Eddleman 1995). Eastern black rails forage on a variety of small (<1 cm) aquatic and terrestrial invertebrates, especially insects, and seeds (e.g., *Typha, Scirpus, Spartina* spp.) by gleaning or pecking at individual items.

In South Carolina, eastern black rails are typically found in salt marsh and managed wetland impoundments. Sea level rise, coupled with increasing storm frequency and intensity, have led to increased flooding of these habitats, which has direct and indirect effects on the eastern black rail. Increases in high tide flooding from sea level rise and an increase in flooding from storm and extreme precipitation events impacts eastern black rails by exposing individuals to increased predation and/or causing nest failure. Because birds require dense vegetative cover as protection from predators, increases in predation on black rails have been observed when individuals are forced to emerge from the dense cover to escape flooding (Evens and Page 1986). In South Carolina, both sites known to support eastern black rails experienced multiple severe flooding events in recent years. These events were associated with Hurricane Joaquin (2015); Tropical Storm Hermine and Hurricane Matthew (2016); Hurricane Irma (2017); and Hurricane Florence (2018). The timing of these storm events occurred during the flightless molt period when adults cannot fly and are more vulnerable. In addition, these events took place during raptor fall migration, and rails exposed by flood waters were likely more at risk to raptor predation in particular as a result (Hand 2018). Sea level rise and storm activity also reduces the availability of suitable habitat for the eastern black rail through increased flooding and inundation, saltwater

intrusion, and land subsidence, by affecting the persistence and structure of the plant species that habitats are comprised of. Patches of high salt marsh along the Atlantic Coast, including in South Carolina, that provide nesting and foraging habitat for the bird are projected to be lost or converted to low marsh or open water as a direct result of sea level rise. Sea level rise and storm activity also threaten the long-term maintenance and management of the State's impoundments that support eastern black rails.

Counties: Beaufort, Charleston, Colleton, Georgetown, Jasper

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Red-cockaded woodpeckers (*Picoides borealis*)

Red-cockaded woodpeckers (RCW) were provided protection with the passage of the Endangered Species Act in 1973. The RCW is a territorial, non-migratory species which makes its home in mature and old-growth pine ecosystems in the southeastern United States. Longleaf pines (*Pinus palustris*) are most commonly preferred, but other species of southern pine are also acceptable. While other woodpeckers bore out cavities in dead trees where the wood is rotten and soft, the RCW is the only one which excavates cavities exclusively in living pine trees. Cavities are excavated in mature pines, generally over 60 years old. The older pines favored by the RCW often suffer from a fungus called red heart disease which attacks the center of the trunk, causing the inner wood, the heartwood, to become soft. The younger trees which are not suitable for cavities serve as foraging habitat for the RCW.

RCWs were once considered common throughout the longleaf pine ecosystem, which covered approximately 90 million acres before European settlement. Historical population estimates were 1-1.6 million "groups", inhabiting the open pine forests from New Jersey, Maryland and Virginia to Florida, west to Texas and north to portions of Oklahoma, Missouri, Tennessee and Kentucky. Destruction and fragmentation of mature, open pine forest habitat has been the greatest threat to the RCW. The longleaf pine ecosystem initially disappeared from much of its original range because of early European settlement, widespread commercial timber harvesting, and the naval stores/turpentine industry. Early to mid-1900 commercial tree farming, urbanization, fire suppression, and agriculture contributed to further declines. Much of the current habitat is also very different in quality from historical pine forests in which RCWs evolved as many of the southern pine forests are young while an absence of fire has created a dense pine/hardwood forest.

At one time RCW was extirpated from most private lands by incompatible management practices, such as clearing, agriculture, urbanization and short-rotation pine silviculture. In more recent years private landowners have begun to manage their lands to improve habitat suitable for the RCW contributing to increasing populations. Management agreements and Safe Harbor Plans are being used to conserve RCW on private lands. In addition, many RCW populations that are on public lands are being intensively managed in an attempt to reach population recovery goals. Use of artificial cavities and translocation from recovered populations has proven to be a very valuable management technique.

Most of the RCWs in SC are found within the coastal plain and, as such, are within the reach of major storms. Loss of habitat after a major storm event may devastate local populations through destruction of pine forests, particularly the longleaf pine. For instance, in 1989 Hurricane Hugo hit SC as a Category 5 and devastated hundreds of acres of longleaf pine in the Francis Marion National Forest. The storm uprooted or snapped over 80% of the cavity trees with a loss of approximately 65 percent of the birds.

All of the RCW groups that are found in the eight coastal counties of SC would be at risk during a major storm event such as Hurricane Hugo. Loss of older longleaf pines and younger foraging quality trees poses a high risk to the RCW groups' survival.

Counties: Allendale, Bamberg, Barnwell, Beaufort, Berkeley, Clarendon, Colleton, Dorchester, Florence, Georgetown, Hampton, Horry, Marion, Jasper, Orangeburg, Williamsburg

Wood Stork (*Mycteria Americana*)

The wood stork is a gregarious nesting species, nesting in colonies (rookeries), and roosts and feeds in flocks, often in association with other species of wading birds. Storks that nest in the southeastern United States appear to represent a distinct population, separate from the nearest breeding population in Mexico. Currently, storks are known to nest in North Carolina, South

Carolina, Georgia, and Florida. This U.S nesting population was listed as endangered on February 28, 1984. Under Wood Stork Recovery Plan, downlisting criteria include having an average of 6,000 nesting pairs and annual regional productivity greater than 1.5 chicks per nest per year, calculated over 3 years. Due to increasing nesting success and breeding pair numbers, the stork was reclassified from endangered to the threatened on June 30, 2014. In order to delist the species, the following criteria must be met: an average of 10,000 nesting pairs (50% of historical population) calculated over 5 years beginning at the time of reclassification, annual regional productivity greater than 1.5 chicks per nest per year (also calculated over a 5-year average). In addition, as a subset of the 10,000 pairs, a minimum of 2,500 successful nesting pairs must occur in the Everglades and Big Cypress systems. There is some indication from the recovery team that the species is nearing or has recently crossed the delisting threshold.

Wood storks use freshwater and estuarine wetlands as feeding, nesting, and roosting sites. The most successful nesting years generally follow a very specific hydrologic sequence; with wet winters followed by a slow and continual dry-down during the nesting season. This allows for water to be under nests during the early stages (initiation, incubation, small chicks) that are extremely vulnerable to predation. As chicks get older, drying waterbodies concentrate fish in shallower pools within isolated wetlands, and provide for development of the maximum foraging depths for adult wood storks (13-19cm). Conversely, mid to late season reversals (abundant precipitation), flood wetlands and disperse fish, leading to reduction of catch-per-effort and numerous nest failures via chick starvation.

In South Carolina, storks nest and forage extensively in human-made and managed wetlands. These include old rice impoundments, ponds, ditches, and canals. Many of these habitat types (particularly nesting habitat) are found on private lands, complicating monitoring, maintenance and ultimate recovery capacity of the species in this portion of the range. A common impediment to successful nesting at various rookeries in the state includes the proliferation of aquatic vegetation in shallow impoundments as well as those that are not drained and burned or mechanically managed on a regular basis. Sea level rise and storms such as hurricanes have the potential to affect both nesting and foraging habitat for the species in South Carolina. Sea level rise will inundate coastal wetlands of all types, reducing dramatically the availability of appropriate (shallow) foraging conditions for storks, particularly in bay/estuary habitats such as tidal creeks and sand spits. Sea level rise will also complicate efficient management of rice ponds and waterfowl areas, which are extremely valuable sources of food for storks in the state. Hurricanes are becoming more and more of an issue in South Carolina, and threaten to impact wood storks primarily via increased precipitation and low prey concentration during the fall, when inexperienced fledgling storks are attempting to forage and survive on their own.

Counties: Allendale, Bamberg, Barnwell, Beaufort, Berkeley, Clarendon, Colleton, Dorchester, Florence, Georgetown, Hampton, Horry, Marion, Jasper, Orangeburg, Williamsburg,

West Indian Manatee (*Trichechus manatus*)

The West Indian Manatee is protected as threatened under the Endangered Species Act and under the Marine Mammal Protection Act. There are two subspecies of West Indian manatees: The Antillean manatee (*Trichechus manatus manatus)* and the Florida manatee (*Trichechus manatus latirostris*). Within areas under U.S. jurisdiction, the threatened West Indian manatee can be found in the southeastern U.S. and in the U.S. Caribbean. The Florida subspecies is commonly found in Florida and may range as far north as Massachusetts and as far west as Texas. The Antillean subspecies is commonly found in Puerto Rico and, on very rare occasions, may range as far east as the U.S. Virgin Islands (USVI).

Each spring, small numbers of Florida manatees migrate north with the onset of warm weather and spend the warmer months in the coastal waters of South Carolina feeding on the abundant marsh grasses. When the weather cools again the manatees return to the warmer waters of Florida for the winter months. In some cases, manatees have been attracted to the warm water outfalls located in South Carolina waters and stay too long at these outfalls and once the ambient water temperatures drop below 68º F they are unable to return to Florida on their own. Due to cold ambient temperatures and lack of nearby food these outfall do not have the ability to sustain manatees throughout the full winter and rescue efforts have had to take place.

The number of Florida manatees inhabiting South Carolina waters in the warmer months is thought to be increasing and may be as high as 60-80 individuals. They occupy coastal marsh habitat, feeding on the marsh grasses, along the coast from Horry County to Beaufort County. Many of the sighting reports and telemetry studies show they are more frequent in the areas around Charleston and in the Cooper River and the Hilton Head area.

Sea-level rise poses some threat to the Florida manatee in South Carolina. As sea-levels rise the amount of food available to manatees in South Carolina waters may decrease. Coastal marshes will need to move further inland to account for the rise in sea levels and due to urban development many of South Carolina's marshes may not have much room to migrate. This is known as a squeezing effect. With the loss of food manatees may need to migrate further north in search of food, which makes their return to Florida waters in the fall even more perilous. The decrease in food resources in the warmer months could lead to a decrease in body condition, putting more individuals at risk of other threats.

Counties: Beaufort, Berkeley, Colleton, Charleston, Dorchester, Georgetown, Horry, Jasper,

Georgia

Federally Listed Threatened and Endangered Species

Georgia Beach Ecosystem

Georgia has approximately 100 miles of coastline and beaches. Approximately 18 miles (~20%) are on the four developed barrier islands that have road access from the mainland. These have various armoring or hardening over most if not all of their length. The beach locations are fixed by property lines and development. Some beach renourishment occurs periodically. The rest of our beaches have some form(s) of land conservation protections. These are considered to be mostly in natural states. The shape of these constantly changes responding to a variety of forces; tides, waves, erosion and accretion, wind, longshore currents, fluctuations in sea level, weather events, and other forces. Georgia's position, the furthest coastline west in the South Atlantic Bight, causes high tidal amplitudes. In this ecosystem occur shorebirds and nesting sea turtles listed under the Endangered Species Act (ESA) of 1973, as amended; (16 U.S.C. 1531 *et seq.*), and other shore and sea birds of concern.

Piping Plover *(Charadrius melodus)*

The piping plover *(Charadrius melodus)* is a small shorebird that has three separate breeding populations named or identified for their breeding locations. When in their breeding locations, the Great Lakes population is ESA listed as endangered, and the Atlantic Coast and Northern Great Plains populations are listed as threatened. All three populations are considered threatened when not on the Great Lakes population breeding range.

Georgia coastal beaches are wintering habitat for birds from all three populations as well as a migratory stop-over for some birds going to other wintering habitats. Migrants are indistinguishable from wintering birds. All piping plovers, regardless of breeding population are considered ESA threatened while in Georgia. Critical habitat (CH) has been designated on portions of Georgia's barrier island beaches. Some islands, generally the developed ones have only the ends of the islands designated, while some of the undeveloped islands have the entire beach designed as CH.

Piping plovers spend up to 10 months of their life cycle on their migration and winter grounds, July 15 through as late as May 15 (USFWS 2010). Southward migration from the breeding ground occurs from July to September, with the majority of birds having migrated by August (USFWS 1996, USFWS 2003). In Georgia, foraging habitat for piping plovers is the moist or wet sand of inter-tidal beaches and tidal flats. Sheltering and roosting habitat is beaches and dunes above the annual high tide. Habitat loss and degradation on the migration and wintering grounds continues to be a serious threat to the species. Since plovers spend at least two-thirds of their annual life cycle as non-breeders, their survival and recovery are fundamentally dependent on the continued availability of sufficient habitat in their migration and wintering range.

The fact that Georgia's coast is relatively undeveloped and has limited shoreline hardening should allow the coast to migrate and adjust better than the more developed shorelines of other states as sea level continues to increase. However, portions of our coast with beach development and shoreline hardening will likely lose their beaches. Another concern is the rapidity with which sea level rise (SLR) is predicted to occur. Establishment of new beaches may not be able to keep pace with net loss of these habitats, thereby significantly reducing the amount of habitat available for these highly specialized birds.

Counties: Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden.

Red Knot (*Calidris canutus rufa)*

The rufa red knot *(Calidris canutus rufa)*(red knot) is ESA listed as threatened. The *rufa* is one of six subspecies of the red knot and the only one to occur in Georgia. No critical habitat has been designated for the red knot. In Georgia, the red knot occupies the same habitat as the piping plover discussed previously. Foraging habitat for both species of listed shorebirds is the moist or wet sand of inter-tidal beaches and tidal flats. Sheltering and roosting habitat is beaches and dunes above the annual high tide. The red knot nests in the summer in the far north, mostly well above the Arctic Circle in Canada, Europe, and Russia. During other seasons, it is strictly coastal, migrating south after breeding to large sandy estuaries and beaches around the world referred to as 'winter habitat'. In Georgia, the mouth of the Altamaha River supports the only known late summer and fall staging site for migrating red knots on the east coast of the United States of America (USA), attracting as many as 12,000 birds at one time. Loss of food resources at Georgia stopover sites is a primary threat to the species, as is habitat loss caused by beach armoring structures that alter and interfere with the natural dynamics of sand deposition.

The fact that Georgia's coast is relatively undeveloped and has limited shoreline hardening should allow the coast to migrate and adjust better than the more developed shorelines of other states as sea level continues to increase. However, portions of our coast with beach development and shoreline hardening will likely lose their beaches. Another concern is the rapidity with which sea level rise is predicted to occur. Establishment of new beaches may not be able to keep pace with net loss of these habitats, thereby significantly reducing the amount of habitat available for these highly specialized birds.

Counties: Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden.

Other shorebird and seabird species of concern

The Western Hemisphere Shorebird Reserve Network (WHSRN) and Manomet, a nonprofit organization using science to solve problems, designated Georgia's coast as a landscape of hemispheric importance for shorebirds. This is more significant than regional or international importance designations, indicating 500,000 or more individual shorebirds or 30% of a population use the area. The Georgia Barrier Islands WHSRN Landscape was designated due to

its supporting more than 30% of the population of both rufa red knot and the Great Lakes breeding population of piping plover. The area also holds more than 10% of the biogeographic populations of American oystercatcher *(Haematopus palliates)* (120 nesting pairs, 1200 wintering individuals), short-billed dowitcher *(Limnodromus griseus)* (maximum count of 14,608 individuals) and black-bellied plover *(Pluvialis squatarola)* (midwinter high count of 10,364). Other noteworthy attributes include one of the largest spring gatherings of whimbrel *(Numenius phaeopus)* in North America, and impressive numbers of wintering shorebirds of many other species including the gull-billed tern (*Gelochelidon nilotica*), and least tern *(Sternula antillarum)*. "For shorebirds dependent on the U.S. Atlantic Coast, Georgia supports a complex mosaic of important habitat that provides food and resting places 12 months of each year," says Manomet's Brad Winn.

Sea level rise is anticipated to couple with increased density (compression and growth) of human development near the coast as available land is decreased. Current areas utilized by all species have some protections; federal, state, or private groups. These areas may be lost due to rising sea levels. Many of the areas landward of them are developed or poised for development. They are not controlled by conservation minded organizations whose goals are to provide habitat for species other than man.

One type of landward area located in the estuaries and tidal creeks behind the barrier islands are shell rakes. This habitat is used by 40% of the American oystercatchers in Georgia. The elevation of these varies but is generally only slightly above the current high tides. These sites are valued for bird usage as they are less erosional than sand islands. These will be some of the first habitats to become inundated and become un-useable with SLR and higher tides.

Extreme storms have the capability to eliminate current offshore bars from the Georgia landscape reports Tim Keyes, wildlife biologist with the Georgia Department of Natural Resources (GADNR). These are important nesting areas for many of the above mentioned shore and sea bird species with the potential for high productivity in times when storms do not coincide with nesting. These species also nest on beaches, and back islands and shell rakes behind the barrier islands. However all these locations have a much higher incidence of nest predation than the offshore bars.

Beneficial use of dredge material to create or enhance; nearshore feeder berms for beaches, offshore bars, shorebird nesting islands, and possibly marsh thin layer placement have the possibility to offset some of the above mentioned habitat loses.

Counties: Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden.

Sea Turtles

Georgia has five species of sea turtles occurring in its marine and estuarine waters. Sea turtle nesting on Georgia beaches is primarily limited to the loggerhead sea turtle *(Caretta caretta)* (loggerhead) with 99.5% of the recorded nests based on a 10-year average from seaturtle.org

data. The Northwest Atlantic Ocean distinct population segment (DPS) of the loggerhead is listed by the ESA as threatened. For the purpose of this study, the loggerhead will serve as our representative species (nesting sea turtles as a group). The other species nesting in Georgia, 0.5% of nests, are the green sea turtle *(Chelonia mydas)* ESA listed threatened, Kemp's ridley sea turtle *(Lepidochelys kempii)* ESA listed endangered, and the leatherback sea turtle *(Dermochelys coriacea)* ESA listed endangered.

The hawksbill sea turtle *(Eretmochelys imbricata)* occurs in Georgia waters but has not been documented as nesting or crawling on the beach in the state. It is ESA listed as endangered. The National Marine Fisheries Service (NMFS) has federal jurisdiction for all sea turtle species in the water. The U.S. Fish and Wildlife Service (Service) has jurisdiction when sea turtles are out of the water on beaches. For an expert opinion on all sea turtles in the water and their aquatic environment consult with NMFS.

Sea turtle nesting season in the state is May 1- August 31, and hatching extends to October 31. Nests take approximately 60 days to hatch. Nesting habitat includes both sandy beach and any sandy areas that wrap around the north and south ends of islands. Sea turtles have some site fidelity to their nesting beaches. A primary threat to these species is loss or degradation of nesting habitat. Most of Georgia’s undeveloped beaches are designated critical habitat for the loggerhead. There is no critical habitat for any other sea turtle species on Georgia beaches.

The fact that Georgia’s coast is relatively undeveloped and has limited shoreline hardening should allow the coast to migrate and adjust better than the more developed shorelines of other states as sea level continues to increase. However, portions of our coast with beach development and shoreline hardening will likely lose their beaches. Another concern is the rapidity with which SLR is predicted to occur. Establishment of new beaches may not be able to keep pace with net loss of these habitats, thereby significantly reducing the amount of habitat available for nesting sea turtles.

Rising sea levels are anticipated to couple with increased density (compression and growth) of human development near the coast as available land is decreased. Current areas utilized by nesting turtles have some protections; federal, state, or private groups. These areas may be lost due to SLR. Many of the areas landward of them are developed or poised for development. They are not controlled by conservation minded organizations whose goals are to provide habitat for species other than man.

Extreme storms during nesting season are likely to include storm surge or extreme tides. These type events can impact large portions of the Georgia coast at one time. Similarly, a storm moving along the coast can impact the entire 100 miles of loggerhead nesting habitat in Georgia. A loggerhead nest is vulnerable to storm inundation drowning eggs and pre-emergent hatchlings for 60-days from creation to hatchlings leaving the nest. Data over a 10-year period indicated a correlation between decreased hatching success, increased tropical storm intensity, and increased number of nests inundated (Van Houtan K. and Bass O., 2007).

Counties: Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden.

Georgia Coastal Tidal Marsh

Inland from Georgia's beaches and barrier islands Georgia has one third of the tidal saltmarsh that occurs on the east coast of the USA. It is estimated at more than 378,000 acres and more than any other state (Seabrook C., 2019). This vast area is a highly valued natural community. Georgia's salt marshes are some of the most biologically productive natural systems on Earth. They produce nearly twenty tons of biomass to the acre—which makes them four times more productive than the most carefully cultivated cornfields, according to the Georgia Department of Natural Resources. The enormous productivity helps to make the salt marshes primary nursery areas for blue crabs, oysters, shrimp, and other economically important fish and shellfish. Young shrimp and other marine organisms also use salt marshes as shelters and hiding places from predators. In addition, salt marshes help filter pollutants from the water and act as buffers against offshore storms. The potential damage from large storm-spawned waves and tides is greatly reduced when they pass over the marshes. This highly productive ecosystem is habitat for the manatee.

West Indian Manatee *(Trichechus manatus)*

The West Indian manatee *(Trichechus manatus)* is ESA protected as threatened and also protected under the Marine Mammal Protection Act of 1972, (16 USC 1361-1407). It is found in tropical and subtropical coastal and river waters along the southeast U.S. coast, the Caribbean coast of Central and South America, and locally throughout the West Indies. The Florida manatee subspecies (*Trichechus manatus latirostris*) (manatee) is a year-round resident in Florida. During the warm months, an unknown portion of the Florida manatee population migrates northward into Georgia and the Carolinas, and westward along the Gulf coast into Alabama, Mississippi, and Louisiana. Manatees are most frequently sighted in Georgia tidal waters from mid-March through late November. Their numbers are greater in waters of the southern coastal counties of Camden, Glynn and McIntosh and lesser in the northern coastal counties of Liberty, Bryan, and Chatham.

Adult manatees average 10 feet long and weigh about 2,200 pounds, although some individuals have been recorded at lengths greater than 13 feet and weighing as much as 3,500 pounds. They commonly forage on saltmarsh cordgrass *(Spartina alterniflora)*. This is Georgia's dominant marsh plant, and the most important primary producer for saltmarsh ecosystems along the east coast (Pomeroy et al., 1981).

Manatee habitats in Georgia include nearshore ocean waters, tidal creeks, estuaries, and the lower reaches of the St. Mary's, Satilla, Altamaha, Ogeechee, and Savannah Rivers in varying salinity extremes. Manatees are difficult to detect in coastal Georgia's dark turbid waters. During winter, manatees are attracted to warm water refuges. Most manatees in Georgia waters migrate to refuges in Florida as water temperatures drop to 17* Celsius. Manatees are attracted to warm water discharges at industrial sites, such as power generating plants and factories and have been documented at may such locations in Georgia. Due to cold surrounding water and limited nearby

food these discharges generally do not have the ability to sustain manatees through the winter and rescue efforts have had to take place. There is no CH designated in Georgia for manatees.

Rising sea levels pose some threat to the manatee in Georgia. As sea levels rise the number of acres of saltmarsh or amount of food available to manatees in Georgia waters may decrease. Coastal marshes will need to migrate inland. However, they may not be able to keep up with the rate of SLR. Additionally, due to current urban development and future development during the same time as SLR is occurring, many of Georgia's marshes may not have much room to migrate. This has been termed 'coastal squeeze'. Georgia has the most marsh to loose on the east coast. With the loss of forage, manatees may need to migrate further north in search of food, which makes their return to Florida waters in the fall a longer migration. The decrease in food resources in the warmer months could lead to a decrease in vigor, putting individuals at risk of other threats.

Kerry Emanuel, professor of atmospheric science at the Massachusetts Institute of Technology states that climate change models predict that the intensity of hurricanes will increase with increasing global mean temperature. Langtimm et al. (2006) found that mean adult manatee survival dropped significantly in years after intense hurricanes and winter storms. These decreases were thought to be due to tidal stranding, animals being swept out to sea, loss of forage, or emigration of animals out of affected areas (Langtimm et al. 2006).

Counties: Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden.

Red-cockaded Woodpecker *(Picoides borealis)*

The red-cockaded woodpecker *(Picoides borealis)* (RCW) is ESA listed as endangered. The RCW lives in mature pine forests - 80 to 120-year-old longleaf pine (*Pinus palustris*) are preferred, but any of the southern yellow pine species trees over 60 years old are acceptable. From the late 1800s to the mid-1900s, RCWs declined rapidly as habitat was altered, primarily for timber and agricultural use. RCWs excavate cavities exclusively in living pine trees, preferring older pines infected with the fungal red heart disease that softens heartwood. RCWs live in groups with a breeding pair and as many as four helpers, usually male offspring from the previous year. Cavity trees occupied by a group are called a cluster and may include 1 to 20 or more trees on 3 to 60 acres. Each RCW group needs about 200 acres of old pine forest to support foraging and nesting habitat needs.

RCWs play a vital role in the intricate web of life of southern pine forests. A number of birds and mammals use the nest cavities that the woodpeckers excavate. Larger woodpeckers may take over a RCW cavity, sometimes enlarging the hole enough to allow screech owls, wood ducks, and even raccoons to move in. Flying squirrels, several species of reptiles and amphibians, and insects, primarily bees and wasps, also use red-cockaded cavities.

Primary threats to RCWs include loss of old growth pine forests, short-rotation pine production that precludes trees old enough to provide nest cavities, and exclusion of fire, which creates a dense pine/hardwood forest that the RCW does not consider to be suitable habitat.

Approximately one third of the RCWs in Georgia are found in coastal plain counties that may be affected by extreme storm events coming in from the Atlantic Ocean. The birds are primarily at Fort Stewart Army Base and Okefenokee National Wildlife Refuge. Loss of habitat after a major storm event may devastate local populations through destruction of pine forest habitat, particularly the longleaf pine. In example, in 1989 Hurricane Hugo made landfall in South Carolina as a Category 5 storm and devastated hundreds of acres of longleaf pine in the Francis Marion National Forest. The storm uprooted or snapped over 80% of the RCW cavity trees with a loss of approximately 65 percent of the birds.

All of the RCW groups found in coastal Georgia would be at risk during a major storm event such as Hurricane Hugo. More importantly, the loss of longleaf pines over 60 years old and somewhat younger foraging quality trees poses a high risk to any RCW groups' survival due to habitat destruction. Replacement of RCW habitat takes over 60 years to grow. Any catastrophic event such as wildfire, pine beetles, or another storm during the 60 years may require starting over again. Replacing the lost RCW habitat would likely take longer and more effort than the recruitment of birds to 'replace' individuals lost to any storm.

Counties: Camden, Liberty, Bryan, Chatham, Charlton, Brantley, Long, and Effingham.

Wood Stork *(Mycteria americana)*

The wood stork *(Mycteria americana)* is ESA listed as threatened. The wood stork is a large, bald-headed wading bird that stands more than 3 feet tall, has a 5-foot wing spread, and weighs 4 to 6 pounds. It is the only stork that breeds in the U.S. It eats primarily fish, foraging in a variety of open, shallow freshwater and estuarine wetlands. It favors areas with falling water levels (when fish and other prey are likely to be more concentrated in pools). Birds forage mainly by wading in shallow water with their bills partly open in the water, so they can quickly snap them shut when contact is made with prey.

The wood stork is a highly colonial species usually nesting in large rookeries with other species of colonial wading birds and feeding in flocks with those same birds. Colony size in Georgia has ranged from fewer than 12 to more than 500 nests. Nests may be located in any size trees that will support the nest and birds. Generally the trees are in standing water or on islands surrounded by water to protect from predators. Nesting periods vary geographically. In Georgia storks lay eggs in March to late May, with fledging occurring July to August. Wood storks have nested in man-made structures. A wood stork tends to use the same colony site over many years, as long as the site remains undisturbed, and there is sufficient feeding habitat in the surrounding wetlands. Wood storks may abandon traditional wetland sites once local or regional drainage schemes remove surface water from beneath the colony trees.

After breeding, wood storks in Georgia generally disperse away from the nesting colonies. They may be found anywhere in Georgia's and the Southeast U.S.'s coastal plain and Piedmont with suitable foraging wetland habitats. Some of the storks that nest in Georgia move south into Florida and into the Everglades when cold weather arrives and return to Georgia in the spring, while others may remain in Georgia year around using the coastal wetlands during the winter months.

The stork population is dependent on, among other factors, breeding success. This involves successful foraging near the rookery site for the chicks before they fledge and are able to forage for themselves. Tidal creeks are an important forage area for many of the Georgia rookeries. As sea-levels rise the amount of tidal creek habitat and associated acres of saltmarsh in Georgia estuaries may decrease. Coastal marshes and associated creeks will need to migrate inland. However they may not be able to keep up with the rate of SLR. Additionally, due to current urban development and future development during the same time as SLR is occurring, many of Georgia's marshes may not have much room to migrate. This has been termed 'coastal squeeze'. Georgia has the most marsh to loose on the east coast. With reduced forage, wood storks may abandon coastal rookeries. That is, the quality of the coastal habitat for wood storks may be diminished.

Extreme storms may destroy rookery sites (nest trees) and depending on time of the year; active rookeries. Storms occurring while chicks are flightless in the nest have caused mortality and decreased nesting productivity. Storms raise water levels causing prey to become less concentrated reducing the quality of foraging sites especially for inexperienced recently fledged young storks.

Counties: Brantley, Camden, Chatham, Glynn, McIntosh, Liberty, and Long.

Other Colonial Nesting Wading Bird Species of Concern

The wood stork is one species of a guild of birds referred to a colonial nesting wading birds. Other species of colonial wading birds found in Georgia include: black-crowned night-heron (*Nycticorax nycticorax*); glossy ibis (*Plegadis falcinellus*); great blue heron (*Ardea herodias*); great egret (*Casmerodius albus*); green heron (*Butorides virescens*); little blue heron (*Egretta caerulea*); roseate spoonbill (*Platalea ajaja*), snowy egret (*Egretta thula*); tricolored heron (*Egretta tricolor*); white ibis (*Eudocimus albus*), yellow-crowned night-heron (*Nyctanassa violacea*), and anhinga (*Anhinga anhinga*). As the name suggests, colonial wading birds nest in large colonies; hundreds of birds can nest in a group of trees. These colonies may or may not include the wood stork. The colony sites and birds do have the same general characteristics as the wood stork and their habitat.

The colonial wading bird population is generally subject to the same threats as the wood stork. They are dependent on, among other factors, breeding success. This involves successful foraging near the rookery site for the chicks before they fledge and are able to forage for themselves.

Tidal creeks are an important forage area for many of the Georgia rookeries. As sea-levels rise the amount of tidal creek habitat and associated acres of saltmarsh in Georgia estuaries may decrease. Coastal marshes and associated creeks will need to migrate inland. However they may not be able to keep up with the rate of SLR. Additionally, due to current urban development and future development during the same time as SLR is occurring, many of Georgia's marshes may not have much room to migrate. This has been termed 'coastal squeeze'. Georgia has the most marsh to loose on the east coast. With reduced forage, colonial wading birds may abandon coastal rookeries. That is, the quality of the coastal habitat for the birds may be diminished.

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Counties: Brantley, Camden, Charlton, Chatham, Glynn, Liberty, Long, McIntosh, and Wayne.

Gopher Tortoise *(Gopherus polyphemus)*

The gopher tortoise *(Gopherus polyphemus)* is an ESA candidate species in Georgia. There is sufficient information on candidate species biological status and threats to be proposed as endangered or threatened under the ESA, but for which development of a proposed listing regulation is precluded by other higher priority listing activities.

The gopher tortoise is a reptile that is found in coastal plain upland habitats with well-drained, sandy soils, an abundance of diverse herbaceous ground cover, and an open canopy which allows sunlight to reach the ground. The gopher tortoise excavates extensive underground burrows that provide shelter from winter cold and summer desiccation. On suitable habitat, groups of tortoises dig burrows nearby each other to form gopher tortoise colonies. The gopher tortoise is seen as a keystone species because its' burrows provide shelter for over 300 other animal species.

The factors for soil suitability for gopher tortoise burrows include depth to the water table and frequency of flooding. Sea level rise could potentially raise the water table and decrease the depth to groundwater in some locations (Walter, D. *et.al*., 2016). This may adversely affect the suitability of sites for the gopher tortoise. Extreme storm events may increase the severity and/or frequency of flooding of burrows thereby reducing the suitability of sites for tortoises.

Counties: Camden, Glynn, McIntosh, Liberty, Bryan, Chatham, Charlton, Brantley, Wayne, Long, and Effingham.

Eastern Indigo Snake *(Drymarchon couperi)*

The eastern indigo snake *(Drymarchon couperi)* is ESA listed as threatened. The indigo snake in Georgia is closely associated with the gopher tortoise, a reptile that excavates extensive underground burrows that provide the snake shelter from winter cold and summer desiccation.

Eastern indigo snakes utilize two different habitats during the year. In warm months, indigo snakes forage during the day on the edge of wetlands where frogs and other snakes typically are abundant. In Georgia adult snakes overwinter in gopher tortoise burrows on sandhills, exhibiting site fidelity. They have large home ranges and may range one to four miles between wintering and summer habitats. Breeding occurs November - April, and females often place eggs in the moist sand of tortoise burrows. Threats to EIS include loss and fragmentation of sandhill habitats that support tortoises and declining gopher tortoise populations.

As SLR and extreme storms may reduce the area of gopher tortoise habitat, this would also impact the availability of wintering habitat for the eastern indigo snake - gopher tortoise burrows.

Counties: Camden, McIntosh, Liberty, Bryan, Charlton, Brantley, Wayne, Long, and Effingham.

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Florida

Federally Listed Threatened and Endandgered Species

Mammals

Mammals
Florida Salt Marsh Vole (*Microtus pennsylvanicus dukecampbelli)*

The endangered Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli)* is found in Levy County. It is a short-tailed rodent with a blunt head and short ears. Its fur is black-brown dorsally and dark gray ventrally. It is closely related to the meadow vole (*M. p. pennsylvanicus*) but can be distinguished by its larger size, darker coloration, relatively small ears, and by certain skull characteristics.

County: *Levy*

Florida Bonneted Bat (*Eumops floridanus*)

The endangered Florida bonneted bat (*Eumops floridanus*) is a member of the Molossidae (free-tailed bats) family within the order Chiroptera. This species is the largest bat in Florida, the Florida bonneted bat is highly variable in color ranging from black to brown to brownish-gray or cinnamon brown with ventral pelage, with short glossy fur.

Counties: *Broward, Charlotte, Collier, DeSoto, Glades, Hardee, Hendry, Highlands, Indian River, Lee, Martin, Miami-Dade, Monroe, Okeechobee, Osceola, Palm Beach, Polk, Sarasota*

Florida Panther (*Puma concolor coryi)*

The endangered Florida panther (*Puma concolor coryi)* is a large, long-tailed cat with a great deal of color variation: pale brown or rusty upper parts, dull white or buffy under parts; tail tip, back of ears, and sides of the nose are dark brown or blackish. Mature male panthers have been examined in the wild in Florida since 1978, their weight can range from 102 - 154 pounds, and measure nearly 7 feet from tip to tail. Females are considerably smaller, with a weight range of 50 to 108 pounds and measuring about 6 feet. Their historical range includes Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Tennessee.

Counties: *Broward, Charlotte, Collier, DeSoto, Glades, Hardee, Hendry, Highlands, Indian River, Lee, Martin, Miami-Dade, Monroe, Okeechobee, Osceola, Palm Beach, Polk, Sarasota, St. Lucie*

Key Deer (*Odocoileus virginianus clavium)*

The endangered Key deer (*Odocoileus virginianus clavium)* is the smallest race of North American deer. Adults measure 25 to 30 inches at the shoulder and have an average weight of 55 to 75 pounds for males and 45-65 pounds for females. The body is stockier, legs shorter, and skull wider than other races of white-tailed deer. The coat varies from a deep reddish brown to a grizzled, gray color. Bucks usually have antlers by their second year, and eight points by the fifth. The Key deer's primary food source is the red mangrove (Rhizophora mangle), but approximately 6O other plants are also known to form part of its diet. Possibly most of the available plant species are used at one time or another. The selection of some food plants changes seasonally, probably reflecting availability and nutritional needs. Other plants are browsed almost continuously resulting in their stunting and near extirpation.

County: *Monroe*

Key Largo Cotton Mouse (*Peromyscus gossypinus allapaticola*)

The endangered Key Largo cotton mouse (*Peromyscus gossypinus allapaticola*) is brown on top with white underparts. It has large ears, protuberant eyes, and a furry tail. This mouse is a nocturnal feeder, existing on the buds, fruits, and seeds of many plant species.

County: *Monroe*

Key Largo Woodrat - Endangered

The endangered Key Largo woodrat (*Neotoma floridana smalli*) is a medium-sized (2OO-26O gram) small mammal with a gray-brown back and head. Its belly, chest, and throat are white, and the tail is hairy. This species is a nocturnal herbivore, feeding on the buds, leaves, and fruit of many plant species. Food may be stored in the stick nests built by this species.

County: *Monroe*

Lower Keys Marsh Rabbit (*Sylvilagus palustris hefneri*)

The endangered Lower Keys rabbit (*Sylvilagus palustris hefneri*) is a subspecies of the marsh rabbit (*S. palustris*), a species widespread in the southeastern United States. The Lower Keys rabbit is distinguished from the adjacent subspecies, *S.p. paludicola*, in skull proportions and sculpturing and in its darker coloration (Lazell 1984). The Lower Keys rabbit is about 16 inches in length, with brownish dorsal and greyish ventral fur.

County: *Monroe*

Silver Rice Rat (*Oryzomys palustris natator*)

The endangered silver rice rat (*Oryzomys palustris natator*) is of generalized rat-like appearance, with a slender skull and coarse fur which is colored silver-gray along its back. This rat has a sparsely-haired tail and reaches 250 millimeters (10 inches) in total length.

County: *Monroe*

Gray Bat (*Myotis grisescens*)

The endangered gray bat (*Myotis grisescens*) has long, glossy fur, light brown to brown in color. Its ears are dark, usually black; longer than in any other myotis; when laid forward extend 1/4 cm (7 mm) beyond nose. Its tragus is long and thin, and calcar keeled. The species historical range included Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kansas, Kentucky, Missouri, Oklahoma, Tennessee, Virginia, West Virginia.

Counties: *Holmes, Jackson, Leon, Washington*

Indiana Bat (*Myotis sodalis*)

The endangered Indiana bat (*Myotis sodalis*) is a medium-sized myotis, closely resembling the little brown bat (*Myotis lucifugus*) but differing in coloration. Its fur is a dull grayish chestnut rather than bronze, with the basal portion of the hairs on the back a dull-lead color. This bat's underparts are pinkish to cinnamon, and its hind feet are smaller and more delicate than in *M. lucifugus*. The calcar (heel of the foot) is strongly keeled. The species historical range included Alabama, Arkansas, Connecticut, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia.

County: *Jackson*

Choctawhatchee Beach Mouse (*Peromyscus polionotus allophrys*) - Critical Habitat

The endangered Choctawhatchee beach mouse (*Peromyscus polionotus allophrys*) has a small body, haired tail, relatively large ears, and protuberant eyes. Head and body length is 2.7 to 3.5 inches; tail length is 1.7 to 2.5 inches. The upper parts are colored orange-brown to yellow-brown, the underparts are white, and the tail has a variable dorsal stripe. A nocturnal herbivore, this beach mouse probably feeds primarily on the seeds of sea oats and bunch-grass. Arthropods are eaten seasonally in spring and summer. To date, no studies on life history or ecology have been conducted on this species.

Counties: *Bay, Okaloosa, Walton*

Saint Andrew Beach Mouse (*Peromyscus polionotus peninsularis*) - Critical Habitat

The St. Andrew beach mouse (*Peromyscus polionotus peninsularis*) is one of seven subspecies of beach mice that occur only in coastal sand dunes where they excavate burrows and feed on plant seeds and insects. Unlike house mice, beach mice do not seek out human dwellings or other structures for food and shelter. This species has a very pale, buff-colored head and back with extensive white coloration underneath and along the sides, with two distinct rump color pigmentations, one a tapered and the other a squared pattern, which extended to the thighs. In specimens studied, the head and body lengths average 2.95 in (7.5 cm), tail mean length 2.05 in (5 cm), and hind foot mean length 0.73 in (2 cm). Trap surveys indicate that the St. Andrew beach mouse is found on frontal dunes as well as on primary and secondary dunes. The habitat is dominated in part by plants whose seeds and fruits are important seasonal components of the beach mouse diet.

Counties: *Bay, Gulf*

Perdido Key Beach Mouse (*Peromyscus polionotus peninsularis*) - Critical Habitat

The endangered Perdido Key beach mouse (*Peromyscus polionotus peninsularis*) has a small body, haired tail, relatively large ears, and protuberant eyes. Its head and body length is 2.7 to 3.3 inches; the tail length is 1.7 to 2.5 inches. The upper parts are colored grayish fawn to wood brown with a very pale yellow hue and an indistinct middorsal stripe. The white of the underparts reaches to the lower border of the eyes and ears, and the tail is white to pale grayish brown with no dorsal stripe. This species is a nocturnal herbivore. Beach mice feed primarily on the seeds of sea oats (*Panicum repens*) and beach grass (*Panicum amarums*). When these seeds are scarce, especially in the late winter or early spring, beach mice may consume invertebrates (Ehrhart in Layne, 1978) or fruiting bodies of sea rocket (Cakile) sp. (U.S. Fish and Wildlife Service, 1987).

The species historical range included Alabama, Florida.

County: *Escambia*

Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)

The threatened Southeastern beach mouse (*Peromyscus polionotus niveiventris*) is the largest beach mouse; it averages 139 millimeters in total length and 52 millimeters in tail length. Although it is darker and more buffy than the Anastasia Island beach mouse, it is still lighter than most inland subspecies of the oldfield mouse.

Counties: *Brevard, Broward, Indian River, Martin, Palm Beach, St. Lucie, Volusia*

West Indian Manatee (*Trichechus manatus*) - Critical Habitat

Manatees are protected under the Endangered Species Act as threatened and under the Marine Mammal Protection Act, which prohibits the take (i.e., harass, hunt, capture, or kill) of all marine mammals. The West Indian manatee (*Trichechus manatus*) includes two distinct subspecies, the Florida manatee (*Trichechus manatus latirostris*) and the Antillean manatee (*Trichechus manatus manatus*). While morphologically distinctive, both subspecies have many common features. Manatees have large, seal-shaped bodies with paired flippers and a round, paddle-shaped tail. They are typically grey in color (color can range from black to light brown) and occasionally spotted with barnacles or colored by patches of green or red algae. The muzzle is heavily whiskered and coarse, single hairs are sparsely distributed throughout the body. Adult manatees, on average, are about nine feet long (3 meters) and weigh about 2,200 pounds (1,000 kilograms). At birth, calves are between three and four feet long (1 meter) and weigh between 40 and 60 pounds (30 kilograms). It is found in tropical and subtropical coastal and river waters along the southeast U.S. coast, the Caribbean coast of Central and South America, and locally throughout the West Indies. Manatees are commonly found in fresh, brackish, or marine water habitats, including shallow coastal bays, lagoons, estuaries, and inland rivers of varying salinity extremes. Manatees spend much of their time underwater or partly submerged, making them difficult to detect even in shallow water. The species historical range included Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, Puerto Rico, South Carolina, and Texas. Rising sea levels pose a threat to manatees in Florida. As sea levels rise, coastal marshes will be inundated and need to migrate inland, reducing the acres of salt marsh and amount of food available to manatees. Additionally, due to coastal development, many of the habitats occupied by manatees will be squeezed between the rising sea levels and hard infrastructure, further reducing the available habitat and food available to the manatee.

Counties: *Bay, Brevard, Broward, Charlotte, Citrus, Clay, Collier, DeSoto, Dixie, Duval, Escambia, Flagler, Franklin, Glades, Gulf, Hendry, Hernando, Highlands, Hillsborough, Indian River, Jefferson, Lake, Lee, Leon, Levy, Manatee, Marion, Martin, Miami-Dade, Monroe, Nassau, Okaloosa, Okeechobee, Palm Beach, Pasco, Pinellas, Putnam, Santa Rosa, Sarasota, Seminole, St. Johns, St. Lucie, Taylor, Volusia, Wakulla, Walton*

Anastasia Island Beach Mouse (*Peromyscus polionotus phasma*)

The Anastasia Island beach mouse (*Peromyscus polionotus phasma*) and the Southeastern beach mouse are two of six existing coastal subspecies of the oldfield mouse (*Peromyscus polionotus*). The oldfield mouse is a wide-ranging species in the Southeast. One of the largest species of beach mice (averaging 138.5 millimeters in length and 53 millimeters in tail length), Anastasia Island beach mouse is much paler than most inland races of the oldfield mouse.

County: *St. Johns*

Florida Salt Marsh Vole (*Microtus pennsylvanicus dukecampbelli)*

The endangered Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli)* is found in Levy County. It is a short-tailed rodent with a blunt head and short ears. Its fur is black-brown dorsally and dark gray ventrally. It is closely related to the meadow vole (*M. p. pennsylvanicus*) but can be distinguished by its larger size, darker coloration, relatively small ears, and by certain skull characteristics.

Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: Bay, Escambia, Holmes, Jackson, Santa Rosa, Walton, Washington

BIRDS

Audubon's Crested Caracara (*Polyborus plancus*)

The Crested Caracara (*Polyborus plancus*) long neck, long yellow legs, and massive gray-blue bill of the caracara make its appearance unique among the raptors. About 58 cm in length, the crested caracara has a white head and throat, white wing tips, and white tail contrasting with a dark body, red face, and signature black crest. The species historical range included Arizona, Florida, Louisiana, New Mexico, and Texas.

Counties: *Brevard, Broward, Charlotte, Collier, DeSoto, Glades, Hardee, Hendry, Highlands, Hillsborough, Indian River, Lee, Manatee, Martin, Miami-Dade, Monroe, Okeechobee, Orange, Osceola, Palm Beach, Polk, Sarasota, St. Lucie*

Bachman's Warbler (*Vermivora bachmanii)*

The Bachman's Warbler (*Vermivora bachmanii)* delicate warbler with slender, decurved bill, standing at 12 cm tall. Adult males can be identified with a black forecrown, grey hind-crown and nape, yellow forehead, eye-ring, lores, supercilium and throat. Yellow underparts with black patch on upper breast and white undertail. Olive-green upperparts, grey wings with olive fringes and yellow lesser coverts, grey tail with white spots on inner webs of all but central rectrices. First-year males can be seen with duller with indistinct black breast patch and no black forecrown. Adult females have duller whitish eye-ring, no black and less well marked head. First year females are even duller and paler below. Juveniles are brownish, buffy-yellow below, whiter on throat, with two buffy wing-bars. The species historical range included Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee.

Counties: *Miami-Dade, Monroe*

Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*)

Cape Sable seaside sparrows (*Ammodramus maritimus mirabilis*) are small birds about 13 centimeters or 5 inches long. Dorsally, they are dark olive-gray with olive-brown on the tail and wings. The greenish cast on the nape is generally difficult to detect. Ventrally, adults are light gray to almost white with dark olive-gray streaks on the breast and sides. Occasionally, the breast streaks converge forming a diffuse central spot. There is a dark whisker on either side of the white throat. These sparrows have yellow lores, brown eyes, and a gray ear patch behind the eye which is fringed by a dark line. There is a small patch of yellow on the edge of the wing. No sexual differences in the plumages are obvious.

Counties: *Collier, Miami-Dade, Monroe*

Everglade Snail Kite (*Rostrhamus sociabilis plumbeus*)

The Everglade snail kite (*Rostrhamus sociabilis plumbeus*) is a medium-sized hawk with a wingspan of about 45 inches, very similar to the marsh hawk but without wavering, tilting flight. The beak is slender and very hooked. The adult males are slate gray with black head and wing tips, a white patch at the base of a square tail, and red legs. The female has a buffy body, heavily streaked with dark lines, a white line above the eye, a white tail patch, yellow legs, and red eyes. The juveniles resemble the females, only they are darker and their eyes are brown. The snail kite is uniquely adapted for a diet almost exclusively of freshwater apple snails (*Pomacea paludosa*). As of 1987, there were only five documented occurrences of Everglade snail kites preying on non-snail items. Exclusive utilization of the genus *Pomacea* is apparently because this is the only large Florida snail occurring near the surface. The kite extracts the snail from the shell by means of its greatly curved beak.

Counties: *Brevard, Broward, Charlotte, Collier, DeSoto, Glades, Hendry, Highlands, Indian River, Lee, Martin, Miami-Dade, Monroe, Okeechobee, Orange, Palm Beach, Polk, Sarasota, St. Lucie, Volusia*

Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*)

Florida grasshopper sparrows (*Ammodramus savannarum floridanus*) are small, short-tailed birds, about 13 centimeters long. They are mostly black and gray and lightly streaked with brown on nape and upper back. Ventrally, adults are whitish and unstreaked, with some buff on the throat and breast. The breast is streaked in the juvenile plumage. The stripe over the eye is ochraceous, and the bend of the wing is yellow; the feet are flesh colored. There are no obvious sexual differences in the plumage.

Counties: *Collier, Desoto, Glades, Hendry, Highlands, Miami-Dade, Okeechobee, Osceola, Polk*

Florida Scrub Jay (*Aphelocoma coerulescens*)

The plumage of male and female adult Florida scrub jay (*Aphelocoma coerulescens*) looks alike, but males are slightly larger than females. The head, nape, wings, and tail are pale blue. The back

and belly are pale gray. The throat and chest are white and bordered by a blue gray bib. Juveniles differ in appearance from adults in that they have dull or dark brown upperparts. Florida scrub jays look similar to other jays, but do not have a crest, white-tipped wings or tail feathers, or black barring.

Counties: *Brevard, Broward, Charlotte, Citrus, Clay, Collier, DeSoto, Flagler, Glades, Hardee, Hernando, Highlands, Hillsborough, Indian River, Lake, Lee, Levy, Manatee, Marion, Miami-Dade, Okeechobee, Orange, Osceola, Palm Beach, Pasco, Polk, Putnam, Sarasota, Seminole, St. Lucie, Sumter, Volusia*

Ivory-Billed Woodpecker (*Campephilus principalis*)

The Ivory-billed Woodpecker (*Campephilus principalis*) is noted for its striking black-and-white plumage; robust white, chisel-tipped bill; lemon-yellow eye; and pointed crest. Males are red from the nape to the top of their crest with black outlining the front of the crest. Females have a solid black crest which is somewhat more pointed and slightly recurved to point forward. The bases of the male's red crest feathers and may allow a spot of white to be displayed on the side of the crest when the feathers are fully erect. There is a lack of morphological data from live birds. The species historical range included Arkansas, Florida, Georgia, Illinois, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas.

Counties: *N/A in Florida*

Kirtland's warbler (*Dendroica kirtlandii*)

The Kirtland's warbler (*Dendroica kirtlandii*), an endangered species, is a songbird that nests in young jack pine stands. The overall length of the bird is less than six inches. The male Kirtland's warblers' summer plumage is composed of a distinctive bright yellow colored breast streaked in black and bluish gray back feathers, a dark mask over its face with white eye rings, and bobbing tail. The female's plumage coloration is less bright; her facial area is devoid of a mask. Until 1995 Kirtland's warblers had only been known to nest in the northern part of Michigan's Lower Peninsula. Today, they also nest in the Upper Peninsula, and since 2007, have nested in Wisconsin and Canada. They migrate from their nesting grounds to the southeastern coast of the United States on their way to wintering grounds in the Bahamas. They can be found in the state of Florida, Michigan, Ohio, South Carolina, and Wisconsin.

Counties: *Collier, Martin, Miami-Dade, Palm Beach, St. Lucie*

Piping Plover (*Charadrius melodus*) - Critical Habitat

Piping Plovers (*Charadrius melodus*) are 18 cm in length. Their color varies by if they are in breeding season or not. During the breeding season, plovers are pale brown above and lighter below, with a black band across the forehead, an orange bill with black tip, orange legs and a white rump. Males have a complete or incomplete black band encircles the body at the breast.

Females have a paler head band and incomplete breast band. In the winter, their coloration includes a black bill, and a lack breast band and headband. The species historical range included Alabama, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, South Dakota, Texas, Virginia, Virgin Islands, Wisconsin, Wyoming.

Counties: *Bay, Brevard, Broward, Charlotte, Collier, Duval, Escambia, Franklin, Gulf, Hillsborough, Jefferson, Lee, Leon, Liberty, Manatee, Martin, Miami-Dade, Monroe, Okaloosa, Palm Beach, Pasco, Pinellas, Santa Rosa, Sarasota, St. Johns, St. Lucie, Taylor, Volusia, Wakulla, Walton, Washington*

Red Knot (*Calidris canutus rufa*)

The red knot (*Calidris canutus rufa*) is a threatened bird at 25-28 cm in length. Adults in spring have finely mottled gray tops, black and light ochre which runs into stripes on crown; the breast and sides of head cinnamon-brown; dark gray line through the eye. The abdomen and undertail coverts to white and is barred with black. Adults in winter are pale ashy gray on top from the crown to rump, with feathers on their back narrowly edged with white and white underparts, have a lightly streaked and speckled breast, and the flanks narrowly barred with gray. Some individual adults in the autumn have underparts that show traces of the "red" of spring.

The species historical range included Alabama, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Puerto Rico, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Virgin Islands, West Virginia, Wisconsin, Wyoming.

Counties: *Alachua, Baker, Bay, Bradford, Brevard, Broward, Charlotte, Citrus, Clay, Collier, Dixie, Duval, Escambia, Flagler, Franklin, Gilchrist, Gulf, Hamilton, Hernando, Hillsborough, Indian River, Jefferson, Lafayette, Lake, Lee, Levy, Madison, Manatee, Marion, Martin, Miami-Dade, Monroe, Nassau, Okaloosa, Orange, Palm Beach, Pasco, Pinellas, Putnam, Santa Rosa, Sarasota, Seminole, St. Johns, St. Lucie, Sumter, Suwannee, Taylor, Union, Volusia, Wakulla, Walton.*

Red-cockaded Woodpecker (*Picoides borealis*)

The endangered Red-cockaded woodpecker (*Picoides borealis*) is 22 cm in length. They are rather small black-and-white woodpeckers with longish bills. Their top is black barred white. Below is white with black spots on flanks. Black crown, nape and moustachial stripe border white cheeks and side of neck. Male has small red mark on the side of nape. Juvenile browner with variable extent of red on crown.

The species historical range included Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, Virginia.

Counties: *Alachua, Baker, Bay, Bradford, Brevard, Broward, Colhoun, Charlotte, Citrus, Clay, Collier, Columbia, Dixie, Duval, Flagler, Franklin, Gadsden, Gilchrist, Glades, Gulf, Hamilton, Hendry, Hernando, Highlands, Hillsborough, Indian River, Jefferson, Lafayette, Lake, Lee, Leon, Levy, Liberty, Madison, Manatee, Marion, Martin, Miami-Dade, Nassau, Okaloosa, Okeechobee, Orange, Osceola, Palm Beach, Pasco, Pinellas, Polk, Putnam, Santa Rosa, Seminole, St. Johns, St. Lucie, Sumter, Suwannee, Taylor, Union, Volusia, Wakulla, Walton*

Roseate Tern (*Sterna dougallii dougallii*)

The roseate tern (*Sterna dougallii dougallii*) is about 40 centimeters in length, with light-gray wings and back. Its first three or four primaries are black and so is its cap. The rest of the body is white, with a rosy tinge on the chest and belly during the breeding season. The tail is deeply forked, and the outermost streamers extend beyond the folded wings when perched. During the breeding season the basal three-fourths of the otherwise entirely black bill and legs turn orange-red. The species historical range included Connecticut, Florida, Maine, Massachusetts, New Jersey, New York, North Carolina, Puerto Rico, Rhode Island, Virginia, Virgin Islands.

Counties: *Monroe*

Whooping Crane - Experimental Population, (*Grus americana*)

The whooping crane (*Grus americana*) occurs only in North America and is North America's tallest bird, with males approaching 1.5 m (5 ft) when standing erect. The whooping crane adult plumage is snowy white except for black primaries, black or grayish alula (specialized feathers attached to the upper leading end of the wing), sparse black bristly feathers on the carmine crown and malar region (side of the head from the bill to the angle of the jaw), and a dark gray-black wedge-shaped patch on the nape. The common name "whooping crane" probably originated from the loud, single-note vocalization given repeatedly by the birds when they are alarmed. Whooping cranes are a long-lived species; current estimates suggest a maximum longevity in the wild of at least 30 years. Whooping cranes currently exist in the wild at 3 locations and in captivity at 12 sites. The July 2010 total wild population was estimated at 383. There is only one self-sustaining wild population, the Aransas-Wood Buffalo National Park population, which nests in Wood Buffalo National Park and adjacent areas in Canada, and winters in coastal marshes in Texas at Aransas. In addition, there is a small captive-raised, non-migratory population in central Florida, and a small migratory population of individuals introduced beginning in 2001 that migrate between Wisconsin and Florida in an eastern migratory population. The last remaining wild bird in the reintroduced Rocky Mountain Population died in the spring of 2002. The captive population contained 152 birds in July, 2010, with annual production from the Calgary Zoo, International Crane Foundation, Patuxent Wildlife Research Center, Audubon Species Survival Center, and the San Antonio Zoo. The total population of wild and captive whooping cranes in July, 2010, was 535. The species historical range included

Alabama, Arkansas, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming.

Counties: N/A

Wood Stork (*Mycteria americana*)

Wood storks (*Mycteria americana*) are large, long-legged wading birds, about 5O inches tall, with a wingspan of 60 to 65 inches. The plumage is white except for black primaries and secondaries and a short black tail. The head and neck are largely unfeathered and dark gray in color. The bill is black, thick at the base, and slightly decurved. Immature birds are dingy gray and have a yellowish bill. The species historical range included Alabama, Arizona, California, Florida, Georgia, South Carolina, and Texas.

Counties: All

INVERTEBRATES

Bartram's Scrub-Hairstreak Butterfly (*Strymon acis bartrami*)

The endangered Bartram's Scrub-Hairstreak (*Strymon acis bartrami*) butterfly is approximately 1 inch (in) (25 millimeters (mm) in length with a forewing length of 0.4 to 0.5 in (10 to 12.5 mm). Bartram's Scrub-Hairstreak is easily observed if present at any density as it alights often, and the brilliance of its grey underside marked with bold white postdiscal lines beneath both wings provides an instant flash of color against the foliage of its host plant, pineland croton (Croton linearis). Bartram's Scrub-Hairstreak only occurs within pine rocklands that retain its only known host plant, pineland croton.

Counties: *Broward, Collier, Miami-Dade, Monroe, Palm Beach*

Florida Leafwing Butterfly (*Anaea troglodyta floridalis*)

The endangered Florida leafwing butterfly (*Anaea troglodyta floridalis*) is a medium-sized butterfly approximately 2.75 to 3 inches (in) (76 to 78 millimeters (mm)) in length. The upper-wing (or open wing) surface color is red to red-brown, the underside (closed wings) is gray to tan, with a tapered outline, cryptically looking like a dead leaf when the butterfly is at rest. The Florida leafwing exhibits sexual dimorphism, with females being slightly larger and with darker coloring along the wing margins than the males. The Florida leafwing occurs only within pine rocklands that retain its host plant, pineland croton. Pineland croton, a subtropical species of Antillean origin, is the only known host plant for the leafwing, the leafwing is restricted to pine rocklands that contain pineland croton.

Counties: *Broward, Collier, Martin, Miami-Dade, Monroe, Palm Beach*

Miami Blue Butterfly (*Cyclargus thomasi bethunebakeri*)

The endangered Miami Blue butterfly (*Cyclargus thomasi bethunebakeri*) is a small (about an inch in length) bright blue butterfly. This butterfly is known to occur only in a few remote areas within the Florida Keys. The only confirmed metapopulation(s) (group of smaller populations that have some interaction) of Miami blue is currently restricted to a few, small insular areas in the extreme southern portion of its historical range; the subspecies appears to be restricted to Key West National Wildlife Refuge (KWNWR) in Monroe County, Florida. Population size is unknown but estimated to be in the hundreds.

Counties: *Miami-Dade, Monroe*

Schaus Swallowtail Butterfly (*Heraclides aristodemus ponceanus*)

The endangered Schaus Swallowtail butterfly (*Heraclides aristodemus ponceanus*) is a large (forewing measuring 1.6 - 2.3 in. = 40 - 58 mm), brownblack butterfly with yellow markings. Markings across the center of the forewing and hindwing appear as a pale yellow band that bifurcates toward the tip of the forewing. Markings along the trailing edge of both the forewing and hindwing appear as a series of crescents, with those on the hind wing larger and generally a deeper yellow. The underside of the hind wing has a large burnt orange patch; tails are black, trimmed with yellow. This butterfly is found in tropical hardwood hammocks (rockland hammocks). Host plants for this species are the Torchwood (*Amyris elemifera*) and rarely the Wild Lime (*Zanthoxylum fagara*).

Counties: *Miami-Dade, Monroe*

Stock Island Tree Snail (*Orthalicus reses*)

The threatened Stock Island tree snail (*Orthalicus reses*) is an arboreal snail inhabiting the hardwood hammocks of the Florida Keys. The Stock Island tree snail is a large, conical snail attaining approximately 45 to 55 mm in length. The external ground color is white to buff, with three poorly developed spiral bands and several flame-like purple-brown axial stripes that stop at the lower of the spiral bands. The thickness of the shell varies, but is usually more lightweight and translucent than other species of Orthalicus (Pilsbry 1946). The axial stripes are typically narrower than their whitish interspaces and do not fork near the upper suture. There are two to three white apical whorls. The last whorl contains two to four darker brown Stock Island tree snail. The columella and parietal callus are white or faint chestnut brown. This species is distinguished from *O. r. nesodryas* by its lighter color pattern of the apical whorl, columella, and parietal callus. These characteristics are chestnut-brown or darker in *O. r. nesodryas*.

Counties: *Miami-Dade, Monroe*

Highlands Tiger Beetle – Candidate (*Cicindela highlandensis*)

The Highlands tiger beetle (*Cicindela highlandensis*) is a candidate species resembling typical tiger beetle form: large head, eyes, and jaws, followed by a narrower neck and elongate, parallel-sided outer wings (elytra). Like most tiger beetles, a fast-running, readily observed predator that flies weakly for only short distances. This species is one of smallest tiger beetles (0.4 - 0.5 in. = 10.5 - 12 mm) and an extremely weak flier, usually flying only 15 - 30 ft. (ca. 5 - 10 m). Head, legs, and elytra black with green, blue, and purple reflections; elytra lack coarse punctures. Abdomen reddish below and with orange-red spot above that shows during flight. Adults present late May - early August; larvae and pupae develop underground for most of the year.

Counties: *Highlands, Polk*

Squirrel Chimney Cave Shrimp (*Palaemonetes cummingi*)

The threatened Squirrel Chimney Cave shrimp (*Palaemonetes cummingi*), also known as the Florida cave shrimp, is a small (1.3 in. = 30 mm), nearly colorless cave shrimp with only a suggestion of white (albinism) in the general body coloration; internal organs of various colors may be visible through the exoskeleton (outer shell). The rostrum (forward projection of shell in front of eyes) is long and serrated, with six teeth on its dorsal surface, and the first and second pairs of legs are of nearly equal length. This species is found to inhabit groundwater within a flooded solution cave in limestone. Known only from a single cave (Squirrel Chimney) in western Alachua County. No cave shrimps have been observed, despite recent surveys, since 1973, and there is concern that the species may be extinct. However, other ecologically similar sites exist within the local limestone plain and may yet harbor undiscovered populations. The private owners of the land surrounding Squirrel Chimney restrict access to the site. Nonetheless, groundwater contamination associated with increasing urban development of the greater Gainesville area poses a potential threat to the species and its habitat, as does the apparently recent invasion of the site by a small fish, the redeye chub (*Notropis harperi*).

County: *Alachua*

MUSSELS

Freshwater mussels face a host of threats due to human development and increased populations. The main threat is the impoundment of fresh waterways. Waterways are impounded for reasons including for fresh water supply, flood control, and hydropower. Impounding waterways cause the water current's velocity to decrease causing sediment to build up in the river and covering the mussels located in the substrate. Impoundments also cause habitat fragmentation, separating mussel populations and also individual mussels from algae and host fish (U.S. Fish & Wildlife Service 2006). River dredging also threatens to destroy freshwater mussel populations on the river floors. Invasive species, can out-compete native mussels for resources. Pesticide and chemical pollution poses a significant threat to mussels since they are filter feeders and may ingest chemicals directly from their habitat.

Oval Pigtoe (*Pleurobema pyriforme*) - Critical Habitat

The endangered Oval pigtoe (*Pleurobema pyriforme*) is a small freshwater mussel that can reach a length of 2.4 inches (six centimeters). This species has a flattened oval-shaped shell that is a yellowish-brown on the outer section with a white or salmon (yellowish-pink) inner section. It also has two large teeth in the left and right valve. It inhabits mid-sized rivers and small creeks with a slow to moderate current and a sandy silt to gravel floor. In Florida, this species can be found in the Chipola, Ochlockonee, and Suwannee river systems and Ecofina Creek. Critical habitat is designated in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida.

Counties: *Alachua, Bay, Bradford, Calhoun, Gadsden, Gulf, Jackson, Leon, Union, Washington*

Fat Threeridge (*Amblema neislerii*) - Critical Habitat

The endangered Fat threeridge (*Amblema neislerii*) is a medium-large bivalve mollusk reaching a length of 4 in. (102 mm). Valves (shell) dark brown to black, strongly sculptured with seven to nine prominent, horizontal, parallel ridges, somewhat square in outline, inflated (deep; highly so in older specimens), solid, and heavy; umbos (raised areas on valves near hinge) toward anterior end of shell. Internally, two nearly equal-sized teeth below umbo of left valve, and usually one large and one small tooth in right valve; nacre (inner lining of valves) bluish white to light purplish, very iridescent. Critical habitat has been designated in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida.

Counties: *Bay, Calhoun, Frankli, Gadsden, Gulf, Jackson, Liberty, Washington*

Chipola Slabshell (*Elliptio chipolaensis*) - Critical Habitat

The threatened Chipola slabshell (*Elliptio chipolaensis*) is a midsized freshwater mussel that can reach a length of 3.3 inches (8.5 centimeters). It is oval shaped with a reddish-brown outer shell, sometimes surrounded with dark and light bands, and a reddish-yellow inner shell (University of Georgia 2008). This species inhabits slow to medium current rivers with sand and silt floor (Bogan 2000). It is found only in the Chipola River in northwest Florida. Critical habitat for this species has been designated in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida. Its historical range includes Alabama and Florida.

Counties: *Bay, Calhoun, Franklin, Gulf, Jackson, Liberty, Washington*

Purple Bankclimber (*Elliptoideus sloatianus*) - Critical Habitat

The threatened Purple bankclimbers (*Elliptoideus sloatianus*) is a very large bivalve mollusk reaching a length of 8 in. (203 mm). Valves (shell) are brownish black to black, heavy and

strongly sculptured, nearly rhomboidal in shape, moderately inflated (deep). A well-developed posterior ridge extends from umbos (raised areas on valves near hinge) to posterior ventral edge of shell; along and near this are several irregular ridges. Umbos are low, barely extending above hinge. Internally, there are two teeth below umbo of left valve, and one in the right valve; nacre (inner lining of valves) are whitish near center to deep purple toward margin, very iridescent posteriorly. This species inhabits small to large rivers with slow to moderate current, and substrate of sand, sometimes mixed with mud or gravel. Critical habitat is designated in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida.

Counties: *Bay, Calhoun, franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Wakulla*

Shinyrayed Pocketbook (*Lampsilis subangulata*) - Critical Habitat

The endangered Shinyrayed pocketbooks' (*Lampsilis subangulata*) is a medium-sized bivalve mollusk reaching a length of 3.3 in. (85 mm). Valves (shell) are a shiny light yellowish brown with medium-wide emerald green rays (darker brown with rays obscured in some older individuals) over entire surface; smooth, roughly elliptical, and solid but fairly thin. Umbos (raised areas on valves near hinge) are broad and somewhat inflated (deep or broad); posterior ridge extending from umbo to posterior margin is rounded, not angular. Internally, there are two large, erect teeth below umbo of left valve, and one large and one flatter tooth in right valve; nacre (inner lining of valves) is white, sometimes with salmon tint in cavity of umbo. This species inhabits medium-sized creeks and rivers with slow to moderate current and clean or silty sand substrates. Its historical range includes Alabama, Florida, and Georgia. Critical habitat for the Shinyrayed pocketbook is designated in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida. *Florida Natural Areas Inventory*, 2001.

Counties: *Bay, Calhoun, Gadsden, Gulf, Jackson, Leon, Washington*

Tapered Pigtoe (*Fusconaia burkei*) - Critical Habitat

The threatened Tapered pigtoe (*Fusconaia burkei*) is a small freshwater mussel that attains a maximum length of 60 mm. The shell is inflated and subelliptical in outline. The anterior margin is broadly rounded and the posterior margin is narrowly pointed. The posterior ridge is well defined with radial ridges on the posterior slope. Chevron-shaped ridges cover much of the disk. Shell sculpture may be indistinct in some specimens. The periostracum is brown or greenish-yellow in young specimens, but becomes dark brown to black in adults. Pseudocardinal teeth are well-developed, divergent, and double in both valves. There are two lateral teeth in left valve and usually one in right valve. The interdentum is very narrow. Shell nacre varies from light purple to bluish-white (Garner et al., in review; Clench and Turner, 1956; Deyrup and Franz, 1994). The Tapered pigtoe inhabits medium-sized creeks to large rivers in stable sand or sand and gravel substrata, occasionally occurring in silty sand in slow to moderate current (Williams and Butler,

1994). Historically found in Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: *Bay, Holmes, Jackson, Walton, Washington*

Narrow Pigtoe (*Fusconaia escambia*) - Critical Habitat

The threatened Narrow pigtoe (*Fusconaia escambia*) is a small to medium-sized freshwater mussel attaining a maximum length of 74 mm. The shell is moderately thick, subcircular, slightly inflated, and has a well-defined posterior ridge. The periostracum is smooth and juveniles are chestnut brown in color. Older individuals become darker brown to blackish in color. Internally, the umbo pocket is moderately deep. The hinge plate and lateral teeth are curved. The nacre is white and sometimes has an iridescent salmon hue (Williams et al., 2000; Clench and Turner, 1956; Deyrup and Franz, 1994). This species is found primarily in the channels of small to medium-sized streams in sand, silty sand, or gravel (Deyrup and Franz, 1994) and in muddy sand in slight current (Heard, 1979). It may also occur in smaller streams. At least one population is found in a silty backwater area. Historically found in Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: *Escambia, Okaloosa, Santa Rosa, Walton*

Round Ebonyshell (*Fusconaia rotulata*) - Critical Habitat

The endangered Round ebonyshell (*Fusconaia rotulata*) is a small to medium-sized freshwater mussel that attains a maximum length of 61 mm. The shell is thick, heavy, inflated, and circular in outline. There is no posterior ridge, but often two slight folds are present. The periostracum is dark brown to black. Internally, the interdentum is moderately broad, with straight to slightly curved lateral teeth. The umbo cavity is deep and wide and nacre is iridescent white (Williams et al., 2000). See also Johnson (1967) and Williams and Butler (1994). Known to occur in river channels with moderate current over sand and gravel substrate (Williams and Butler, 1994). Historically found in Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: *Escambia, Santa Rosa*

Southern Sandshell (*Hamiota australis*) - Critical Habitat

The threatened Southern sandshell (*Hamiota australis*) is a small to medium-sized freshwater mussel that attains a maximum length of 83 mm. It has a long, elliptical, somewhat pointed shell with moderate inflation. Shell thickness is moderate. Externally, the shell of young specimens is yellowish with green rays and in adults is typically dark brown to black with obscured rays (Williams et al., 2000). Sexual dimorphism is present as a slight rounding of the ventral shell margin of females (Athearn, 1964). Internally, lateral teeth are somewhat curved, interdentum is

wide, and pseudocardinal teeth are delicate and slightly compressed (Williams et al., 2000). The nacre is bluish white and iridescent posteriorly (Deyrup and Franz, 1994). It occurs in clear medium-sized creeks to rivers with slow to moderate current and sandy substrates (Deyrup and Franz, 1994; Williams and Butler, 1994). Historically found in Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: *Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, Washington*

Gulf Moccasinshell (*Medionidus penicillatus*) - Critical Habitat

The endangered Gulf moccasinshell (*Medionidus penicillatus*) is a small bivalve mollusk reaching a length of 2.2 in. (55 mm). Valves (shell) yellowish to greenish brown with fine, often broken, green rays; mostly smooth, elongated elliptical to rhomboidal in shape, somewhat inflated (deep), with relatively thin valves with nearly straight to slightly rounded ventral margins. A rounded to slightly angled ridge runs from umbo (raised area on valve near hinge) to end of shell; behind this is a series of low, thin, radiating ridges. Internally, two stubby teeth below umbo of left valve and one tooth in right valve; nacre (inner lining of valves) smokey purple or greenish, slightly iridescent posteriorly. The Gulf moccasinshell inhabits Medium-sized creeks to large rivers with sand, muddy sand, and gravel substrates and slow to moderate currents; occasional in backwater areas with no current. This species is known to be found in Ecofina Creek and the Chipola River in northwest Florida. It also may be found in the Choctawhatchee, Apalachicola, and Yellow Rivers in northwest Florida. Critical habitat for this species has been designated in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida.

Florida Natural Areas Inventory, 2001.

Counties: *Bay, Calhoun, Gulf, Jackson, Washington*

Ochlockonee Moccasinshell (*Medionidus simpsonianus*) - Critical Habitat

The endangered Ochlockonee moccasinshell (*Medionidus simpsonianus*) is a small freshwater mussel that can reach a length of 2.2 inches (5.5 centimeters). This species is oval-shaped with an outer shell color that is light brown with dark green rays carved into the shell, and a bluish-white inner shell. Its valves are thin with two teeth in the left valve and one in the right (Florida Natural Areas Inventory 2001). It inhabits large creeks and mid-sized rivers of moderate current that contain a sandy, gravel floor. Distribution is very limited as it is only found in the Ochlockonee River system in Georgia and Florida (Florida Natural Areas Inventory 2001). Critical habitat for this species is located in Alachua, Bay, Bradford, Calhoun, Columbia, Franklin, Gadsden, Gulf, Jackson, Leon, Liberty, Union, Wakulla, and Washington counties, Florida.

Counties: *Franklin, Gadsden, Leon, Liberty, Wakulla*

Fuzzy Pigtoe (*Pleurobema strodeanum*) - Critical Habitat

The threatened Fuzzy pigtoe (*Pleurobema strodeanum*) is a small freshwater mussel that attains a maximum length of 58 mm. The shell is moderately thick, sub triangular in outline, with a rounded anterior margin and a bluntly pointed posterior margin. The posterior ridge is poorly defined and the posterior slope is slightly concave. Externally, the periostracum is cloth-like, and varies in color from dark olive to brown to almost black. Internally, the pseudo cardinal teeth are heavy, and triangular, with two divergent teeth in left valve and one in the right. The lateral teeth are short and almost straight. The nacre is bluish-white with a slight iridescent hue (Williams et al., 2000; Garner et al.,in review; Deyrup and Franz, 1994). It is found in medium-sized creeks and rivers, in sand and silty sand substrates with slow to moderate current (Williams and Butler, 1994; Williams et al., 2000). Historically found in Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: Bay, *Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, Washington*

Southern Kidneyshell (*Ptychobranchus jonesi*) - Critical Habitat

The endangered Southern kidneyshell (*Ptychobranchus jonesi*) is a small to medium-sized freshwater mussel that attains a maximum length of 65 mm. It has a moderately thick, elliptical shell with the dorsal and ventral margins nearly parallel. The shell is very inflated with prominent biangulation on the posterior end. The periostracum is smooth, olive green to blackish in color, sometimes with irregularly distributed green rays. Internally, lateral teeth are curved and thin, and pseudo cardinals are compressed. The nacre is bluish-white and iridescent (Johnson, 1967; Williams et al., 2000). It inhabits medium-sized creeks to rivers in silty sand substrates with slow current and woody debris (Williams and Butler, 1994). It has also been located in claystone pockets with sand (Blalock-Herod et al., 2005). Historically this species is found within Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: *Bay, Escambia, Holmes, Jackson, Santa Rosa, Walton, Washington*

Choctaw Bean (*Villosa choctawensis*) - Critical Habitat

The endangered Choctaw bean (*Villosa choctawensis*) is a small freshwater mussel with a moderately thick shell that obtains a maximum length of 49 mm. The shell is somewhat inflated, ovate in outline, with rounded anterior and posterior margins. Sexual dimorphism is present, in that females may be somewhat more broadly rounded posteriorly. The posterior ridge is low and rounded. The umbo is broad and full, extending little, if any, above hinge line and positioned well anterior of center. The periostracum is shiny and smooth. External shell color is chestnut to dark brown or black, with variable fine, green rays, which may be obscure in older specimens. Internally, two well-developed pseudo cardinal teeth occur in left valve and one well-developed and two rudimentary pseudo cardinal teeth are present in the right valve. The lateral teeth are

short and almost straight. The interdentum is moderately wide and the umbo cavity is moderately deep. Shell nacre is white to bluish and sometimes iridescent, but may be blotched and brown (Garner et al., in review). See also Athearn (1964) and Deyrup and Franz (1994). This species inhabits large creeks and rivers with moderate current over sand to silty-sand substrates (Deyrup and Franz, 1994; Williams and Butler, 1994). Historical range included Alabama and Florida. Critical habitat has been designated in Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, and Washington Counties, Florida.

Counties: Bay, Escambia, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, Washington

PLANTS

Carter's Mustard (*Warea carteri*)

The endangered Carter's mustard (*Warea carteri*) is a species of plant in the mustard family, *Brassicaceae*. This plant is a fire-dependent annual herb, it is 0.2 to 1.5 m tall with erect green stems. The plants usually have many slender, ascending branches forming an open, rounded crown. The leaves lack stipules and are arranged alternately on the stem. Lower leaves are lost by the time the plant flowers. Leaf size and shape varies with age and position on the plant. At the time of flowering, leaf petioles range from 0.8 to 3.9 mm with blades 1 to 3 cm long. Towards the tips of stems, the leaves are smaller and narrowly elliptical to almost linear, while closer to the bases of stems and branches, the leaves are larger and oblanceolate or spatulate. All leaves are rounded at the tip, their margins entire, and their bases attenuate to cuneate. The lower leaves can also be undulate, margined or lobed. Flowers September–October. Habitat includes sandhill, scrubby flatwoods, inland and coastal scrub. Carter's mustard appears only after fire, making population estimates difficult. Protection and management: Protect privately owned sandhill and scrub by purchase or conservation easement; Manage sites with prescribed fire, and prevent trampling and ORV use; Eradicate invasive exotic grass species.

Florida Natural Area Inventory, 2000.

Counties: Brevard, Glades, Highlands, Miami-Dade, Polk

Chapman's Rhododendron (*Rhododendron chapmanii*)

The endangered Chapman's rhododendron (*Rhododendron chapmanii*) is an evergreen shrub 2 - 9 feet tall, with stiff, erect branches tipped by terminal buds. Young twigs, buds, and leaves covered with small, round, rust colored scales. Leaves 1 - 3 inches long, evergreen, alternate, wider above the middle, usually with enrolled margins. It has pink flowers in showy clusters at the tips of its branches, each flower 0.5 to 1.5 inches long, with 5 lobes, and 10 stamens about the same length as the petals. Fruit an elongated capsule about 0.5 inch long, present nearly year-round, covered with rusty scales. Flowers mid-March to mid-April. Habitat includes wet, mesic, or dry scrubby flatwoods; borders of titi or bay swamps; disturbed areas, pine plantations. All of

the Panhandle populations are on private timber lands; a population in Clay County, possibly cultivated, occurs on Camp Blanding. Protection and management: Burn periodically to stimulate flowering and sprouting; Avoid mechanical site preparation, tree planting, or other soil disturbances; plants re-sprout following light disturbance, but timber harvesting, site preparation, and pine planting will kill plants. *Florida Natural Area Inventory*, 2000.

Counties: Clay, Gadsden, Gulf, Liberty

Britton's Beargrass (*Nolina brittoniana*)

The endangered Britton's beargrass (*Nolina brittoniana*) is a rare species of flowering plant in the asparagus family. It is a perennial that grows from a short, thick, fleshy, bulblike rootstock. The leaves are 1 to 2 m long and 6 to 13 mm wide, forming a rosette with the youngest leaves upright and the oldest lying nearly flat on the ground. The flowering stem, usually solitary, grows 1 to 1.5 m tall from the rosette in April. The inflorescence is a panicle with about 6 to 20 branches. When in bloom, the branches are covered with small, white flowers, making the plant very conspicuous (Wunderlin et al. 1980, Kral 1983). The flowers are moderately fragrant when open (The Nature Conservancy 1995). *N. brittoniana* has symmetrical fruits, triangular in cross-section. Flowers March–May, but fruits, leaves, and growth habit are distinctive all year. The species is generally dioecious. Habitat includes scrub, sandhill, scrubby flatwoods, and xeric hammock. More than 90% of Britton's beargrass habitat has been lost to agriculture and development. Protection and management: Apply prescribed fire to stimulate flowering and eliminate competition by shrubs and trees; Complete purchases of Lake Wales Ridge scrub sites. *Florida Natural Area Inventory*, 2000.

Counties: Highlands, Lake, Marion, Orange, Osceola, Polk

Aboriginal Prickly-apple (*Harrisia aboriginum*) - Candidate

The endangered Aboriginal prickly-apple (*Harrisia aboriginum*) is an erect tree cactus, with slender, cylindrical, spiny stems 3 - 16 feet tall, with 10 or more ridges, sometimes branched or leaning. Spines are gray with yellow tips, 9 - 13 per cluster, 1 - 1.5 inches long, one spine longer than the others. Flowers are showy, solitary, 5 - 8 inches long, with a long, scaly floral tube; petals numerous, long and narrow, fragrant, white when flowers open at night and turning pink the next morning; inner petals without teeth at the tip. Fruits usually one per plant, red, round, 2 inches across, with wooly spines. Flowers April–May and September–October; fruits July–October. Habitat includes scrubby flatwoods and xeric hammocks on the Atlantic Coastal Ridge, with sand live oak, myrtle oak, cabbage palm, and prickly pear. Protection and management: Preserve upland coastal habitats; monitor known populations; protect plants from off-road-vehicles and plant poachers with fences; remove exotic species; avoid use of herbicides in right-of way maintenance; effect of fire is unknown. *Florida Natural Area Inventory*, 2000.

Counties: Charlotte, Lee, Sarasota

Brooksville Bellflower (*Campanula robinsiae*)

The endangered Brooksville bellflower (*Campanula robinsiae*) is an annual herb that grows up to 6 inches tall, usually much smaller, inconspicuous, and sprawling. Its stems are smooth, angled, usually branched, and rooting at the nodes. Leaves are 0.2 - 0.5 inch long, alternate, hairless, toothed, oval to lance-shaped but variable in both size and shape. The flowers are less than 0.5 inch long, solitary, blue to purple, with 5 lobes spreading from a bell-shaped tube. Fruit is small, rounded with low angles, and with a persistent calyx. Flowers January–May, depending on water levels in ponds, usually March–April. Habitat includes wet, grassy slopes and drying pond edges in the vicinity of Chinsegut Hill, in Hernando County. Protection and management: Monitor fluctuations in water level of ponds and the effect on germination; Limit cattle grazing and trampling; Eradicate exotic pest plants. *Florida Natural Area Inventory*, 2000.

Counties: Hernando, Hillsborough

Cooley's Water-willow (*Justicia cooleyi*)

The endangered Cooley's Water-willow (*Justicia cooleyi*) is a perennial herb up to 16 inches tall, with erect, square, hairy stems with few branches. Leaves can reach 2 inches long, and are opposite, short-stalked, ovate or lance-shaped, with long hairs and short, brown lines on the upper surface. Flowers in zigzag form, usually 2-branched clusters on long stalks emerging from angle of leaf and stem. Flower are about 0.5 inch long, dark pink with purple and white spots, glandular-hairy, 2-lipped with the lower lip 3- lobed; stamens 2, attached to the lip; sepals 4, linear; flower bracts linear, sepal-like. Flowers August - December. The fruit a capsule, about 0.5 inches long, hairy. Cooley's water-willow is endemic to Florida, and found in mesic hardwood hammocks over limestone. The habitat of this species has been greatly diminished by limerock mining, clearcutting, and agricultural and residential development. Known populations are also threatened by exotic plant invasion. Protection and management strategies include eradicating exotic pest plants, monitoring and protecting roadside populations, avoiding mechanical disturbance in hardwood hammocks, and protecting populations on private lands by purchase or conservation easement. *Florida Natural Area Inventory*, 2000.

Counties: Hernando, Sumter

Blodgett's Silverbush (*Argythamnia blodgettii*) - Candidate

The candidate species, Blodgett's silverbush (*Argythamnia blodgettii*), is an erect perennial with a woody base and non-woody, often unbranched, green stems, up to 2 feet tall. Leaves range 0.6 - 1.6 inches long, and are evergreen, metallic blue-green, alternate, well spaced along the stem,

entire or slightly toothed, oval to elliptic, hairy, with 3 main veins branching from the base, often folded up along the midvein. Female and male flowers are found on the same plant, but in separate clusters in leaf axils, small with 5 sepals and 5 white petals. Fruit is a 3-parted capsule with round, patterned seeds. Flowers and fruits all year. Blodgett's silverbush is endemic to the Florida Keys and found in sunny gaps and edges in pine rockland, rockland hammock, and coastal berm. Protection and management includes using prescribed fire to maintain an open subcanopy and reduce litter, eradicating exotic pest plants, and preserving remaining rocklands. *Florida Natural Area Inventory*, 2000.

Counties: Miami-Dade, Monroe

Florida Brickell-bush (*Brickellia mosieri*) - Candidate

The candidate species, Florida Brickell-bush (*Brickellia mosieri*), is a perennial herb ranging from 1 - 3.5 feet tall, and is slender, erect, and branching. Leaves range from 0.4 - 1.2 inches are long, alternate, narrow, linear, thick, usually spreading or curved downward, entire or slightly toothed, resin-dotted. Flower heads are in loose, open clusters at the ends of branches. Disk flowers are white in small, dense heads surrounded by hairy, slightly ribbed bracts; there are no ray flowers, although long style branches (white, sometimes brown) may appear to be rays. Flowers primarily August–October, but occasionally all year. The Florida brickell-bush is endemic to Miami Rock Ridge in Dade County, Florida and found in pine rocklands with open shrub layer, exposed limestone, and minimal leaf litter. Protection and management of this species includes acquiring and protecting private sites, using frequent prescribed fire to create a mosaic of open habitats in pine rocklands, and eradicating exotic pest plants.

Florida Natural Area Inventory, 2000.

County: Miami-Dade

Big Pine Partridge Pea (*Chamaecrista lineata keyensis*) - Candidate

The candidate species, Big Pine partridge pea (*Chamaecrista lineata keyensis*), is a perennial legume. The yellow flowers have five petals, with reddish-brown stamen. It can grow to about 30 inches tall and has compound leaves. It is endemic to rock pineland habitat in South Florida Keys. This species is threatened by habitat fragmentation and degradation. Protection and management of this species includes acquiring and protecting private sites, using frequent prescribed fire to create a mosaic of open habitats in pine rocklands, and eradicating exotic pest plants.

County: *Monroe*

Pineland Sandmat (*Chamaesyce deltoidea pinetorum*) - Candidate

The candidate species, Pineland Sandmat (*Chamaesyce deltoidea pinetorum*), is a small perennial herb, with greenish oval-shaped leaves and reddish stems with straight, spreading hairs. The extensive root system of pine sandmat indicates that it is a long-lived plant. The species will flower and fruit year-round, with peaks in the fall, as well as after stimulation after fire. This species can be found in pine rocklands, marl prairies, and within the ecotone between both habitats in Miami-Dade County. The current range of this species consists of 20 populations in Miami-Dade County, including Everlades National Park. One historical population in Miami-Dade County (Larry and Penny Thompson Park) has disappeared due largely to habitat loss.

County: *Miami-Dade*

Wedge Spurge (*Chamaesyce deltoidea serpyllum*) - Candidate

The candidate species, Wedge spurge (*Chamaesyce deltoidea serpyllum*) has hairy prostrate stems, twisted leaf hairs, and a silver-gray appearance. Found in pine rockland habitat.

County: *Monroe*

Cape Sable Thoroughwort (*Chromolaena frustrata*) - Candidate

The candidate species, Cape sable thoroughwort (*Chromolaena frustrata*), is an erect herb 8 - 40 inches tall, with 1 to several hairy stems. Leaves range 0.6 - 1.6 inches long, and are aromatic, opposite, slightly toothed, hairy, oval to lance-shaped, with 3 conspicuous veins and short but definite leaf stalks. There are flower heads on long stalks at the ends of branches; bracts surrounding each head in several series, all bracts similar in appearance and forming an involucre 0.2 - 0.3 inches tall. Disk flowers 20 - 25 per head, blue or lavender, no ray flowers. Flower all year. Cape Sable thoroughwort are found on coastal rock barrens and berms, sunny edges of rockland hammock. Protection and management include acquiring populations on private lands and managing for conservation and controlling exotic pest plants.

Florida Natural Area Inventory, 2000.

Counties: Miami-Dade, Monroe

Florida Bristle Fern (*Trichomanes punctatum ssp. floridanum*) - Candidate

The endangered Florida bristle fern (*Trichomanes punctatum ssp. floridanum*) is a small fern with crowded, overlapping leaves and long, thread-like stems. Leaves less than 1 inch long, filmy and delicate; blades rounded or elongated, with dark, branched hairs on margins (visible with magnification). Midvein extends less than halfway up the leaf then repeatedly forks. Spores are produced in several tiny, conical, flaring, dark-lipped structures (soral involucres) on the tips of each leaf; a bristle protrudes from each involucre. Filmy ferns may be mistaken for moss,

algae, or liverworts; look for veins on the leaf blades, dark hairs and soral involucres on the leaf margins, or root-like hairs on the creeping stems to confirm that the plant is a filmy fern. Habitat includes tree trunks in hammocks, edges of lime sinks, and limestone boulders, often with mosses and liverworts. Logging, limerock mining, and wetland draining have destroyed most populations. Lowering of the water table threatens ferns that grow on limestone outcrops. Exotic pest plants also threaten several populations. Protection and management: Eradicate exotic pest plants; Purchase sites on private lands or protect with conservation easements; Protect and restore natural hydrology and maintain water table.

Counties: Miami-Dade, Sumter

Florida Semaphore Cactus (*Consolea corallicola*) - Candidate

The candidate species, Florida semaphore cactus (*Consolea corallicola*), is an erect cactus about 3 - 15 feet tall, with a gray, spiny, cylindrical trunk up to 8 feet tall. Older branches (pads, joints) are green, flattened, oblong and curved, 2 - 4 times as long as they are wide, held at right angles to the ground, not segmented, and very spiny. Young joints on ends of older branches are cylindrical, with fruits or flowers at their tips. Spines range 1 - 4 inches long and are in numerous clusters, with 2 - 4 spines per cluster. Leaves are small, deciduous, and scale-like. Flowers are orange to red with numerous stamens, and about 1 inch across. Flowers all year, primarily December–April. Fruit are 1 - 3.2 inches long, flattened, yellow, fleshy, and spiny. Habitat for this species is buttonwood zone between rockland hammock and coastal swamp. All plants are severely threatened by a deadly exotic moth. Protection and management includes support reintroduction programs; Control or eradicate moth pests and destroy all infected cacti plants throughout the Keys; Eradicate exotic pest plants; Protect coastal habitats from development; Continue research into reproductive biology. *Florida Natural Areas Inventory*, 2000.

Counties: Miami-Dade, Monroe

Florida Prairie-Clover (*Dalea carthagenensis floridana*) - Candidate

The candidate species, Florida prairie-clover (*Dalea carthagenensis floridana*), is a perennial shrub that grows to about three to six feet tall, with a light brown woody stem and non-woody, light brown or reddish branches. Its flowers are whitish, but turn maroon with age. Fruit is produced small, hairy, one-seeded pods. This species can be found in pine rocklands, rockland hammocks, marl prairies, adjacent roadsides and within the ecotone between these habitats. Florida prairie-clover is found within Big Cypress National Preserve (mainland Monroe County), as well as seven locations in Miami-Dade County (including one reintroduction site, Virginia Key). Florida prairie-clover has disappeared from four historical locations within Miami-Dade County, including Everglades National Park. In addition, the subspecies has disappeared from at least one location in Palm Beach.

Counties: Collier, Miami-Dade, Monroe, Palm Beach

Florida Pineland Crabgrass (*Digitaria pauciflora*) - Candidate

The candidate species, Florida pineland crabgrass (*Digitaria pauciflora*), is a small perennial clumping grass, blue-green to gray in color with hairy, reddish-brown stems. The plant's flowers are dull green and very small. It is found in pine rocklands, marl prairies, and within the ecotone between both habitats. Florida pineland crabgrass lives only within the Long Pine Key region of Everglades National Park (Miami-Dade County) and the Lostman's Pines region of Big Cypress National Preserve (mainland Monroe County). The species had disappeared from historic Miami-Dade County locations adjacent to Everglades National Park, due largely to habitat loss.

Counties: Miami-Dade, Monroe

Sand Flax (*Linum arenicola*) - Candidate

The candidate species, Sand flax (*Linum arenicola*), is a perennial herb with several wiry, angled stems ranging 8 - 28 inches tall, usually without leaves by flowering time. Leaves are less than 0.5 inch long, very narrow, with a pair of small red glands at the base that persists after leaf fall; opposite on lower stem, alternate on middle and upper stem. Flowers are less than 0.5 inch wide with 5 yellow, spreading petals, 5 gland-toothed sepals, and 5 separate styles. Fruit are a rounded capsule with a tiny, pointed beak and persistent sepals, opening into 10 segments. Flowers and fruits in March–November. Petals fall soon after the flowers open in the morning. Habitat for this species includes pine rockland, marl prairie, and adjacent disturbed areas. Protection and management practices: Apply prescribed fire every 3 - 7 years to create a mosaic of rockland habitats; Eradicate exotic pest plants; Restore suitable habitat and re-establish this species in conservation areas; Purchase and protect remaining fragments of pine rockland.

Florida Natural Areas Inventory, 2000.

Counties: Miami-Dade, Monroe

Carter's Small Flowered Flax (*Linum carteri var. carteri*) - Candidate

The candidate species, Carter's small flowered flax (*Linum carteri var. carteri*), is an annual herb ranging 4 - 24 inches tall with smooth, narrowly wing-angled stems. Leaves are 0.4 - 1.2 inches long, very narrow; Alternate, upper leaves are gland-toothed. Flowers about 0.5 inch wide, with 5 yellow-orange petals and 5 gland-toothed sepals; style undivided for almost entire length. Fruit are a rounded capsule, opening into 5 segments; sepals shed by time of fruit maturity, not persisting at base of fruit. Flowers and fruits in Feb–May; Flowers open in the morning and shed petals by mid-day. Habitat for this species includes pine rocklands, pine flatwoods, and adjacent disturbed areas. Protection and management practices: Purchase and

protect remaining fragments of pine rockland; Re-establish plants in conservation areas; Apply prescribed fire every 3 - 7 years to create a mosaic of rockland habitats; Eradicate exotic pest plants.

Florida Natural Areas Inventory, 2000.

County: Miami-Dade

Everglades Bully (*Sideroxylon reclinatum ssp. austrofloridense*) - Candidate

The candidate species, Everglades bully (*Sideroxylon reclinatum ssp. austrofloridense*), is a perennial single or many-stemmed shrub that grows to about three to six feet tall, with white flowers. It is found in pine rocklands, marl prairies, and within the ecotone between both habitats. The current range of this species consists of 10 populations in Miami-Dade County, including Everglades National Park, and an additional small population within Lostman's Pines region of Big Cypress National Preserve in Monroe County (mainland only).

Counties: Miami-Dade, Monroe

Florida Golden Aster (*Chrysopsis = Heterotheca) floridana*)

The endangered Florida golden aster (*Chrysopsis = Heterotheca) floridana*) is a perennial herb that form rosettes with leaves covered with dense, white, short-wooly hairs. Upright stems that grow from the rosettes are 0.3-0.4 meters (1-1.5 feet) tall, with closely-spaced, obovate-elliptic, hairy leaves. The leaves are nearly as large at the top of the stem as at the bottom. The flower heads are arranged in a more or less flat-topped cluster. Each head is slightly over 2.5 centimeters (1 inch) in diameter. Both the central disc and the rays are yellow. This plant is short-lived, and reproduces entirely by seeds. Its seeds are apparently dispersed primarily by the wind. The species grows in open, sunny areas. It occurs in sand pine-evergreen oak scrub vegetation on excessively-drained fine white sand. Historically, it also grew on beach dunes.

The most significant threat is the direct loss of habitat due to residential and commercial development. Other threats include mowing, dumping, and the effects from excessive grazing or off-road vehicle use. Developing management plans and guidelines for protected sites should receive high priority. In many situations, soil disturbance and removal of overstory vegetation would promote germination and establishment of the species.

Counties: Hardee, Hillsborough, Pinellas

Florida Bonamia (*Bonamia grandiflora*)

The threatened Florida bonamia (*Bonamia grandiflora*) is a perennial with sturdy prostrate stems about a meter (3 feet) long. The leathery oval or ovate leaves, up to about 4 centimeters (1.6

inches) long, are either upright or spreading. The flowers are solitary in the leaf axils. The funnel-shaped corolla is 7 to10 centimeters (2.7 to 3.9 inches) long and 7 to 8 centimeters (2.7 to 3.1 inches) across, pale but bluish purple with a white throat, similar to the cultivated "Heavenly Blue" morning glory. The fruit is a capsule. Habitat for this species is in openings or disturbed areas in white sand scrub on central Florida ridges, with scrub oaks, sand pine, and lichens. Urban and agricultural development, especially citrus groves, have extirpated the plant from most of its former range and continue to be the main threats. It is also susceptible to trash dumping, invasion by exotic plants and weeds, and damage from off-road vehicles. Normal ecological succession also poses a threat to Florida bonamia unless the habitat is kept open by occasional fires or equivalent mechanical land disturbance.

Counties: Hardee, Highlands, Hillsborough, Lake, Marion, Orange, Osceola, Polk, Sarasota

Pygmy Fringe-tree (*Chionanthus pygmaeus*)

The endangered Pygmy fringe-tree (*Chionanthus pygmaeus*) is a shrub or small tree, usually less than 10 feet tall. Stems are often buried in sand; twigs gray, with conspicuous leaf scars. Leaves 2 - 4 inches long, simple, entire, oval, somewhat leathery, yellow-green with maroon leafstalks, opposite or slightly alternate, the leaf scars knobby and slightly offset. Flowers less than 0.5 inch long, each with four narrow petals, white, fragrant, in showy clusters. Fruit are oval, 1 inch long, purplish-brown when ripe. Flowers in spring, but may be identified by leaves in the summer and knobby twigs in the winter. Habitat for this species is scrub, sandhill, and xeric hammock, primarily on the Lake Wales Ridge. May form thickets with evergreen scrub oaks and shrubs. Protection and management: Preserve scrub and sandhill by purchase or conservation easement; use prescribed fire to maintain sunny gaps, reduce competition, and create a mosaic of xeric habitats. *Florida Natural Areas Inventory*, 2000.

Counties: DeSoto, Highlands, Hillsborough, Lake, Manatee, Osceola, Polk, Sarasota, Seminole

Florida Perforate Cladonia (*Cladonia perforata*)

The endangered Florida perforate cladonia (*Cladonia perforata*) is a conspicuous lichen forming large dense clusters 20 to 60 millimeters (mm) tall. The branches arise from spore-producing structures and not from the vegetative body of the fungus as is the case with other branched lichens. The pale yellowish-gray, more or less glossy-surfaced podetia grow in intricate tufts. This lichen occurs on a barrier island in the Florida panhandle (Okaloosa County) and in scrub vegetation in central Florida south of Lake Placid (Highlands County), at Jonathan Dickinson Park near the southeastern coast in Martin County, and (subject to confirmation), a nearby site in northern Palm Beach County. There is a reasonable possibility that the lichen will be found at widely scattered localities elsewhere in Florida. However, very extensive searches have shown that this is an extremely rare lichen.

Counties: Highlands, Manatee, Martin, Okaloosa, Palm Beach, Polk, Santa Rosa

Scrub Wild Buckwheat (*Eriogonum longifolium var. gnaphalifolium*)

The threatened Scrub wild buckwheat (*Eriogonum longifolium var. gnaphalifolium*) is a perennial herb. It has a taproot and one to three above-ground stems up to 1 m tall, but upwards of 10 stems have been observed in vigorous specimens, especially post-fire. It has a basal rosette of leaves that are 15 to 20 cm long, narrow, and white-woolly on the underside. The stem leaves are smaller than the rosette leaves. The stem terminates in a corymb, with each branch of the corymb ending in a cup-shaped involucre that holds a cluster of 15 to 20 small flowers, with each flower hanging on its stalk down below the involucre. The involucre is silvery, silky-pubescent, and the flowers are green with pink anthers (Rickett 1967). This plant occurs in high pine and in turkey oak barrens habitats from Marion County to Highlands County (Christman 1988). The northern range limits for are in Ocala National Forest and in areas of mixed scrub and high pine south of Ocala in Marion County. It historically occurred near Eustis in Lake County (where it was collected around the turn of the century), and it still occurs near Clermont in remnants of high pine with Polygala lewtonii and several other endangered plant species.

Counties: Highlands, Hillsborough, Lake, Marion, Orange, Osceola, Pasco, Polk

Pigeon Wings (*Clitoria fragrans*)

The threatened Pigeon wings (*Clitoria fragrans*) is a 15 to 100 cm tall, long-lived perennial herb with an erect habit. The thick horizontal root, which may grow to more than 2 m long, bears one to several purplish, glaucous, wiry, very straight stems. The somewhat leathery leaves consist of three leaflets. Leaflets of the upper leaves are obtuse at the tip and narrower than those of lower leaves (58 FR 25746). Clitoria fragrans have chasmogamous (insect pollinating) and cleistogamous (self-pollinating) flowers. The chasmogamous flowers usually occur in pairs, each corolla consisting of one 3.5 to 4.5 cm-long (Fantz 1977) or 4.5 to 5 cm-long (Isely 1990) standard petal and a small white keel. The common name of this species refers to the petals of the chasmogamous flowers, which resemble wings (Fantz 1979). Pigeon wings plants are easily recognizable due to the inverted position of these pale purple flowers (Fantz 1979). The flowers are inverted so that the anthers and stigma touch the backs of visiting insects (the only other legume genus with inverted flowers is Centrosema, with two species in central Florida). The seed pod (legume) is 5 to 8 cm long and extends from the calyx (Fantz 1979).

Counties: Highlands, Lake, Orange, Osceola, Polk

Papery Whitlow-wort (*Paronychia chartacea*)

The threatened Papery whitlow-wort (*Paronychia chartacea*) is an annual herb with spreading, wiry stems rising from a stout taproot. Stems either dense and compact (female-flowered plants) or with spindly, forking branches forming cross shaped patterns (male-flowered plants). Leaves tiny, opposite, papery, and scale-like with strongly enrolled margins. Flowers are tiny, with 5 white, deeply hooded sepals and no petals; in small clusters, 0.5 to 1.5 inches wide.

Counties: Bay, Highlands, Lake, Orange, Osceola. Polk, Walton, Washington

Wide-leaf Warea (*Warea amplexifolia*)

The endangered Wide-leaf warea (*Warea amplexifolia*) is an annual herb in the mustard family (Brassicaceae). Plants may be 30 to 100 cm tall and the stalk may be unbranched or, more often, branching midway up the stem. Leaves are alternate, from 2 to 5 cm long, and 1 to 3 cm wide, smaller as they ascend the stalk, with a rounded apex and entire margin. On young plants, the leaves are slightly folded along the midrib, tipped upward, and the lobes at the base of leaves reach around the stem. This characteristic has led to one of the common names for the species, clasping warea. The heart-shaped clasping leaf bases and its pale green, slightly glaucous leaves readily distinguish W. amplexifolia from the three other species in its genus in Florida. The characteristic leaves can be used in field identification even if the plants are not flowering. The pale lavender flowers of W. amplexifolia vary in individuals from almost white to almost purple. Flowers appear at the ends of the branches in spherical clusters about 5 to 6 cm across. Superficially, the flowers look like small versions of the garden cleome (*Cleome hasslerana*), a member of the family Capparaceae. The inflorescences Wide-leaf Warea (or Clasping Warea) *Warea amplexifolia* (Nutall) are endangered (April 29, 1987) with no critical habitat designated. Florida Status: Endangered. County distribution of wide-leaf warea are dainty, and in the field the flowering plants look almost fluffy. Individual flowers are about 1.5 cm across, with four petals and six long stamens. *Warea amplexifolia* is also readily identifiable in seed, even as the stalk turns brown and the leaves wither, by the clusters of narrow down-curving seed pods, from 5 to 7 cm long. The pods split longitudinally, with small black seeds on either side of the center membrane. *Polonisia tenuifolia*, an annual in the family Capparaceae, which grows about as tall as *W. amplexifolia*, might be mistaken for *W. amplexifolia* when the plants are brown and dry at the end of the season. However, *Polonisia* seed pods, which are about the same size as those of Warea, appear singly in the leaf axils and are erect and straight (FWS 1993).

Counties: Lake, Osceola, Polk

Longspurred Mint (*Dicerandra cornutissima*)

The endangered Longspurred mint (*Dicerandra cornutissima*) is a strongly aromatic plant that grows up to 1.6 feet tall, with erect, non-woody flowering shoots growing from a woody base. The leaves are about .58 of an inch long, linear, with entire margins, and covered with conspicuous sunken glands. The leaves are borne opposite one another on the stems, often with

two smaller leaves at each node. Flowers are borne in groups in the axils of the leaves on the upper parts of the stems. The petals are 7 millimeters (0.3 of an inch) long, forming a tube with two lips, bent at a 90-degree angle in the middle, and colored purplish-rose with deep purple markings and a whitish throat. The anthers are tipped by a spur 1.2 millimeters long, for which the plant is named. Longspurred mint (*Dicerandra cornutissima*) flowers in September and produces fruits in the form of four small nutletshis is a short-lived perennial that grows from seed; the species does not spread vegetatively.

Counties: Marion

Lewton's Polygala (*Polygala lewtonii*)

The endangered Lewton's Polygala (*Polygala lewtonii*) is a relatively short-lived (5 to 10 year) perennial herb. Each plant produces one to several annual stems, which are spreading, upward-curving or erect, and are often branched. The leaves are small, sessile, rather succulent, broader toward the tip, and are borne upright, tending to overlap along the stem, like shingles. The normally opening flowers are in erect, loosely flowered racemes about 1.5 cm (Wunderlin et al. 1981) or 3.3 cm (Weekley 1996) long. The flowers are about 0.5 cm long and bright pink (Wunderlin et al. 1981) or purplish-red (Ward and Godfrey 1979). Two of the five sepals are enlarged and wing-like, between which the largest of the three petals forms a keel that ends in a tuft of finger-like projections (Ward and Godfrey 1979). The plant also produces two types of small, cleistogamous (non-sexual) flowers (L. Miller, Ocala NF, personal communication 1996, Weekley 1996).

Counties: Highlands, Lake, MArion, Orange, Osceola, Polk

Scrub Lupine (*Lupinus aridorum*)

The endangered Scrub lupine (*Lupinus aridorum*) is a biennial or perennial herb with a soft-woody base and shrubby appearance. Stems silvery, upright or spreading, to 3 feet tall. Leaves 1 - 3 inches long, simple, the lower ones clustered, the upper alternate; oval with rounded base and pointed tip, with short, silver, silky-satiny hairs; stipules (bracts at the base of each leaf) absent or tiny. Flowers pink, pea-like with a maroon-red spot on the banner petal; in erect clusters; calyx two-lipped and silky. Fruit a wooly legume.

Counties: Orange, Osceola, Polk

Sandlace (*Polygonella myriophylla*)

The endangered Sandlace (*Polygonella myriophylla*) is a sprawling shrub that looks somewhat like the ornamental creeping juniper (Juniperus horizontalis). Its many branches zigzag along the ground and root at the nodes, forming low mats. The lower parts of the creeping branches have

bark that cracks and partly separates in long, flat, interlacing strips. The short lateral branches end in flowering racemes. *P. myriophylla* has the sheathing leaf stipules (ocreae and ocreolae) typical of the jointweed family. The leaves are needle-like and are from 0.3 to 10.0 mm long. The small, white or cream colored flowers have white petallike sepals up to 3.4 mm long (Kral 1983).

Counties: Desoto, Highlands, Orange, Osceola, Polk

Etonia Rosemary (*Conradina etonia*)

The endangered Etonia rosemary (*Conradina etonia*) is a shrub that grows up to 1.5 meters (5 feet) and has numerous, frequently arching primary branches. The leaves have margins that are tightly rolled to the underside. The dull green upper side of the leaf is covered with short, downy hairs and numerous minute glands. The lower side is slightly paler and concave with tiny hairs that are very dense even on the midrib. The midrib, at the base of a strong median groove on the upper surface, is strongly raised on the lower surface and has two to four strong branch nerves on each side, a characteristic unique to this species of *Conradina*. Clusters of three to seven flowers are produced from all or most nodes from the midstem up. The flower's characteristic corolla tube is sharply bent above the middle. The sepals form two lips. The upper lip is three-toothed and upswept while the lower lip with two teeth is split almost to the base. The corolla is strongly two-lipped with a lavender-blue to lavender-rose corolla tube and throat. The upper lip is uniformly lavender and the lower lip and throat have a broad longitudinal zone of white or cream mottled with spots and streaks of deep purple. The four stamens consist of a shorter pair extending almost to the tip of the upper lip and a longer pair extending slightly beyond, arching outward and downward. The pollen sacs on the anthers are dark purple with white hairs. The S-shaped style extends beyond the anthers. Generally, four brown, egg-shaped nutlets are produced. Flowering occurs from early spring to late fall.

County: *Putnam*

Rugel's Pawpaw (*Deeringothamus rugelii*)

The endangered Rugel’s pawpaw (*Deeringothamus rugelii*) is a shrub with a woody base and slender, non-woody shoots that die back to the ground in the winter, 4 - 8 inches long, arching or erect, seldom branched. Leaves 1.5 - 3 inches long, alternate, erect, leathery, oblong, tips blunt or notched, with raised veins on underside and rolled under margins. Flowers fragrant, solitary in leaf axils, with 3 sepals and 6 yellow petals. Fruit yellow-green, peanut-shaped, 1 - 3 inches long.

County: *Volusia*

Okeechobee Gourd (*Cucurbita okeechobeensis ssp.okeechobeensis*)

The endangered Okeechobee gourd (*Cucurbita okeechobeensis ssp.okeechobeensis*) is an annual or perennial, fibrous-rooted, high-climbing vine with tendrils, belonging to the gourd family (*Cucurbitaceae*). It possesses heart- to kidney-shaped leaf blades, with 5 to 7 angular, shallow lobes, and irregularly serrated margins (Walters and Decker-Walters 1993). Young leaves are covered with soft hairs. The cream-colored flowers are bell-shaped, with the corolla 6 to 7 cm long. They can be distinguished from flowers of *C. martinezii* (Martinez gourd) by the presence of dense pubescence on the hypanthium of the male flower and on the ovary of the female flower. The light green gourd is globular or slightly oblong, with 10 indistinct stripes, and hard shelled with bitter flesh. The seeds are gray-green and flat (Small 1930, Tatje 1980, Walters and Decker-Walters 1991). The stems produce adventitious roots at the nodes and will separate from the parent plant if they contact soil or water (Minno and Minno 1995).

Counties: Glades, Hendry, Martin, Okeechobee, Palm Beach

Avon Park Harebells (*Crotalaria avonensis*)

Avon Park harebells (*Crotalaria avonensis*) is a spreading, perennial herb with one to three moderately hairy, flowering stems that may grow 2 to 10 cm above the surface. It has a large taproot, up to 14 mm thick and 40 cm long. The leaves of this plant are 8 to 19 mm long, broadly elliptic or round, somewhat succulent, and coated with white or yellowish-white hairs. The stems terminate in flowering racemes. Flowering is from March until June. The flower, shaped like a typical pea flower, has a yellow corolla 8 to 9 mm long. The seed pods are inflated and 14 to 25 mm long. These pods are tan to grey or maroon, and can be nearly as long as the upright stems that hold them in place. The pods contain up to 18 seeds, chestnut to maroon in color and 3.4 to 3.8 mm long by 2.4 to 2.6 mm wide. The plant generally appears to resemble clusters of fuzzy grayish leaves hugging the ground and sometimes appears bushy (DeLaney and Wunderlin 1989).

Counties: Highlands, Polk

Beach Jacquemonita *(Jacquemontia reclinata)*

The endangered Beach jacquemonita *(Jacquemontia reclinata)* is a perennial vine which has a main stem with numerous laterals spreading out from a stout rootstock (Robertson 1971). These reclining, partly twining or ascending, slender stems are woody at the base and may twine over other plants (Robertson 1971, Austin 1979). The older leaves and stems of this species can be glabrous, but the pubescence makes younger leaves and stems appear whitish (Austin 1979). The leaves are entire, alternate, estipulate, spirally arranged, and almost always petiolate, reaching 1 to 3 cm in length and 0.5 to 2.5 cm in breadth (Small 1905, Robertson 1971, Austin 1979). The flowers of this species are white to light pink and the sepals are persistent. The inflorescences

can be axillary cymose or solitary with branches 8-40 mm long, usually not exceeding the leaves (Robertson 1971, Austin 1979). The fruit is a light brown capsule about 4-5 mm long (Small 1905, Robertson 1971).

Counties: Broward, Martin, Miami-Dade, Palm Beach

Crenulate Lead-plant (*Amorpha crenulata*)

The endangered Crenulate lead-plant (*Amorpha crenulata*) is a rhizomatous, deciduous, perennial shrub that grows to 1.5 m in height and is endemic to Miami-Dade County, Florida (DOT 1997). The branches of this plant are red/purple, and contain 25 to 33 leaflets borne on leaves that are 0 to 15 cm long, with petioles 1 cm long or less. The crenulate leaflets are grey/green above, paler and glandular dotted below, and 5 to 11 cm long. The racemes are terminal, 15 to 20 cm long, solitary or in clusters of two to three. The 8 mm-long flowers are held in loose clusters. The calyx is dark green or purplish, 3.2 to 4.0 mm long with the upper half glandular dotted. The showy white standard flower is 5.2 mm long, and 4.2 mm wide with long exerted stamens. The fruit is 6 to11 mm long, laterally compressed, and glandular dotted on the upper two-thirds. The seeds produced in the fruit are 5 mm long and compressed.

County: Miami-Dade

Deltoid Spurge (*Chamaesyce deltoidea ssp. deltoidea*)

The endangered Deltoid Spurge (*Chamaesyce deltoidea ssp. deltoidea*) is a small, monoecious, prostrate to decumbent herb occurring in mats over exposed limestone. The stems are terete (circular although slightly oblong) in cross section, brown, and 0.3 to 0.6 mm in diameter. The leaves are smooth above to slightly hairy below, with an obtuse apex, cordate base, margins entire; stipules laciniate, brown to reddish brown with light tips, and smooth. The inflorescence is found singly, in leaf axils, with a short peduncle (1 mm long). The cyathium is 1.2 mm long, 1.0 mm wide and smooth (glabrous). It is green and ovate in shape with four glands and minute appendages. The fruit is a capsule, 1.0 mm long and 1.0 mm wide, and completely glabrous. The pedicel is also glabrous. It is fully exerted at maturity. There are three seeds, 1.0 mm long and 0.5 mm wide, ovate in shape and glabrous. The seeds are laterally four-ridged and yellowishwhite (Remus 1979).

County: Miami-Dade

Florida ziziphus (*Ziziphus celata*)

The endangered Florida ziziphus (*Ziziphus celata*) is a spiny shrub that averages between 0.5 to 1.5 m in height, but can grow to over 2 m. Plants occur in groups of stems, arising from what are assumed to be connected root systems. The primary branches are jointed and bent, and give rise

to short, straight, spiny, branchlets. The oblong-elliptic to obovate leaves are alternate and deciduous. The leaves are characterized by rounded tips, cuneate bases, and entire margins. The upper leaf surface is dark glossy green, while the underside is a dull light green. Leaves vary from 4.5 to 21 mm in length, and from 3 to 13 mm in width. Fragrant Z. celata flowers are small, axillary, and solitary, but are tightly bundled on short shoots. Flowers are perfect, with five greenish-yellow sepals, and five white petals clasping five stamens; however, three-and four-merous flowers have been observed (Race and Weekley 1996). The bright yellow drupes range from 10 mm to 20 mm long, and 3 mm to 10 mm wide (Judd and Hall 1984, DeLaney et al. 1989, Race and Weekley 1996).

Counties: Highlands, Polk

Four-petal Pawpaw (*Asimina tetramera*)

The endangered Four-petal pawpaw (*Asimina tetramera*) is a 1 to 3 m tall aromatic shrub that has one to several stems arising from a deep taproot. Leaves are oblong to oblanceolate, 5 to 10 cm long, arranged alternately on the stem, and are yellow-green to deep green. The leaves are narrow at the base (A. Cox, Florida International University, personal communication 1995), have broadly acute or blunt tips, and lack stipules. The flowers are maroon and fetid. They occur singly in the leaf axil; however, if the plant is burned or damaged, two or three flowers may develop. Perianth parts are typically in whorls of three but may vary. The petals usually form whorls. The stamens are spirally arranged on an elevated torus or ball-shaped receptacle, surrounding one too many separate carpels. After fertilization, the receptacle expands as the fruit develops. The fruit is an aggregate of developing carpels, or monocarps, on the expanding receptacle. The monocarps are indehiscent and berry-like. An individual flower may produce from one to eight monocarps with one to nine seeds each (A. Cox, Florida International University, personal communication 1995). The fruit is oblong and greenish-yellow, emitting a banana-like aroma when ripe (A. Cox, Florida International University, personal communication 1995). The laterally flattened seeds are dark brown and shiny (Austin and Tatje 1979, Kral 1983). Many flowers of *A. tetramera* are four-merous, with sepals, inner petals and outer petals arranged in groups of four (Kral 1960). Some flowers may have a combination of three- and four-merous parts.

Counties: Martin, Palm Beach

Fragrant Prickly-apple (*Cereus eriophorus var. fragrans*)

The endangered Fragrant prickly-apple (*Cereus eriophorus var. fragrans*) is a solitary tree cactus that may have from one to eight, spiny, cane-like, stout, and succulent stems. The columnar

stems are 2.5 to 5.0 cm in diameter and have 10 or 12 ridges alternated with deep, sharp grooves (Benson 1982). Stems may be erect, or for longer stems, the plant may recline over neighboring vegetation. The branching can be extensive, and the roots of this cactus are coarse, fibrous, and shallow (Small 1920). The spine-bearing regions (areoles) are aligned along its ridges about 2 cm apart. Each areole bears 9 to 13 spines, which are mostly grayish and yellowish at the tip, with one spine longer (2 to 4 cm) than the rest. *Cereus eriophorus var. fragrans* has initial flower buds that are 1 cm long, white, and exceedingly hairy. Buds often appear on the plant one to two months prior to flower growth. About 9 days after initiation of flower growth, the flower opens (Rae 1995). The flowers are fragrant, showy, solitary, and open only at night. The buds are 12 to 20 cm long when about to open and 7.5 to 10 cm in diameter when open. The ovary bears many lanceolate scales while the flower tube has only a few scattered scales. A tuft of long white hairs (10 to 15 mm long) protrudes from the axil beneath each scale. The sepals are narrowly linear, with green outer sepals and nearly white inner ones. There are numerous spatulate petals, white or pinkish, with unevenly toothed margins. The stamens are numerous and are composed of white filaments and yellow anthers. The style is elongate with 9 to 12 stigmas (FWS 1988). The fruits are attached at the narrower end. They average 4 to 6 cm in diameter and are a dull red. The fruit does not split and has long tufts of white hairs that remain persistent with the scale bases (Leon and Alain 1953). The fruits are swollen at the base and finely pitted; each contains approximately 1,500 black seeds that are about 3 mm long (Rae 1995).

Counties: Indian River, St. Lucie

Garber's Spurge (*Chamaesyce garberi*)

The threatened Garber's Spurge (*Chamaesyce garberi*) is a prostrate to erect herb with pubescent stems. The leaves are ovate in shape and 4 to 9 mm long, with entire or obscurely serrate leaf margins. The cyathia are about 1.5 mm long and borne singly at the leaf axils. The appendages are minute or completely absent. The fruit is a pubescent capsule 1.5 mm wide. The seeds are either smooth or have transverse ridges, but are not wrinkled; this is not, however, a distinctive character for this species.

Counties: Collier, Miami-Dade, Monroe

Garrett's Mint (*Dicerandra christmanii*)

The endangered Garrett's mint (*Dicerandra christmanii*) is a small, fragrant shrub that reaches 50 cm in height (Huck et al. 1989). Both its floriferous and vegetative shoots are stiff and ascend from a ramose (many branched, branching), woody base. Its taproot is branched with extensive, spreading, fibrous roots. The leaves of Garrett’s mint (*Dicerandra christmanii*) are sessile and have rounded apices, cuneate bases, entire margins and glandular pitted upper and lower surfaces (Huck et al. 1989). Leaves found on the determinate, flowering shoots are narrowly ovate to narrowly oblong. Those that subtend the cymes are 2 to 8 mm long and 0.5 to 1.8 mm wide,

while those that do not subtend the cymes are approximately 5 to 11 mm long, and 1 to 2.5 mm wide. The leaves of overwintering, vegetative shoots are similarly shaped, but larger. The inflorescence is a verticillaster (Huck et al. 1989), with each cyme containing 1 to 3 flowers. The calyx is 6.5 to 10 mm long, approximately 2 mm wide (at midpoint), and bordered with an indistinct white band. The corolla is funnel shaped and abruptly bent to about 90 degrees. Its tube is 7 to 10 mm long, and its limb (from geniculum to distal edge of upper lobe) is 5 to 10 mm long. The corolla buds yellow, but at maturity, it is a pale cream (eventually fading to white). It has vivid purple-red markings that are often trellis-patterned on the upper lobe, but irregularly spotted on the lower lobe. The upper lobe is a recurving, cleft standard, and the lower lobe is tripartite (three parted) with a recurving middle petal. The flowers have four, paired stamens, which are exerted slightly beyond the lower corolla lip (Huck et al. 1989). The filaments are white, the anther sacs are brilliant yellow, and the connective is widened and may be covered with a few small, reddish and yellow glands at the basal end. The pollen is white and sticky. The pistil is white and has a slender, hirtellous style. The fruit is a schizocarp of four ovoid, brown, smooth nutlets.

County: Highlands

Highlands Scrub Hypericum (*Hypericum cumulicola*)

The endangered Highlands scrub hypericum (*Hypericum cumulicola*) is a small, short-lived perennial herb reaching 20 to 70 cm in height. It is branched from the base and has a woody, fibrous root system. The stems are shorter and more numerous in winter and spring before reproductive stalks are differentiated. Usually there are three stems, but there can be as many as 17 stems on a healthy plant (Quintana-Ascencio and Morales-Hernández in press). During the reproductive season, all stems of mature individuals bear flowers and fruits. The leaves of *H. cumulicola* are opposite, simple, entire, and needle-like. Flowers are small, bisexual, and arranged in cymes. The calyx consists of five distinct sepals, while the corolla consists of five bright yellow petals shaped like the blades of a propeller. There are approximately 27 anthers. The gynoecium has three, sometimes four locules, and the ovary is superior with approximately 22 ovules aligned around the walls of the ovary (parietally). The style has three, sometimes four, white lobes. Fruits are small capsules, red when immature and dark purple at the time of dehiscence. Mature seeds are small and dark brown. This species, as other *Hypericum*, may contain hypericin, a promising compound with protective effect in the control of viral diseases in animals (Duke 1989).

Counties: *Highlands, Polk*

Key Tree-cactus (*Pilosocereus robinii*)

The endangered Key tree-cactus (*Pilosocereus robinii*) is a large, tree-like cactus with erect columnar stems, reaching 10 m in height. At maturity, the plants are either much-branched (in

variation *robinii*), or remaining few-branched (in variation *deeringii*). The stems of the tree-cactus are cylindrical, green, succulent, and 5 to 10 cm thick, with nine to 15 prominent ribs. Areoles bear 15 to 30 acicular spines that are up to 2 cm long and are thickly pubescent when young. Flowers are solitary in the upper areoles, nocturnal, and 5 to 6 cm long. The outer perianth segments of the flowers are green, with tips pointed (in variation *robinii*) or rounded (in variation *deeringii*). The inner perianth segments of the flowers are white. The style is slightly exserted (in variation *robinii*) or included (in variation *deeringii*). The fruit of the Key tree-cactus (*Pilosocereus robinii*) is globose, depressed, and 3.5 to 4.0 cm in diameter. The coat of this fruit is thin, leathery, bright red, and splits open at maturity. The seeds are small, hard, shiny black, and set in a soft, white pulp (Benson 1982, Britton and Rose 1937, Small 1931).

County: Monroe

Lakela's Mint (*Dicerandra immaculata*)

The endangered Lakela's mint (*Dicerandra immaculata*) is a small, fragrant shrub that reaches 50 cm in height (Kral 1982). Its growth is bushy when in open sun but becomes lax when in shade. It forms small mats or domes of ascending to spreading or sprawling branches. The primary branches arise from a stout, deep, woody-branched taproot, and its numerous innovations arise from spreading or sprawling older growth. The main leaves are spreading (horizontal) or ascending (pointing upward), while those in the inflorescence (flower cluster) are sometimes reflexed (pointing downward) (Kral 1982). All leaves are linear, oblong-linear, linear-elliptic, linear-lanceolate or linear-oblanceolate in shape. They are 2 to 3 cm long, 2 to 4 mm wide, smooth, flattened, subsessile, narrowly rounded at the apical end, often slightly emarginate, and entire, though larger leaves can be minutely serrulate at the apical end. The inflorescence is usually 15 to 25 cm long (Kral 1982). Its flowering cymes overlap and each has one, three, or five flowers. The calyx body is 7 to 8 mm long and is usually purplish, becoming white or roseate toward the orifice. The corolla is 1.9 to 2.0 cm long, immaculate (not spotted), and is a bright lavender-rose. The upper corolla lip is broadly ovate to obovate, approximately 7 mm long, apically upswept, and broadly rounded-emarginate. The lower lip is broadly obovate, trilobate, 9 to 10 mm long, and downswept. The lateral lobes are spreading, oblong, broadly rounded, or oblique-truncate and the medial lobe is emarginate. The anthers are exserted, and the style is projecting. The color of the corolla, lavender-rose to purplish, and its lack of spots separates *D. immaculata* from other species of the *Dicerandra* genus (FWS 1985).

Counties: Indian River, Martin, St. Lucie

Scrub Blazing Star (*Liatris ohlingerae*)

The endangered Scrub blazing star (*Liatris ohlingerae*) is a long-lived perennial herb having a thickened, cylindric root. Its stems are erect, usually unbranched, and it can grow up to 1 m tall. Its leaves are fleshy and narrow (1 to 2.5 mm), and generally 3 to 8 cm long (Wunderlin et al. 1980). Flower heads are well separated on the stem with individual disc flowers up to 1 cm broad; the inflorescences are up to 3 cm across. The corollas are bright purplish-pink in color. The broad flower heads and narrow leaves distinguish *L. ohlingerae* from the eight other *Liatris* species in central Florida.

Counties: Highlands, Polk

Scrub Mint (*Dicerandra frutescens*)

The endangered Scrub mint (*Dicerandra frutescens*) is a dense or straggly, low-growing shrub (Kral, 1983). It reaches 50 cm in height and grows from a deep, stout, spreading-branching taproot. Its branches are mostly spreading, and sometimes are prostrate. Its' shoots have two forms, one which is strictly leafy and overwintering, and another which is flowering and dies back after fruiting. The leaves vary in shape. They can be narrowly oblong elliptic, linear-elliptic, or linear-oblanceolate (Kral 1983). The upper surface of the leaves is dark green, with the midrib slightly impressed. The lower surface is slightly paler, with the midrib slightly raised. They are 1.5 to 2.5 cm long, 2 to 3 mm wide, subsessile, flattish but somewhat fleshy, narrowly or broadly rounded at the apical end, have entire margins, and are not revolute. It has an inflorescence that is elongated and interrupted, and, at least half of the flowering shoot is floriferous (Kral 1983). The calyx, at anthesis, is approximately 9 to 10 mm long, nearly erect, proximally and medially green, and distally tinged with red, with a broad white zone around the orifice. The corolla is 1.9 to 2.0 cm long, with an erect tube that is approximately 7 mm long. The external surface of the throat and limb is white or yellowish white. The upper lip is marked internally with a trellis pattern of lines and dots of deep purple, while the lower lip is maculate with larger, concentric spots from lobe bases to base of the lip. The flower has two pairs of stamens, with one pair slightly longer than the other (Kral 1983). The filaments are white, and the anthers are purple. Styles are almost white and bent forward or curved downward (usually above the anthers). *Dicerandra frutescens* is very similar in appearance to another *Dicerandra* species, *D. christmanii*. These two mints are separated using the following characteristics. One, *D. frutescens* has a minty aroma, whereas *D. christmanii* smells of menthol (Huck et al. 1989). Two, the leaves of *D. frutescens* are longer than those of *D. christmanii* (Huck et al. 1989). Three, the anthers of *D. frutescens* are deep purple to white in color, while the anthers of *D. christmanii* are a brilliant yellow (Huck et al. 1989). Four, the corolla of *D. frutescens* fades from a cream color to white within 1 to 3.5 hours of anthesis, while the corolla of *D. christmanii,* retains its cream color throughout most of the first day of anthesis (Huck et al. 1989). Five, the anther connectives of *D. frutescens* have more, and larger, glands than those of *D. christmanii* (Huck et al. 1989).

Counties: Highlands, Polk

Scrub Plum (*Prunus geniculata*)

The endangered Scrub plum (*Prunus geniculata*) is a heavily branched, broad-crowned shrub that can reach 2 m in height, although 0.5 m may be more typical at sites with frequent fires. It grows from gnarled, half-buried trunks and spreads by sucker shoots. Its young twigs are strongly geniculate (zig-zag shaped), while its lateral branches are either short, stubby, spur shoots bearing leaves and flowers, or are strongly tapering and spine-like. The bark of old stems is thin, gray, usually lichen-encrusted, and forms small rectangular or square plates. The bark of new shoots is lustrous reddish-brown or purplish and smooth. The scrub plum's (*Prunus geniculata*) leaves are crowded on the spur shoots (an arrangement typical of the *Rosaceae* family) and are widely spaced on the normal shoots. The stipules are linear-subulate, roughly 5 mm long, green, and pectinate fringed at the margins with reddish glands. The leaf blades are ovate to obovate or elliptic, 1 to 3 cm long, shortacuminate, and serrulate with gland-tipped teeth. The leaf base is rounded or broadly cuneate. The leaf stalk is a third to half as long as the blade. The scrub plum (*Prunus geniculata*) has small, fragrant flowers that are 11 to 13 mm across when open. Like the leaves, flowers found on the spur shoots are rather crowded, while those found on the regular shoots or the spine bases are spaced further apart. The pedicels extend only slightly beyond the bud scales, so the flowers give the appearance of being sessile. The flowers are radially symmetrical with a 3 mm long hypanthium (the cup-shaped structure formed by the united portions of the bases of the sepals, petals, and stamens). The 5 calyx lobes are radially symmetrical, spreading to ascending triangular with acute apices, sparsely ciliate on the margins, reddish or green, with the bottom surfaces smooth and the upper surfaces white-tomentose. The 5 petals are white, spreading, and about 5 mm long. The petal blades are ovate to obovate with rounded tips and attenuated bases ending in short, ciliate margins claws. The stamens are numerous, roughly 0.5 mm long, and borne on the rim of the hypanthium. The fruit of the scrub plum (*Prunus geniculata*) is an ovoid or ellipsoidal drupe, 12 to 25 mm long, and dull reddish in color. It has a thin, bitter flesh and a slightly flattened seed.

Counties: Highlands, Lake, Orange, Osecola, Polk

Short-leaved Rosemary (*Conradina brevifolia*)

The endangered Short-leaved rosemary (*Conradina brevifolia*) is a short lived, erect, woody, perennial shrub that reaches about 1 m in height (Kral 1983). It is very similar to the relatively widespread, and quite variable *C. canescens* of the Florida panhandle, Alabama, and Mississippi, and it is similar to the endangered *C. glabra* of the Apalachicola bluffs (Gray 1965, FWS 1994). As its name implies, *C. brevifolia's* alternate leaves are shorter than *C. canescens*. The larger leaves on well-developed flowering branches are 6.0 to 8.2 mm long, and mostly shorter than the internodes, whereas *C. canescens'* leaves are 7 to 20 mm long and are mostly longer than the internodes. *C. brevifolia* also tends to have more flowers per axle than *C. canescens*: one to six per axle versus one to three in *C. canescens.*

Counties: Highlands, Polk

Small's Milkpea (*Galactia smallii*)

The endangered Small's milkpea (*Galactia smallii*) is a small, trifoliolate, perennial legume with small, purple flowers and a prostrate habit. The stems are grayish, due to a covering of short hairs, and grow up to 2 m long. The stem internodes are well-developed and have long, straight, soft hairs. The 1 to 2.2 cm long leaflets are broadly ovate to elliptic. The undersides of the leaves have long, soft, wavy hairs lying almost flat against the surface. The upper surface of the leaves are either hairless (glabrate) or have sparse, stiff hairs, lying flat on the surface (strigose). The inflorescences are 2 to 6 cm long with one to five flowers at the apex or along the axis. The flower buds are 5 to 7 mm long, and the calyx is about 7 mm long and loosely strigulose. The corolla is 11 to 12 mm long and pinkish purple or lavender. The legume is 3 to 4 cm by about 4 m in size and is strigulose or villosulous (Isley 1990).

Counties: Miami-Dade

Snakeroot (*Eryngium cuneifolium*)

The endangered Snakeroot (*Eryngium cuneifolium*) is an aromatic perennial herb with a long, woody taproot, and persistent rosette of dark green. It usually has several erect, branching, flowering stems. It ranges from 0.25 to 0.5 m in height, rarely reaching as high as 0.9 m. The leaves are clustered at the base of the plant. The basal leaves are long, stalked, and shaped like narrow wedges, with 3 to 5 bristle-tipped teeth at the apex. Stem leaves are smaller and lack leaf stalks. The flowers are small, with white petals, filaments, styles and stigmas but powdery blue anthers form small heads, with bristly bracts. The sepals and petals are each about 1.5 to 2 mm long. The inferior ovary develops into a fruit about 1.5 to 2 mm long. The flowers and bristle bracts form heads 4 to 8 mm in diameter (Bell 1963, Wunderlin et al. 1981). Sterile plants are easily recognized in the field by their basal rosettes (Wunderlin et al. 1981). Flowering is from August to October (other *Eryngium* species, including *E. aromaticum* and *E. baldwinii* have blue flowers).

County: Miami-Dade

Tiny Polygala (*Polygala smallii*)

The endangered Tiny polygala (*Polygala smallii*) a is an erect short-lived herbaceous species. Most plants germinate and die within one year. It forms a rosette and grows no more than 8 cm tall (Kennedy 1998). It has one to four, short, usually unbranched stems, and a well-developed, scented taproot. Its leaves are oblanceolate to lanceolate, from 1.5 to 5 cm long and 0.2 to 1.4 cm broad and occur in a basal rosette. The inflorescence is a cylindric raceme from 0.4 to 7 cm long

and 0.5 to 1.8 cm thick and usually surpassed by the basal leaves (Kennedy 1998) The flowers have both functional stamens and pistils (perfect) and are not radially symmetrical (zygomorphic). The calyx has five sepals. The lateral pair is decurrent, large and petaloid. The corolla is a greenish-yellow color with three petals. The fruit is a thin-walled, two-celled capsule that splits down the center of the compartment. The seed is 1.2 to 1.4 mm long, with sparse rather short, stiff, appressed hairs (strigose). It also has a pair of aril-like outgrowths about half the length of the capsule (Gann and Bradley 1995, Smith and Ward 1976).

Counties: Broward, Martin, Miami-Dade, Palm Beach, St. Lucie

Apalachicola Rosemary (*Conradina glabra*)

The endangered Apalachicola rosemary (*Conradina glabra*) is a densely branched, low shrub, less than 2.5 feet tall, with a strong minty odor. Leaves are evergreen, opposite, needle-like; leaves in clusters, giving the branches a bushy look. Upper surface of the leaves are smooth and hairless; lower surface are covered by densely matted, but nearly invisible hairs (visible with magnification). Flowers usually in groups of 2 or 3. Flower are 0.5 - 0.75 inches long, flower bent sharply upward, lower lip of flower three-lobed, white to pale lavender-pink with a band of purple dots on the white throat. Calyx smooth or with a few short hairs. It flowers March–June, and will occasionally flower until December. Habitat for this species includes the upper edges of steep heads that transition to sandhills, edges of pine plantations, highway and utility rights-of-way. Protection and management will consist of removing competing vegetation by thinning, clipping, or carefully monitored use of prescribed fire, along with avoiding repeated or severe disturbances such as road widening, clearcutting, site preparation for silviculture, and pine plantation. Use of herbicides in rights-of-way should also be avoided.

Florida Natural Areas Inventory, 2000.

County: Liberty

Telephus Spurge (*Euphorbia telephioides*)

The threatened Telephus spurge (*Euphorbia telephioides*) is a perennial herb with numerous, erect stems up to 1 foot tall. Stems and leaves are smooth and fleshy with milky sap. Leaves span 1 - 2 inches long, alternate, without leaf stalks; Widest above the middle, usually with maroon midribs and margins. The flowers are in reddish-green cyathia (cup-like structures) with 1 female flower (an ovary less than 0.5 inch long), and several male flowers (one stamen each) on short stalks, surrounded by 4 - 5 minute, petallike glands. Fruit are a 3-lobed capsule. Habitat for this species includes longleaf pine savannas, scrubby and mesic flatwoods, and coastal scrub on low sand ridges near the Gulf of Mexico. Suggested protection and management is a burn every 2 - 5 years. Plants may survive silvicultural site preparation due to large, deeply buried taproots, but

will die as the plantation canopy closes; Mowing may partly mimic fire; avoid use of herbicides in rights-of-way. *Florida Natural Areas Inventory*, 2000.

Counties: Bay, Franklin, Gulf, Wakulla, Walton

Harper's Beauty (*Harperocallis flava*)

The endangered Harper's beauty (*Harperocallis flava*) is a perennial herb up to about 2 feet tall. It has distinctive showy, yellow, solitary flowers that bloom in April and May, and tuberculate ovaries and fruits. This species occurs on gentle slopes, seepage savannas between pinelands, and cypress swamps to precariously open roadside depressions.

Counties: Bay, Franklin, Liberty

White Birds-in-a-nest (*Macbridea alba*)

The endangered White birds-in-a-nest (*Macbridea alba*) is a perennial herb, 1 - 1.5 feet tall, with erect, square stems. Leaves range 2 - 4 inches long, opposite in 6 - 8 pairs, thick and usually rough-hairy, widest above the middle with rounded tips, dotted with glands; leaf margins with low, widely spaced teeth tipped with glands; leaf stalks with narrow wings. Flowers are held erect in short, leafy heads usually at the ends of branches; flowers are showy, over 1 inch long, snowy white with 4 stamens with cottony hairs; upper lip hood-like, lower lip 3-lobed. This species flowers from May to mid-July. Habitat for this species includes wet to mesic pine flatwoods and associated roadsides. Suggested protection and management is to burn the flatwoods every 2 - 3 years. Also avoid conversion of flatwoods to pine plantation as canopy closure. Mechanical site preparation kills this species. *Florida Natural Areas Inventory*, 2000.

Counties: Bay, Franklin, Gulf, Liberty

Godfrey's (violet) Butterwort (*Pinguicula ionantha*)

The threatened Godfrey's (violet) butterwort (*Pinguicula ionantha*) is a perennial herb with a rosette up to 6 inches wide. Leaves are fleshy, oblong, bright green, with inrolled edges and rounded tips, upper surfaces covered with short, glandular hairs that exude a "greasy" substance and capture insects. Flower stalks are 4 - 6 inches tall, leafless, with glandular hairs. Flowers are nearly 1 inch across when fully open, lavender to white, with 5 spreading, notched petals; throat and tube darker purple with deep purple veins; spur 0.2 inch long, yellow to olive; palate (cylindrical structure protruding from flower center) yellow with purple base, covered with yellow hairs. This species flowers from late February to April,it is difficult to identify otherwise. This species' habitat includes seepage slopes, bogs, transition zones between flatwoods/wet

prairies and cypress stringers, roadside ditches, and depressions in wet pine flatwoods and wet prairies; Often in shallow standing water. Suggested protection and management are prescribed fires every 2-3 years, to prevent shrubby encroachment and to promote flowering in this species. Also avoid using heavy machinery that can rut and compact soils in wetlands; Allow prescribed fires to burn into cypress edges and avoid placing firebreaks in wetland ecotones.

Florida Natural Areas Inventory, 2000.

Counties: Bay, Calhoun, Franklin, Gulf, Liberty, Wakulla

American Chaffseed (*Schwalbea americana*)

The endangered American chaffseed (*Schwalbea americana*) is a perennial herb with erect, usually unbranched, hairy stem up to 2 feet tall. Leaves are 0.8 - 1.6 inches long, largest at the base, gradually decreasing in size upwards, entire, alternate, lance-shaped, without leafstalks, overlapping in a spiral up the stem. Flowers are about 1 inch long, two-lipped, yellow suffused with purple, especially near the lips, in a spike at the top of the stem. Fruit are a capsule, splitting into 4 sections. This species flowers from April–June, depending on the timing of recent fire; Without fire, plants remain short and inconspicuous. Brown, dead stems with old fruits are conspicuous for about a year after flowering. Habitat for this species includes moist, grassy ecotones around ponds in longleaf pine sandhills, longleaf pine savannas, sandhills, and flatwoods. Plants are semi-parasitic on the roots of gallberry, huckleberry, St. John's-wort, silk grass, and others. Protection and management: Burn every 2 - 3 years during the growing season; Avoid mowing, soil disturbance, and cutting fire lanes around ponds.

Florida Natural Areas Inventory, 2000.

Counties: Gadsden, Leon

Miccosukee Gooseberry (*Ribes echinellum*)

Miccosukee Gooseberry (*Ribes echinellum*) is a threatened perennial deciduous shrub, low and spiny, it can grow up to 3.5 feet tall, forming small thickets. Stems have shredding bark, rooting at the tips where they touch the soil. Leaves are less than 1 inch long, simple, alternate, 3-lobed with each lobe toothed, and veins spread outward from the top of the leaf stalk into the lobes. They are deciduous in summer, with new leaves appearing in fall and overwintering. They have pale green flowers, hanging from long stalks and are usually solitary, with 5 small petals and 5 conspicuous, spreading sepals. Stamens dangle well below the petals and sepals. The round, glandular-hairy floral tube matures into a very spiny berry, less than 1 inch wide. The present confinement of the gooseberry to two disjunct localities indicates that it is a very rare species, yet in both locations the plants are abundant. The sites have high floristic diversity, dominated by a mixed hardwood forest containing deciduous species, on mesic and well drained soils with an underlying rock of limestone.

Counties: Jefferson, Leon, Edgefield, McCormick

Florida Skullcap (*Scutellaria floridana*)

The Florida skullcap (*Scutellaria floridana*) is a threatened vascular plant native to the Florida Panhandle. They are a perennial herb with quadrangular stems and opposite leaves. The flowers are solitary, with a bell shaped calyx and bright lavender-blue corolla. The corolla has two lips, the lower one being white in the middle. The stigma sticks out from under the flower hood with the anthers residing inside. Plants flower from mid-April through early July and are most prolific after a fire.

Counties: Bay, Franklin, Gulf, Liberty

Fringed Campion (*Silene polypetala*)

The endangered Fringed campion (*Silene polypetala*) is a perennial herb that has long, slender, weak, thinly pilose stems, and are simple or sparingly branched, up to 40 cm long. They spread vegetatively by long, slender, stolon-like rhizomes and lax, leafy offshoots, both terminating in overwintering rosettes. Pale green leaves are opposite of the rosettes and the lower stem leaves spatulate, 2- 6 cm long, mostly 1.0-1.5 cm broad, they look obtuse and often apiculate. The surfaces are glabrous or thinly subpilose with soft, pale, spreading hairs along the margin and midrib beneath. Leaves are progressively shorter up the stem, becoming elliptic, oblong, or lanceolate, with rounded to clasping bases. The flowers are on slender and hairy, erect or slightly spreading from the stalks. Their bracts are large and foliaceous, with pedicels at 1-2 cm long and densely villous. Petals at the base of these flowers are showy, in groups of 5, at 3-4 cm long, and flabellate. Ten stamen protrude from the middle, not much longer than the petal claws, with filaments scantily arachnoid-pilose near the base.

Counties: Gadsden, Jackson

Gentian Pinkroot (*Spigelia gentianoides*)

The endangered Gentian pinkroot (*Spigelia gentianoides*) is a perennial herb belonging to *Loganiaceae*, a family mainly distributed in the tropics and subtropics. This small herbaceous species possesses a single, erect, sharply ridged stem 10-30 centimeters (cm) long. The leaves are opposite, sessile, and in pairs at right angles to the next set of leaves. The leaves are largest at the top of the stem, 3-5 cm long, with lower leaves smaller. Flowers are borne in a short, few-flowered, terminal, determinate cyme. The flower consists of a narrow corolla tube of about 2.5-5 cm long, with five triangular lobes, each 5-6 mm long. The corolla is pale to dark pink; slightly

darker at the margins of the lobes for the *var. gentianoides*. The stamens are within the flower, and the pollen grains are deposited along the bristles of the style. The green sepals are 4-6 cm long. The fruit is a capsule with two conspicuous round lobes. Peak flowering season occurs between May and June, however, plants have been seen flowering as early as April and as late as October. In a greenhouse, individual flowers last 2 to 5 days before wilting. Most seeds can be collected in June or July.

Counties: Calhoun, Jackson, Washington

Cooley's Meadowrue (*Thalictrum cooleyi*)

Cooley's meadowrue (*Thalictrum cooleyi*) is an endangered perennial herb which grows from a rhizome. The stems are usually 3.3 feet in height, but sometimes grow as high as 6.6 ft on recently burned sites. The compound green leaves are divided into three parts and the leaflets are lance-shaped and less than 2 centimeters long. The plant has both basal and stem leaves. All parts of the plant are glabrous, having virtually no hairs or glands. The flowers have no petals. The sepals on the male plants are pale yellow to white. There are numerous stamens, and the filaments are pale lavender. Female plants have green sepals, and their short-stalked, ribbed carpels develop into narrowly ellipsoidal achenes. Cooley's meadowrue (*Thalictrum cooleyi*) flowers in mid June to early July. The fruits are spindle-shaped carpels which develop into 6 millimeter long achenes, maturing in August or September, and remaining on the plant till October.

Counties: Walton, Washington

Florida Torreya (*Torreya taxifolia*)

The Florida torreya (*Torreya taxifolia*) is an endangered conical tree of the yew family with whorled branches. The small tree contains evergreen needle-like leaves that are 1 to 1.5 inches long and .13 inches wide. These needles are stiff and sharply pointed at the tip, arranged on both sides of the twigs in a single plane. The leaves and twigs have a resinous odor. Pollen cones and ovules are borne on separate trees. Torreya seeds are 1-1.5 inches long.

Counties: Gadsden, Jackson, Liberty

Wireweed (*Polygonella basiramia*)

The endangered Wireweed (*Polygonella basiramia*) is a short-lived, perennial herb endemic to the central ridges of the Florida peninsula. One of a suite of herbs found primarily in the rosemary phase of sand pine scrub, Wireweed (*Polygonella basiramia*) requires periodic disturbance, such as fire, to maintain habitat suitable for its survival and persistence. When vegetative, the plant consists entirely of basal, compressed stems with narrow, alternate leaves.

Ocreae, the sheaths formed at stem nodes, are ciliate. Stems and leaves range in color from green to dark red; red coloration in the stems and leaves appears to be associated with individuals more exposed to sunlight and with older vegetative parts (although even seedlings are often red). As basal stems elongate, plants develop 1 to 46 slender, flowering, spike-like panicles as tall as 0.8 m.This species is gynodioecious and plants have either only female flowers or hermaphroditic flowers. Individual flowers are small, white to slightly pink with 5 sepals (no petals), pink pistils, and black anthers. The gynoecium consists of 3 united carpels, 1-ovuled, ovary superior. Flowering occurs from the top spikelet downward on each stem. The fruit is a three-sided achene 1 to 3 mm in length.

Counties: Highlands, Polk

FISH

Gulf Sturgeon (*Acipenser oxyrhynchus desotoi*) - Critical Habitat

The Gulf sturgeon (*Acipenser oxyrhynchus desotoi*) is a threatened gulf subspecies of sturgeon with five rows of bony plates known as scutes that run along its body and a snout with four barbels (slender, whisker-like, soft tissue projections) in front of its mouth. Similar to sharks, Gulf sturgeon (*Acipenser oxyrhynchus desotoi*) have tails where one side, or lobe, is larger than the other. The species' historical range included Alabama, Florida, Georgia, Louisiana, and Mississippi.

Critical habitat has been designated in Escambia River System in Santa Rosa and Escambia Counties, Florida; Yellow River System in Santa Rosa and Okaloosa Counties, Florida; Choctawhatchee River System in Holmes, Washington, and Walton Counties, Florida; Apalachicola River System in Franklin, Gulf, Liberty, Calhoun, Jackson, and Gadsen Counties, Florida; Suwannee River System in Hamilton, Suwannee, Madison, Lafayette, Gilchrist, Levy, Dixie, and Columbia Counties, Florida; Pensacola Bay System in Escambia and Santa Rosa Counties, Florida; Santa Rosa Sound in Escambia, Santa Rosa, and Okaloosa Counties, Florida; Florida Nearshore Gulf of Mexico Unit in Escambia, Santa Rosa, Okaloosa, Walton, Bay, and Gulf Counties in Florida; Choctawhatchee Bay in Okaloosa and Walton Counties, Florida; Apalachicola Bay in Gulf and Franklin County, Florida; Suwannee Sound in Dixie and Levy Counties, Florida.

Counties: Bay, Calhoun, Charlotte, Collier, Columbia, Dixie, Escambia, Franklin, Gadsden, Gilchrist, Gulf, Hamilton, Holmes, Jackson, Jefferson, Lafayette, Lee, Levy, Leon, Liberty, Madison, Monroe, Okaloosa, Santa Rosa, Sarasota, Suwannee, Wakulla, Walton, Washington

Shortnose Sturgeon (*Acipenser brevirostrum*)

Shortnose sturgeon (*Acipenser brevirostrum*) can grow to approximately 4.5 feet long and weigh up to 60 pounds. They are yellowish-brown and generally have a black head, back, and sides. Their bellies are white to yellow. They have five major rows of scutes and a protruding snout with four barbels (fleshy, whisker-like projections). Shortnose sturgeon are similar in appearance to Atlantic sturgeon, but can be distinguished by their smaller size, larger mouth, smaller snout shape, and tail scute pattern (*National Oceanic and Atmospheric Administration*). The species historical range included Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Rhode Island, South Carolina, Virginia.

The National Marine Fisheries Service is the lead Federal agency responsible for managing this species. For additional information on this species, including NMFS regulatory actions such as critical habitat designation or recovery planning, please visit the National Marine Fisheries website (https://www.fisheries.noaa.gov/species-directory/threatened-endangered).

Counties: N/A

Okaloosa Darter (*Etheostoma okaloosae*)

The Okaloosa darter (*Etheostoma okaloosae*) is a threatened species that only resides in the panhandle of Florida with a body length of only two inches. This darter species has a green-yellow to red-brown coloration with five to eight brown spots along the lateral surface of its body, and a well established spot above the base of its pectoral fins. Male Okaloosa darters develop an orange band along the edges of its first dorsal fin. As an obligate bottom dweller, they have no swim bladder.

Counties: Okaloosa, Walton

REPTILES

American Crocodile (*Crocodylus acutus*)

The endangered American crocodile (*Crocodylus acutus*) is a large, greenish-gray crocodilian with black mottling. In Florida, adults reach lengths of about 3.8 m, although a specimen measuring 4.7 m was reported in the late 1800s (Moler 1992). In other portions of their range, individual crocodiles may reach 6.0 m (Ross and Magnusson 1989). Like all other crocodilians, males are larger than females. All adults have a hump above the eyes which may or may not be distinct, and irregular, asymmetrical dorsal armoring. Hatchlings measure approximately 27 cm and are normally yellowish tan to gray with dark cross markings on the body and tail. These markings fade as the animal grows. A lateral Page 4-505 Federal Status: Endangered (Sept. 25, 1975) Critical Habitat: Designated (December 1979) Florida Status: Endangered. Florida distribution of the American crocodile; this species is only found in mangrove habitats within the

shaded counties. American Crocodile Crocodylus acutus indentation of the upper jaw leaves the fourth tooth of the lower jaw exposed when the mouth is closed. Compared to the alligator, the American crocodile may be distinguished by its longer, narrower, more tapered snout and the exposed fourth tooth of the lower jaw.

Counties: Collier, Lee, Miami-Dade, Monroe

Atlantic Salt Marsh Snake (*Nerodia clarkii taeniata*)

The threatened Atlantic salt marsh snake (*Nerodia clarkii taeniata*) is a partially striped salt marsh snake that reaches a maximum length of at least 82 cm, although it is typically less than 65 cm in length. The pattern consists of a gray to pale olive background with black to dark brown stripes anteriorly, the stripes breaking up into rows of spots posteriorly. The extent of the striping is variable, but most individuals from the coastal marshes of Volusia County are striped on at least the anterior 30 percent of the body. The ventral is black with a central row of large cream to yellowish spots. As in the case of the dorsal striping, this ventral pattern is best developed anteriorly and tends to break down posteriorly.

Counties: Brevard, Volusia, Indian River

Bluetail Mole Skink (*Eumeces egregius lividus*)

The threatened Bluetail mole skink (*Eumeces egregius lividus*) is a small, shiny, brownish to pink, cylindrical, lizard. Juveniles usually have a blue tail which makes up slightly more than half of the 13 cm length (Christman 1992; P. Moler, GFC, personal communication 1998). Regenerated tails and the tails of older individuals are typically pinkish. The legs are somewhat reduced in size and are used only during surface locomotion, not when the animal swims through the sand (Christman 1992). The coloration in the blue-tailed mole skink is brown with lighter paired dorsolateral stripes diverging posteriorly (Christman 1978). During the breeding season, males develop a colorful orange pattern on their sides.

Counties: Highlands, Osceola, Polk

Eastern Indigo Snake *(Drymarchon corais couperi)*

The threatened Eastern indigo snake *(Drymarchon corais couperi)* is the longest non-venomous snake in the United States (R. Hammer, Metro Dade Park and Recreation, personal communication 1998), reaching lengths of up to 265 cm (Ashton and Ashton 1981). Its color is uniformly lustrous-black, dorsally and ventrally, except for a red or cream-colored suffusion of the chin, throat, and sometimes the cheeks. Its scales are large and smooth (the central 3 to 5 scale rows are slightly keeled in adult males) in 17 scale rows at midbody. Its anal plate is

undivided. Its antepenultimate supralabial scale does not contact the temporal or postocular scales.

Counties: Broward, Charlotte, Collier, DeSoto, Glades, Hardee, Hendry, Highlands, Indian River, Lee, Martin, Miami-Dade, Monroe, Okeechobee, Osceola, Palm Beach, Polk, Sarasota, St. Lucie

Green Sea Turtle (*Chelonia mydas*)

The endangered Green Sea Turtle (*Chelonia mydas*) is among the largest of the sea turtles; adults commonly reach 1 m in carapace length and 150 kg in mass. The mean size of female green turtles nesting in Florida is 1.5 m standard straight carapace length and 136.1 kg body mass (Witherington and Ehrhart 1989). Hatchling green turtles weigh approximately 25 g, and the carapace is about 50 mm long. The dorsal surface is black, and the ventral surface is white. The plastron of Atlantic green turtles remains a yellowish white throughout life, but the carapace changes in color from solid black to a variety of shades of grey, green, brown and black in starburst or irregular patterns. Characters that distinguish the green turtle from other sea turtle species are a smooth carapace with four pairs of lateral (or coastal) scutes and a single pair of elongated Page 4-583 Federal Status: Endangered (Florida, Pacific coast of Mexico; July 28, 1978) Threatened (except as above; July 28, 1978) Critical Habitat: Designated (September 1998): Waters of Culebra Island, Puerto Rico, and its outlying keys. Florida Status: Endangered. Florida nesting distribution of the green sea turtle. Green Sea Turtle Chelonia mydas Recovery Plan Status: Contribution: May 1999 Geographic Coverage: South Florida prefrontal scales between the eyes. The nuchal scute does not touch the first costal scute and the inframarginal scutes do not have pores. Each flipper has a single claw and the carapace is oval-shaped and depressed. The crawls of nesting green turtles are deeply cut, with symmetrical diagonal marks made by the front flippers (Pritchard et al. 1983).

Counties: Nearly all coastal counties in South Florida, the largest nesting occurs along the east coast of Florida in Brevard, Broward, Indian River, Martin, Palm Beach, St. Lucie

Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The endangered Hawksbill sea turtle (*Eretmochelys imbricata*) is one of seven species of sea turtles found throughout the world. One of the smaller sea turtles, it has overlapping scutes (plates) that are thicker than those of other sea turtles. This protects them from being battered against sharp coral and rocks during storm events. Adults range in size from 30 to 36 inches (0.8-1.0 meters) carapace length, and weigh 100 to 200 pounds (45-90 kilograms). Its carapace (upper shell) is an attractive dark brown with faint yellow streaks and blotches and a yellow plastron (under shell). The name "hawksbill" refers to the turtle's prominent hooked beak.

Counties: Bay, Brevard, Broward, Charlotte, Collier, Duval, Escambia, Flagler, Franklin, Gulf, Hillsborough, Indian River, Jefferson, Lee, Manatee, Martin, Miami-Dade, Monroe, Nassau, Okaloosa, Palm Beach, Pinellas Santa Rosa, Sarasota, St. Johns, St. Lucie, Volusia, Wakulla, Walton

Kemp's Ridley Sea Turtle (*Lepidochelys kempii)*

The endangered Kemp's ridley sea turtle (*Lepidochelys kempii)* is the smallest of the sea turtles, with adults reaching about 2 feet in length and weighing up to 100 pounds. The adult Kemp's ridley has an oval carapace that is almost as wide as it is long and is usually olive-gray in color. The carapace has five pairs of costal scutes. In each bridge adjoining the plastron to the carapace, there are four inframarginal scutes, each of which is perforated by a pore. The head has two pairs of prefrontal scales. Hatchlings are black on both sides. The Kemp's ridley has a triangular-shaped head with a somewhat hooked beak with large crushing surfaces. This turtle is a shallow water benthic feeders with a diet consisting primarily of crabs.

Counties: Bay, Escambia, Franklin, Gulf, Lee, Okaloosa, Santa Rosa, Walton

Leatherback Sea Turtle (*Dermochelys coriacea*)

The endangered Leatherback sea turtle (*Dermochelys coriacea*) is the largest, deepest diving, and most migratory and wide ranging of all sea turtles. The adult leatherback can reach 4 to 8 feet in length and 500 to 2000 pounds in weight. Its shell is composed of a mosaic of small bones covered by firm, rubbery skin with seven longitudinal ridges or keels. The skin is predominantly black with varying degrees of pale spotting; including a notable pink spot on the dorsal surface of the head in adults. A toothlike cusp is located on each side of the gray upper jaw; the lower jaw is hooked anteriorly. The paddle-like clawless limbs are black with white margins and pale spotting.

Counties: Bay, Brevard, Broward, Charlotte, Collier, Duval, Escambia, Flagler, Franklin, Gulf, Hillsborough, Indian River, Lee, Manatee, Martin, Miami-Dade, Monroe, Okaloosa, Palm Beach, Pinellas, Santa Rosa, Sarasota, St. Johns, St. Lucie, Volusia, Walton

Loggerhead Turtle (*Caretta caretta*) - Critical Habitat

The endangered Loggerhead turtle (*Caretta caretta*) were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The carapace (top shell) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the plastron (bottom shell) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides

and bottom. Mean straight carapace length of adults in the southeastern U.S. is approximately 36 in (92 cm); corresponding weight is about 250 lbs (113 kg).

Counties: Nearly all coastal counties in Florida

Gopher Tortoise (*Gopherus polyphemus*) - Candidate

The Gopher tortoise (*Gopherus polyphemus*) is a candidate species, it has a large, (shell 15 to 37 centimeters or 5.9 to 14.6 inches long) dark-brown to grayish-black terrestrial turtle with elephantine hind feet, shovel-like forefeet, and a gular projection beneath the head on the yellowish, hingeless plastron or undershell (Ernst and Barbour 1972). The sex of individual turtles can usually be determined by shell dimensions. A male turtle has a greater degree of lower shell concavity, and a longer gular projection. However, the sex of tortoises at maturity size is difficult to determine (U.S. Fish and Wildlife Service 199O).

Counties: Nearly all coastal Florida counties

Sand Skink (*Neoseps reynoldsi*)

The threatened Sand skink (*Neoseps reynoldsi*) reaches about 13 cm, about half of which is tail. It is slender, shiny and usually gray to grayish-white, although it may occasionally be light tan. Hatchlings have a wide black band extending from the tip of the tail to the snout along each side. This band is reduced in adults and may only occur from the eye to snout on some individuals (Telford 1959). The sand skink's legs are vestigial and practically nonfunctional. Other adaptations to a fossorial existence include greatly reduced eyes, lack of external ear openings, a wedge-shaped snout, and a countersunk lower jaw.

Counties: Highlands, Lake. Marion, Orange, Osceola, Polk, Putnam

AMPHIBIANS

Striped Newt (*Notophthalmus perstriatus*) - Candidate

The Striped newt (*Notophthalmus perstriatus*) a small salamander, is considered a federal candidate for listing as a threatened species. The U.S. Fish and Wildlife Service made the announcement June 7, 2011 in the *Federal Register*. Striped newts (*Notophthalmus perstriatus*) are only found in the lower southeastern coastal plain of Florida and Georgia. Striped newts are less than five inches long. They are found in what were historically longleaf pine-dominated

savanna, scrub, or sandhill habitats, and they breed in shallow, isolated, temporary ponds. The primary threats to the species survival are habitat loss, disease, and drought.

Counties: Alachua, Clay, Columbia, Dixie, Duval, Gilchrist, Jefferson, Lake, Leon, Levy, Marion,Orange, Osceola, Putnam, St. Johns, Sumter, Taylor, Volusia,

Reticulated Flatwoods Salamander (*Ambystoma bishopi*) - Critical Habitat

The Reticulated flatwoods salamander (*Ambystoma bishopi*) is a long and slender salamander that can reach a body length of 5.2 inches (13 centimeters) (Ashton 1992). It has a silvery-gray or black body with white spots that are more distinct than on the frosted flatwoods salamander, Ambystoma cingulatum (Goin 1950 as cited in Pauly et at. 2007). Reticulated flatwoods salamanders also have a small head and a black belly.The diet of the reticulated flatwoods salamanders primarily consists of earthworms and spiders (Goin 1950, P. Moler pers. comm. 2011). Flatwoods salamanders migrate to ponds or small puddles to breed from October to January during wet weather. Females lay clumps of eggs among vegetation such as twigs and pine needles. The maximum clutch size for the flatwoods salamander is 35 eggs, which hatch 48 hours after being laid. Larvae metamorphose in 90 days (Ashton 1992, J. Himes pers. comm. 2011).

Counties: Bay, Calhoun, Escambia, Gulf, Holmes, Jackson, Okaloosa, Santa Rosa, Walton, Washington

Frosted Flatwoods Salamander (*Ambystoma cingulatum*) - Critical Habitat

The flatwoods salamander (*Ambystoma cingulatum*) is a medium-sized mole salamander, reaching an adult length of 5 inches (13 centimeters) (Means 1986, Conant and Collins 1991, Ashton 1992). Body color ranges from silvery gray to black, with the back heavily mottled with a variable gray cross-band pattern. The underside is plain gray with faint creamy blotches (Palis 1996). The head is small and equal to the neck in diameter. Optimum habitat for the frosted flatwoods salamander is an open mesic woodland of longleaf/slash pine flatwoods maintained by frequent fires. Adult flatwoods salamanders are fossorial and either live in enlarged crayfish burrows (Ashton 1992) or build their own. Adult flatwoods salamanders move to their wetland breeding sites during rainy weather, in association with cold fronts, from October to December (Palis 1997a). Breeding sites are generally shallow and relatively small isolated pond cypress, blackgum, or slash pine dominated depressions which dry completely on a cyclic basis. The females lay their eggs, either singly or in clumps, beneath leaf litter, under logs and sphagnum moss mats, or at bases of bushes, small trees, or clumps of grass (Anderson and Williamson 1976, Means 1986) Embryos begin development immediately, but the egg must be inundated before it will hatch. Depending on when eggs are inundated, the larvae usually metamorphose in March or April; the length of the larval period varies from 11 to 18 weeks (Palis 1995d). Adult

flatwoods salamanders have been found greater than 1,700 meters from their breeding pond (Ashton 1992). The species historical range included Florida, Georgia, and South Carolina.

Counties: Baker, Bradford, Duval, Franklin, Jefferson, Liberty, Wakula

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Alabama

Federally Listed Threatened and Endangered Species

Alabama beach mouse (*Peromyscus polionotus ammobates*)

The Alabama beach mouse (ABM) is among only a handful of 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 (U. S. Fish and Wildlife Service 2006).

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). Beach mice are found 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%). The Alabama beach mouse was listed as an Endangered Species in 1985 (U. S. Fish and Wildlife Service 2006).

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. 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 (U. S. Fish and Wildlife Service 2006).

Counties: Baldwin

West Indian Manatee (*Trichechus manatus latirostris*)

The West Indian manatee was listed in 1967 as endangered throughout its range, and received federal protection with the passage of the ESA in 1973. West Indian manatees are also protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1461 et seq.). The MMPA establishes, as national policy, maintenance of the health and stability of marine ecosystems, and whenever consistent with this primary objective, obtaining and maintaining optimum sustainable populations of marine mammals. It also establishes a moratorium on the taking of marine mammals.

Adult manatees average 10 feet long and weigh cdom 800 to 1,200 pounds, although some individuals have been recorded at lengths greater than 13 feet and weighing as much as 3,500 pounds. Manatees are commonly found in fresh, brackish, or marine water habitats, including shallow coastal bays, lagoons, estuaries, and inland rivers of varying salinity extremes. Manatees spend much of their time underwater or partly submerged, making them difficult to detect even in shallow water.

Manatees are seasonal inhabitants of Alabama, typically from April through October, although some individuals may remain longer during the fall season before traveling south for the winter. Observations have been made throughout the year in rare cases. Total numbers have been increasing, possibly due to climate change (warmer water temperatures), larger populations in Florida causing individuals to roam further, increased observation efforts, or a combination of the three.

Though the reasons are not fully understood, manatee survival rates are significantly lower during years with extreme storms (Langtimm et al. 2006). Manatees do not typically move considerable distances as major storms approach, but may remain in protected areas within their typical range. Storm surges can sweep slow-moving manatees to other locations or even out to sea. When waters recede, manatees may be trapped in isolated ponds, canals, or even upland locations. Debris in turbulent waters may cause injury or death. Langtimm and Beck (2003) postulate that storms may carry a manatee away from warm winter refugia, while stirring up colder waters (particularly late in the storm season), resulting in cold stun injuries or deaths. Manatees that are caught in extreme storms in more northerly portions of the summer range may be more susceptible to cold water effects, because of the potential for colder waters, more rapid cooling of water during and after storms, and the greater distance from warmer waters. An increase in intensity or number of storms in a season would exacerbate these effects to manatees.

Counties: Baldwin and Mobile

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). The Alabama Gulf coast may be regionally important for the production of male sea turtles. Each year, approximately 10-15 loggerhead sea turtle nests are found on the Bon Secour Refuge beaches. The highest concentration of sea turtle nesting occurs on the Perdue Unit. The endangered Kemp's ridley sea turtle (*Lepidochelys kempii*) and the threatened Green sea turtle (*Chelonia mydas*) also nest occasionally on the Alabama coast.

The 2016 nesting / hatching season was a record breaker for the Alabama coast. From the ***2016 Alabama Sea Turtle Nesting Summary Report*** of the Share the Beach program:

"A total of 237 nests were located on the beaches of Alabama in 2016. Four of these nests were confirmed as Kemp's ridley's while the rest were loggerhead's. Data gathered indicate that 22,240 eggs were laid on the beach, yielding 15,035 viable hatchlings of which 14,104 hatchlings made it to the Gulf of Mexico. This was a hatchling success rate of 67.91% and a survival rate of 63.71%."

Although there was a large increase in the number of nests laid, there were a total of 66 nests lost to water inundation caused by tidal surge from Hurricane Hermine and other storm events. An additional 4 nests were lost to predation.

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. 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. Studies of the effects of these projects in Florida found that loggerhead turtle nests declined in the years immediately following beach renourishment (Rumbold et al. (2001). 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 mammals, shorebirds, and fish as a result of these projects (Lindeman and Snyder 1999, Greene 2002). 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. 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).

Counties: Baldwin and Mobile

Alabama red-bellied turtle (*Pseudemys alabamensis*)

This is a large (20 to 25 centimeters or 8 to 10 inches carapace length) freshwater turtle, normally with an orange to reddish plastron and a prominent notch at the tip of the upper jaw, bordered on either side by a toothlike cusp. The elongated carapace is highly arched and elevated along the midline; its highest point is often anterior to the midbody where the carapace is widest. The carapace is brown to olive, with yellow, orange, or reddish streaks and mottling that form distinct, light vertical bars on the pleural scutes. The skin is olive to black with yellow to light orange stripes. The Alabama red-bellied turtle seems to feed almost entirely on aquatic plants.

The Alabama Red-bellied Turtle (*Pseudemys alabamensis*) was federally listed as endangered on June 16, 1987 (52 FR 22939), and is also listed as endangered by the two states where the species is known to occur: Alabama and Mississippi. A recovery plan for the species was finalized in 1990 (U.S. Fish and Wildlife Service 1990). When the Alabama Red-bellied Turtle was listed in 1987, it was not known to occur in Mississippi. Although a red-bellied turtle had been observed in Mississippi, the assumption was that it was a different species and it was not studied in depth until the early 1990's. Currently, the Alabama Red-bellied Turtle is known from the lower Mobile River delta and drainages surrounding Mobile Bay in Baldwin and Mobile

Counties, Alabama; and from the lower watersheds of the Pascagoula, Tchoutacabouffa and Biloxi rivers and the Back Bay of Biloxi in Harrison and Jackson Counties, Mississippi. As there are no apparent connections between the Mobile River system (Alabama) and the Pascagoula River system (Mississippi), the distribution of the species across the two states is assumed to be disjunct. Presence/absence surveys conducted in both states indicate the species status may be stable, however an analysis of threats indicates that several new threats have been identified while the threats present at the time of listing are still present (U.S. Fish and Wildlife Service 2015). During the development of the SSA, ten Alabama Red-bellied Turtle populations were delineated based on the species' occupancy of specific watersheds, six in Alabama and four in Mississippi (U.S. Fish and Wildlife Service 2019a). The Alabama Red-bellied Turtle is assigned a recovery priority number of 5, indicating a species with high degree of threat and low recovery potential. Habitat Requirements and Limiting Factors: Alabama Red-bellied Turtles typically occur in broad, vegetated expanses of shallow water (1-2 meters or 3.3-6.6 feet in depth) in the backwater areas of bays, in and along river channels, and less frequently in oxbow lakes. Snags and dense beds of submersed and emergent aquatic vegetation provide turtles with a substrate for cover, predator avoidance, food, and structure for basking and thermoregulation. Although regarded as a freshwater species, the occasional presence of barnacles on shells of *P. alabamensis* indicates that the turtle is tolerant, to some extent, of saline waters. The Alabama Red-bellied Turtle exhibits different habitat preferences within the two states where it occurs, probably based on habitat availability. In Mississippi, *P. alabamensis* inhabits 3 fresh to brackish marshes with shallow, slow-flowing waters and extensive beds of aquatic vegetation. Freshwater marshes upstream of brackish marshes are also utilized but to a lesser extent. In Alabama, the turtle occupies the freshwater of shallow side-channel coves along the main river channels draining into Mobile Bay, as well as smaller tributary streams, and broad, shallow brackish bays surrounding Mobile Bay. The extant Alabama Red-bellied Turtle populations are in many cases small, isolated, and have limited potential for recolonization should they be extirpated. Abundant submerged aquatic vegetation (SAV) is an important element of habitats in both states. The greatest threats to this species are loss or degradation of habitat, especially the loss and degradation of the SAV on which the turtle depends. Results from the SSA process indicated that the main driver of future habitat degradation or loss was sea level rise (U.S. Fish and Wildlife Service 2019a; U.S. Fish and Wildlife Service 2019b).

Counties: Baldwin and Mobile

Gopher Tortoise *(Gopherus 200olyphemus)*

The gopher tortoise (*Gopherus 200olyphemus*) is a large dark-brown to grayish-black terrestrial tortoise. The shell is approximately 15-37 centimeters—or 5.9-14.6 inches—long. The gopher tortoise has elephantine hind feet, shovel-like forefeet, and a gular projection beneath the head of the yellowish, hingeless plastron or undershell. For refuge, gopher tortoises dig burrows which average 5 to 10 feet in depth and may be 10 to 20 feet—or more—in length. A number of other species may share gopher tortoise burrows, including the eastern indigo snake, the eastern

diamondback rattlesnake, the black pine snake, and the gopher frog, as well as several small mammals.

The range of the gopher tortoise extends along the coastal plain from South Carolina through Florida to southeastern Louisiana. The gopher tortoise most often lives on well-drained sandy soils in transitional (forest and grassy) areas. It is commonly associated with a pine overstory and an open understory with a grass and forb (non-woody) groundcover and sunny areas for nesting. Gopher tortoises can also sometimes be found in more marginal habitat such as roadsides, ditch banks, utility and pipeline rights-of-way, pastures, and even marginal wetland habitat, especially if their preferred habitat has been lost. The gopher tortoise is Federally listed as threatened across the western portion of its range. This area extends west from the Tombigbee and Mobile Rivers in Alabama across Mississippi and into Southeastern Louisiana.

There are many direct and indirect factors contributing to threats to the gopher tortoise, including (but not limited to): 1) habitat fragmentation by roads (potentially causing road mortality, reproductive isolation, small and discontinuous populations, and edge effects that may increase predation); 2) habitat modification (either deliberately or from inattention), including conversion of open pine (e.g., longleaf pine) forests to other silvicultural or agricultural habitats, mining, shrub/hardwood/sand pine encroachment (mainly from fire exclusion or insufficient fire management), and establishment and spread of invasive species (potentially causing the aforementioned indirect effects due to canopy closure and decline of available forage/groundcover); and 3) habitat destruction from activities such as urbanization, solar farm construction, and sand extraction (potentially causing direct mortality and/or displacement of tortoises to undesirable habitats) (U.S. Fish and Wildlife Service 2019c).

Other threats include overutilization for commercial, recreational, scientific, or educational purposes; disease; predation; and inadequacy of existing regulatory mechanisms. Additional factors that threaten the continued existence of gopher tortoises include long-term herbicide exposure, road mortality, and climate change. For impacts from climate change, there is the potential for a loss of coastal dune habitat from sea level rise, habitat fragmentation from water table rise in inland habitats, temporal shifts in behavioral seasons such as nesting and overwintering, and a skewed sex ratio in some populations since tortoises have temperature-dependent sex determination (U.S. Fish and Wildlife Service 2019c). An increase in the number and intensity of storms, along with sea level rise and saltwater intrusion, will escalate impacts to near-coastal pine forests.

Counties: Baldwin and Mobile

Eastern indigo snake (*Drymarchon corais couperi*)

Average adult size is 60-74 inches (152-188 cm), record is 103.5 inches (262.8 cm). Adults are large and thick bodied. The body is glossy black and in sunlight has iridescent blue highlights. The chin and throat is reddish or white, and the color may extend down the body. The belly is

cloudy orange and blue-gray. The scales on its back are smooth, but some individuals may possess some scales that are partially keeled. There are 17 dorsal scale rows at midbody. The pupil is round. Juveniles are black-bodied with narrow whitish blue bands. This snake seems to be strongly associated with high, dry, well-drained sandy soils, closely paralleling the sandhill habitat preferred by the gopher tortoise. During warmer months, indigos also frequent streams and swamps, and individuals are occasionally found in flat woods. Gopher tortoise burrows and other subterranean cavities are commonly used as dens and for egg laying.

The eastern indigo snake (*Drymarchon corais couperi*, was federally-listed as threatened on March 3, 1978 (U.S. Fish and Wildlife Service 1978) under the Endangered Species Act due to threats from habitat modification, collections for the pet trade and gassing while in gopher tortoise (*Gopherus 202olyphemus*) burrows.

Historical records exist for Alabama and Mississippi, but no naturally-occurring populations remain in these states (U.S. Fish and Wildlife Service 2019d), although fairly recent observations (and one capture and release) have been made in Mobile County. Repatriation is ongoing at Conecuh National Forest in Conecuh County, Alabama. Habitat loss, degradation and fragmentation from development and sea level rise were identified as the primary negative factors influencing resiliency of populations (U.S. Fish and Wildlife Service 2019d). Like that of the gopher tortoise, an increase in the number and intensity of storms will likely impact their coastal pine forest habitats.

Counties: Baldwin, Conecuh and Mobile

Piping Plover (*Charadrius melodus*)

Piping plovers are small, sand-colored shorebirds approximately seven inches long (18 cm) with a wingspan of approximately 15 inches (38 cm). Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks. Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons or salt marshes (U.S. Fish and Wildlife Service 2014). Piping plovers occur in three different populations in North America: Northern Great Plains, Great Lakes, and Atlantic Coast. It is federally listed as a threatened species along the Atlantic Coast and in the Northern Great Plains and endangered in the Great Lakes region.

Wintering grounds range from North Carolina to Florida and along the Florida Gulf Coast to Texas, Mexico, and the Caribbean Islands. On the wintering grounds, piping plovers forage and roost along barrier and mainland beaches, sand, mud, and algal flats, washover passes, salt marshes, and coastal lagoons. Piping plovers spend up to 10 months of the year on the wintering grounds, thus emphasizing the importance of sufficient and suitable wintering habitat. Threats to populations and habitat are similar on the breeding and wintering ranges. Habitat destruction and degradation are pervasive and have reduced physically suitable habitat. Human disturbance

and predators further reduce breeding and wintering habitat quality and affect survival (U.S. Fish and Wildlife Service 2014).

It can be expected that these habitats will be affected by sea level rise and increased stormy conditions. These dynamic geomorphic features can experience major changes in ecology as a result of severe storms. As the rise in sea level accelerates, extreme storms will likely cause barrier islands to experience more beach and dune erosion, more overwash, more frequent island breaching, and more rapid landward migration.

Climate change studies indicate a trend toward increasing numbers and intensity of hurricane events. Combined with the predicted effects of sea level rise, this trend indicates potential for increased cumulative impact of future storms on habitat. Major storms can create or enhance piping plover habitat while causing localized losses elsewhere in the wintering and migration range. The habitat in some areas may be improved where wave overwash reduces denser vegetation creating low moist feeding areas. Some new habitat will likely be created to replace what is lost where the shoreline can respond by receding unimpeded. The presence of human development may prevent new habitat from being created as the shoreline recedes. The implementation of shoreline stabilization measures to protect development or human infrastructure could also adversely affect plover habitat.

Piping plovers are found along the Alabama coast during the nonbreeding season; however, they were observed in all months aside from December and February during Alabama Audubon's monitoring period of March 2018 through August 2019. The number of individuals observed at any given place and time ranged from 1 to 10 and they were generally seen foraging. Over 90% of the observations were on Dauphin Island, which is a dynamic barrier island system that is threatened by erosion, sea level rise, and increased frequency and intensity of storms (L. Kozcur, pers. Comm. 2019). Forty-one species of shorebirds are known or suspected to occur on the Bon Secour Refuge. In 2001, Critical Habitat was designated for wintering piping plovers on the Little Dauphin Island Unit and on the western Fort Morgan Unit. Banded piping plovers from the endangered Great Lakes breeding population have been identified at Fort Morgan (U. S. Fish and Wildlife Service 2003).

Counties: Baldwin and Mobile

Red Knot (*Calidris canutus rufa*)

The red knot is the second largest *Calidris* sandpiper, measuring 23 to 26 cm long with a 47 to 53 cm wingspan. The body shape is typical for the genus, with a small head and eyes, a short neck and a slightly tapering bill that is no longer than its head. It has short dark legs and a medium thin dark bill. Red knots can double their weight prior to migration. Their diet varies according to season; arthropods and larvae are the preferred food items at the breeding grounds, while various hard-shelled mollusks are consumed at other feeding sites at other times. The red knot (*Calidris canutus*) is divided into six subspecies, the subspecies *rufa* has been proposed for

listing as threatened by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 2014). The biggest threat to the *rufa* red knot in Alabama is the loss of foraging and resting habitat associated with the mainland and barrier islands. Severe storms, climate change, land subsidence, and sea level rise are all threats to this essential habitat.

Small numbers of red knots are seen on the Alabama coast during the nonbreeding season and have been observed during March through June, and September through October. The number of individuals observed during Alabama Audubon's monitoring period of March 2018 through August 2019 ranged from 1 to 13. Approximately 75% of observations occurred on Dauphin Island (L. Kozcur, pers. Comm. 2019).

Counties: Baldwin and Mobile

Red-Cockaded Woodpecker (*Picoides borealis*)

The red-cockaded woodpecker was Federally listed as Endangered on October 13, 1970. Its decline is attributed primarily to the reduction of pine forest with trees 80 years old and older and to the encroachment of hardwood midstory due to fire suppression. The red-cockaded woodpecker is approximately seven inches long, with a wingspan of about 15 inches. There are black and white horizontal stripes on its back, and its cheeks and underparts are white. Its flanks are black streaked. The cap and stripe on the side of the neck and the throat are black. The male has a small red spot on each side of the black cap. After the first post fledgling molt, fledgling males have a red crown patch. The red-cockaded woodpecker feeds primarily on beetles, ants, roaches, caterpillars, wood-boring insects, and spiders, and occasionally fruits and berries (U. S. Fish and Wildlife Service 2017).

This bird's range is closely tied to the distribution of southern pines. Historically, the red-cockaded woodpecker occurred from East Texas and Oklahoma, to Florida, and North to New Jersey. The present distribution is similar, except the species has been extirpated from Missouri, Maryland, and New Jersey. The remaining populations are fragmented into isolated, island populations (U. S. Fish and Wildlife Service 2017). Red-cockaded woodpeckers have increased in number range-wide in response to recovery and management programs, from an estimated 4,694 active clusters in 1993 to 6,105 in 2006. Management plans have been developed for federal and state agencies with recovery populations. On private lands, more than 40 percent of the known red-cockaded woodpeckers are benefiting from management approved by the U. S. Fish and Wildlife Service through Memorandum of Agreements, Safe Harbor Agreements, and Habitat Conservation Plans (U. S. Fish and Wildlife Service 2019e).

Open stands of pines with a minimum age of 80 to 120 years, depending on the site, provide suitable nesting habitat. Longleaf pines (*Pinus palustris*) are most commonly used, but other species of southern pine are also acceptable. Dense stands (stands that are primarily hardwoods, or that have a dense hardwood understory) are avoided. Foraging habitat is provided in pine and pine hardwood stands 30 years old or older with foraging preference for pine trees 10 inches or

larger in diameter. In good, well-stocked, pine habitat, sufficient foraging substrate can be provided on 80 to 125 acres (U. S. Fish and Wildlife Service 2017).

Roosting cavities are excavated in living pines, and usually in those which are infected with a fungus producing what is known as red-heart disease. The cavity tree ages range from 63 to 300 plus years for longleaf, and 62 to 200 plus years for loblolly and other pines. The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Completed cavities in active use have numerous, small resin wells which exude sap. The birds keep the sap flowing apparently as a cavity defense mechanism against rat snakes and possibly other predators. The territory for a group averages about 200 acres, but observers have reported territories running from a low of around 60 acres, to an upper extreme of more than 600 acres. The expanse of territories is related to both habitat suitability and population density (U. S. Fish and Wildlife Service 2017).

The effects of sea level rise and storm surge include inundation of pine forest habitat and intrusion of saltwater into estuaries and inland areas, including occupied pine forest habitat. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of the mature pine forests that provide habitat for the red-cockaded woodpecker. The duration of inundation by sea level rise will make a difference: habitat that is perpetually flooded have no tree regeneration and thus sea level rise could result in loss of habitat over time at locations where inundation becomes perpetual.

Counties: Baldwin, Covington, Escambia, Geneva and Mobile

Wood Stork (*Mycteria americana*)

Wood storks are large, long-legged wading birds, about 50 inches tall, with a wingspan of 60 to 65 inches. The plumage is white except for black primaries and secondaries and a short black tail. The head and neck are largely unfeathered and dark gray in color. The bill is black, thick at the base, and slightly decurved. Immature birds are dingy gray and have a yellowish bill. Wood storks are considered a longlived species with delayed breeding, with first breeding generally occurring for 3- to 4-year old birds. The specialized feeding behavior of the wood stork involves tactilocation, also called grope feeding, where the stork uses its bill to find small fish. Wood storks also occasionally consume crustaceans, amphibians, reptiles, mammals, birds, and arthropods. Wood storks forage in a variety of shallow wetlands, wherever prey concentrations reach high enough densities, in water that is shallow and open enough for the birds to be successful in their hunting efforts. Typical foraging sites include freshwater marshes, swales, ponds, hardwood and cypress swamps, narrow tidal creeks or shallow tidal pools, and artificial wetlands, such as stock ponds or ditches (U. S. Fish and Wildlife Service 2012a).

Wood storks use a wide variety of freshwater and estuarine wetlands for nesting, feeding, and roosting throughout their range and thus are dependent upon a mosaic of wetlands for breeding and foraging. The wood stork is a gregarious nesting species, nesting in colonies (rookeries), and

roosts and feeds in flocks, often in association with other species of wading birds. Due to increasing nesting success and breeding pair numbers, the stork was reclassified from endangered to threatened on June 30, 2014. Although its range is expanding, the wood stork is found in Alabama only feeding and roosting, as yet not breeding.

Sea level rise and storms such as hurricanes have the potential to affect both nesting and foraging habitat for the species. Sea level rise will inundate coastal wetlands of all types, reducing the availability of appropriate (shallow) foraging conditions for storks. Hurricanes are becoming more and more of an issue and threaten to impact wood storks primarily via increased precipitation and low prey concentration during the fall, when inexperienced fledgling storks are attempting to forage and survive on their own. The marshes and wetlands they use may be impacted by climate change depending on their location but wood storks have been shown to find other habitat if existing locations become unavailable. Abandonment of old colonies and formation of new ones is a typical and fairly rapid process in wood storks (U. S. Fish and Wildlife Service 2012a).

Counties: Baldwin, Covington, Escambia, Geneva and Mobile

Eastern Black Rail (*Laterallus jamaicensis jamaicensis*)

The eastern black rail (*Laterallus jamaicensis jamaicensis*) is a subspecies of black rail, a small secretive marsh bird occurring in localized populations across coastal and interior areas of the United States (east of the Rocky Mountains), and in the Caribbean, Central America, and Brazil. The eastern black rail was proposed for listing as threatened under the Endangered Species Act on October 9, 2018. The black rail is the smallest rail in North America. Adults range from 10-15 centimeters (cm) in total length and have a wingspan of 22-28 cm (Eddleman et al. 1994).

Eastern black rails are primarily associated with herbaceous, persistent, emergent wetland plants that can be tidally or non-tidally influenced, and range in salinity from salt to brackish to fresh. Vegetation associations are different between habitats in the interior portion of the range and those associated with the coastal areas of the contiguous United States (U.S. Fish and Wildlife Service 2018). From the Florida Gulf Coast and panhandle west to the Pearl River in Mississippi (therefore, including coastal Alabama), black needlerush (*Juncus roemerianus*) is the dominant plant species (Mendelssohn et al. 2017). The subspecies requires dense overhead cover and soils that are moist to saturated (occasionally dry) and interspersed with or adjacent to very shallow water (typically ≤ 3 cm) (Eddleman et al. 1994). Eastern black rails occur across an elevational gradient that lies between the lower and wetter portions of estuarine and palustrine marshes and the higher and drier adjacent uplands. Flooding is a frequent cause of nest failure for eastern black rails; therefore, water levels must be lower than nests during egg-laying and incubation in order for nests to be successful. Transition areas also provide critical refugia during flooding events and minimize the risk of predation to black rails when well vegetated (Evens and Page 1986). Because black rails require dense vegetative cover that allows movement underneath the canopy and because birds are found in a variety of salt, brackish, and freshwater marsh habitats

that can be tidally or non-tidally influenced, plant structure is considered more important than plant species composition in predicting habitat suitability (Flores and Eddleman 1995). Increases in high tide flooding from sea level rise and an increase in flooding from storm and extreme precipitation events may impact eastern black rails by exposing individuals to increased predation and/or causing nest failure.

In some locations, loss of salt marsh associated with conversion to open water due to sea level rise is being offset to some extent by salt marshes becoming established in areas where saltwater intrusion occurs also due to sea level rise. Although this would not continue indefinitely depending on a variety of relevant local conditions. These emergent wetland gains due to landward expansion of sea level would be hampered by barriers to wetland migration such as roads, levees, canals, and other social infrastructure. This would also include natural barriers (e.g., topographic features) and existing and future barriers related to human actions (e.g., shoreline rip-rap, hardened surfaces, sea walls) (U.S. Fish and Wildlife Service 2018).

Counties: Baldwin and Mobile

Bald Eagle (*Haliaeetus leucocephalus*)

A large raptor, the bald eagle has a wingspread of about 7 feet. Adults have a dark brown body and wings, white head and tail, and a yellow beak. Juveniles are mostly brown with white mottling on the body, tail, and undersides of wings. Adult plumage usually is obtained by the 6th year. In flight, the Bald Eagle often soars or glides with the wings held at a right angle to the body. As in most other raptors, females are larger than males; sexes otherwise similar in appearance.

Although the bald eagle was officially removed from the List of Endangered and Threatened Species as of August 8, 2007, it continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. Eagles usually mate for life, choosing the tops of large trees to build nests, which they typically use and enlarge each year. Bald eagles may also have one or more alternate nests within their breeding territory. In treeless regions, they may also nest in cliffs or on the ground. The birds travel great distances but usually return to breeding grounds within 100 miles of the place where they were raised.

Bald eagles generally nest near coastlines, rivers, and large lakes where there is an adequate food supply. They nest in mature or old-growth trees, snags (dead trees), cliffs, and rock promontories. Recently, and with increasing frequency, bald eagles are nesting on artificial structures such as power poles and communication towers, and away from large water bodies. In forested areas, bald eagles often select the tallest trees with limbs strong enough to support a nest that can weigh 1,000 pounds or more. Nest sites typically include at least one perch with a clear view of the water, where they forage. Eagle nests are constructed with large sticks, and may be lined with moss, grass, plant stalks, lichens, seaweed, or sod.

The effects of sea level rise and storm surge include inundation of forest habitat and intrusion of saltwater into estuaries and inland areas, including occupied habitat and waterbodies used for foraging. Sea level rise and its effects (e.g., increased flooding and inundation, saltwater intrusion) may affect the persistence of the forests that provide nesting habitat for the bald eagle. The duration of inundation by sea level rise will make a difference: habitat that is perpetually flooded have no tree regeneration and thus sea level rise could result in loss of habitat over time at locations where inundation becomes perpetual.

Bald eagle nests are threatened by damage or loss during large, intense storms, particularly those that occur during the nesting season. Nests may be destroyed or trees may be toppled by high winds. Eaglets may be killed or injured by being blown from a nest, or when a nest falls during a storm. An increase in the number and intensity of storms will exacerbate these threats.

Counties: Baldwin, Covington, Escambia, Geneva and Mobile

Waterbird Nesting Colonies

During Alabama Audubon's monitoring period of March 2018 through August 2019, least terns nested in large numbers on mainland and barrier island sites, specifically on Dauphin Island and Alabama Point in the city of Orange Beach. At the Orange Beach sites, terns nested close to or in the back dunes and therefore were not affected by tidal overwash. However, these sites are vulnerable to sea level rise and increased frequency and intensity of storms. There are four nearshore islands that are used by colonial and solitary nesting birds. In 2019, the recently restored and enlarged Marsh Island (by the State, using DWH funds) supported hundreds of nesting black skimmers, gull-billed terns, royal terns, Caspian terns, sandwich terns, and laughing gulls, and also a small number of black-necked stilts and reddish egrets. Coffee Island had a small colony of least terns and two pairs of American oystercatchers. It also supported nesting great egrets, tricolored herons, snowy egrets, white ibis, reddish egrets, cattle egrets, black-crowned night-herons, willets, and clapper rails. Cat Island had a small colony of least terns and one pair of American oystercatchers. Tern Island is a low elevation shoal that had over 600 pairs of least terns, 30 pairs of black skimmers and 1 pair of American oystercatchers in 2019. Nearly all of the nests and chicks on Tern Island were lost to overwash from storm-driven high tides. These islands provide important habitat for colonial nesting birds as they are free from mammalian predators. They also provide important loafing habitat to a variety of species throughout the year. Each of these islands is vulnerable to erosion and overwash during storm events, which will be exacerbated by sea level rise (L. Kozcur, pers. comm. 2019).

Gaillard Island, a Corps dredging disposal island in Mobile Bay, is utilized by a variety of species including terns, gulls, brown pelicans, etc. for loafing, foraging and nesting. Due to its elevation it should not be impacted by sea level rise, erosion or overwash but would still be affected by increased frequency and intensity of storms.

Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)

The Gulf subspecies of the Atlantic sturgeon, *Acipenser oxyrinchus desotoi,* is distinguished from the lake sturgeon, *A. fulvescens,* by a narrower mouth (less than 55 percent of interorbital width in the former, compared to more than 62 percent in the latter) and paired postdorsal and preanal scutes (one row in the lake sturgeon). Other characteristics include a V-shaped snout that is frequently upturned at the tip, a small spiracle behind and slightly above the eye, and a bilobed lower lip. The back is medium to light brown, grading into cream on the belly. Fins are light tan to cream (Mettee, et al. 1996).

Known spawning populations of Gulf sturgeon in Alabama are in the Choctawhatchee and Conecuh Rivers. Migrating and/or foraging sturgeon have also been documented in Fish River on the eastern side of Mobile Bay, in Mobile Bay, Perdido Bay and in the Mobile, Tombigbee, Tensaw, Yellow, Pea and Perdido Rivers. Historically, Gulf sturgeon spawned upstream in the major waterways of the Mobile River Basin but are now unable to reach those grounds due to damming. For this reason, Critical Habitat was not established in the bays or rivers of Alabama.

Gulf sturgeon are anadromous, living in saltwater and spawning in fresh water. From November through January, individuals reside in estuaries and near shores, where they feed on amphipods, isopods, midges, crabs, and shrimp. Upstream spawning runs usually begin in February. After spawning, adults retreat to deeper pools and remain there until August or September, when they return downstream. When these fishes are in fresh water, feeding apparently ceases.

Threats include pollution and contamination from industrial, agricultural, and municipal activities which are believed to cause a variety of physical, behavioral, and physiological impacts to sturgeon worldwide. Dredging activities can significantly impact aquatic ecosystems by directly removing or burying organisms, causing turbidity/siltation effects, resuspending contaminants, making noise and causing disturbance, altering the hydrodynamic regime and physical habitat, and destroying riparian habitat. Dredging operations may also destroy benthic feeding areas, disrupt spawning migrations, and resuspend fine sediments causing siltation over required substrate in spawning habitat. Because Gulf sturgeon are benthic omnivores, the modification of the benthos affects the quality, quantity, and availability of prey. Dams significantly impact Gulf sturgeon by blocking passage to historical spawning habitats, which reduces the amount of available spawning habitat or entirely impedes access to it. The ongoing operations of these dams also affect downstream habitat. Global climate change may lead to accelerated changes in Gulf sturgeon habitat through saltwater intrusion, changes in water temperature, exacerbation of the world's largest dead zone, and extreme weather periods that could increase both the frequency and intensity of droughts, floods and storms (NOAA 2019). These tropical storms could easily result in alteration of foraging habitat, increased erosion and runoff resulting in water quality degradation and, as we have witnessed locally, debris being piled up in a river such that a large number of sturgeon were trapped and eventually died.

Counties: Baldwin, Coffee, Covington, Dale, Escambia, Geneva and Mobile

Saltmarsh Topminnow (*Fundulus jenkinsi*)

From the petition to list this species (WildEarth Guardians 2010) - The Saltmarsh Topminnow occurs sporadically in fragile marsh habitat along the U.S. coast of the Gulf of Mexico, from Galveston, Texas to Escambia Bay, Florida (Peterson et al. 2003). Specialists in marine science have long considered this fish to be extremely rare. It either occurs in very small populations or is simply absent from the reports of most fish studies of the northern Gulf of Mexico. *Id*. The Topminnow's imperilment is directly linked to the destruction of its habitat, the saltmarsh. Recent scientific research confirms that there is a direct link between *Fundulus jenkinsi* abundance and coastal saltmarsh habitat embedded within a reduced range of estuarine salinity (Lopez et al. 2010). "Subtle habitat differences such as vegetation density and complexity, water depth, and bank slope may affect…local abundance of *F. jenkinsi* in selected marsh areas." *Id*. The dendritic nature of the saltmarsh habitat is vital to the Saltmarsh topminnow; the small dendritic creeks off of main channels in saltmarshes are "important vectors for marsh access by *F. jenkinsi*." *Id*.

Therefore this minnow's specialized restrictions and habitat would be quite vulnerable to future tidal changes, erosion, sea level rise, and increased frequency and intensity of storms.

Counties: Baldwin and Mobile

Gulf Coast Solitary Bee (*Hesperapis oraria*)

This species is considered Critically Imperiled and it was petitioned to be protected under the ESA on March 27, 2019. It only occurs in certain coastal areas within 1-2 km of the mainland shore and on certain islands from extreme southeast Mississippi to the western Florida panhandle (Cane et al. 1996). Its entire range has been estimated as less than 100 square kilometers and all known occurrences may be in danger from development, sea level rise and hurricanes. It has been found in three locations in Alabama, including Bon Secour National Wildlife Refuge. This species is apparently dependent solely upon the flowers of the Coastal Plain honeycomb head (*Balduina angustifolia*) which grows in soft, deep sandy soils of coastal dune habitat (Cane et al. 1996). As the Gulf Coast solitary bee's range is much smaller than that of the honeycomb head, its habitat is restricted by several other factors, most likely bare areas of fine sandy soil for nesting (Lyons et al. 2015) as well as the intermediate disturbances needed to maintain the bee's dune habitat. Dune habitat is dynamic and disturbance dependent and so constantly changing due to forces of wind, water, storms, and fire, which has led to naturally patchy distribution of the honeycomb head and other vegetation on the dune ecosystem (Hunsberger 2013). The bee and plant are found in higher densities on the coastal mainland sites, potentially due to reduced high intensity storm disturbance in these areas (Hunsberger 2013). In addition, low intensity fires are a common and natural component of these ecosystems that maintains bare ground and patchy vegetation. The bee's coastal and island habitats are separated from the non-coastal mainland patches of honeycomb head by development or dense vegetation that has built up due to suppression of natural fire, reducing habitat connectivity (Hunsberger 2013). As such, the Gulf

Coast solitary bee and its host plant appear to require a moderate level of disturbance in their naturally shifting dune habitats.

Counties: Baldwin and Mobile

American chaffseed (*Schwalbea americana*)

American chaffseed (Schwalbea americana L.) is a monotypic perennial member of the figwort family. The range of American chaffseed once included all the coastal States from Massachusetts to Louisiana, and the inland States of Kentucky and Tennessee. Although the range was widespread, the historical record shows that the species was always relatively rare and local in distribution. Due to extirpation of the species from over half its historical range and a decline in known occurrences, *Schwalbea americana* was federally-listed as an endangered species pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) on September 29, 1992 (U.S. Fish and Wildlife Service 1992). Threats to the species persist, primarily due to fire suppression resulting in vegetative succession of the ecosystem on which the species depends. American chaffseed is found in open pine flatwoods, savannas, and other open areas, in moist to dry acidic sandy loams or sandy peat barns (U.S. Fish and Wildlife Service 1995). In Alabama, it is known from Splinter Hill Bog in Baldwin County and Sehoy Plantation in Macon County. This species would not be expected to be impacted by sea level rise but could still be affected by increased frequency and intensity of storms.

Counties: Baldwin

Gentian pinkroot (*Spigelia gentianoides*)

Spigelia gentianoides (gentian pinkroot) is a narrow endemic plant in the Family Loganiaceae. It was federally listed as an endangered species under the Endangered Species Act of 1973, as amended, on November 26, 1990 (55 FR 49046). Currently, this species comprises two varieties: *S. gentianoides* var. *gentianoides*, known from only five populations located in Jackson and Calhoun counties (Florida) and Geneva County (Alabama); and *S. gentianoides* var. *alabamensis*, restricted to the Bibb County Glades (Alabama). The plant is found on both public and private lands. *Spigelia gentianoides* is a small herbaceous plant found in fire-dependent ecosystems. Variety *gentianoides* is restricted to longleaf-wiregrass, pine-oak-hickory woods, and in open space within forests (glades) of Florida and Alabama, whereas var. *alabamensis* is only found in open areas within woodlands (glades) of Bibb County, Alabama. The primary threat to gentian pinkroot is habitat loss and alteration. Factors contributing to this threat include clearcutting and/or selective thinning, mechanical site preparation, conversion of land to pine plantations, disruption of fire regimes, and permanent habitat loss through development (U.S. Fish and Wildlife Service 2012b). This species would not be expected to be impacted by sea level rise but could still be affected by increased frequency and intensity of storms.

Counties: Covington and Geneva

Pondberry (*Lindera melissifolia*)

Pondberry, *Lindera melissifolia* (Walt.) Blume, is a deciduous shrub, growing from less than 1 foot (30 cm) to, infrequently, more than 6 feet (2 m) in height. Leaves are aromatic, alternate, elliptical, somewhat thin and membranaceous, with entire margins. Shrubs usually are sparsely branched, with fewer branches on smaller plants. Plants are rhizomatous, frequently propagating by vegetative sprouts and forming clonal colonies. Plants are dioecious--each plant is either a male or a female--and produce clusters of small, yellow flowers in early spring prior to leaf development from buds on branches produced from the growth during the preceding year. Fruits are drupes that green when immature and ripen to red by fall. The species historical range included Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, and South Carolina. This species would not be expected to be impacted by sea level rise but could still be affected by increased frequency and intensity of storms.

Counties: Covington and Geneva

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Mississippi

Federally Listed Threatened and Endangered Species

MAMMALS

Gray Bat *(Myotis grisescens)*

The endangered gray bat *(Myotis grisescens)* is a historical resident of Tishomingo County. They are the only listed bat species in Mississippi that roosts year round in caves. Activities that impact caves or suitable mines could adversely affect this species. Protection measures for the gray bat include preventing human entry into caves with hibernating or maternity gray bat colonies by installing bat friendly gates and establishing a buffer of undisturbed vegetation around bat caves.

County: Tishomingo

Indiana Bat (*Myotis sodalis*)

The endangered Indiana bat (*Myotis sodalis*) is a migratory bat that hibernates in caves and abandoned mines in the winter, then migrates to wooded areas (roost sites) in the spring to bear and raise their young over the summer. Reproductive females occupy roost sites under the exfoliating bark of large, often dead, trees. Roost trees are typically within canopy gaps in the forest where the primary roost tree receives direct sunlight for more than half the day. Habitats include riparian zones, bottomland and floodplain habitats, wooded wetlands, and upland communities. A significant threat to the survival and recovery of Indiana bats in Mississippi is the destruction of maternity and foraging habitats; therefore, we recommend that all tree removal

activities in areas supporting Indiana bat habitat take place in the non-maternity season (September 1st – May 14th).

Counties: *Alcorn, Benton, Marshall, Prentiss, Tippah, and Tishomingo*

Northern Long-eared Bat (*Myotis septentrionalis*)

The northern long-eared bat (*Myotis septentrionalis*) (NLEB) was listed as threatened on May 4, 2015. The NLEB is a migratory bat that hibernates in caves, mines, and occasionally culverts and migrates to wooded areas to raise young over the summer. During the summer, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live trees and snags (dead trees). NLEB seem to be flexible in selecting roosts, choosing roost trees based on suitability to retain bark or provide cavities or crevices.

A final 4(d) rule was published in 2016 exempting incidental take of otherwise legal actions related to tree clearing, except when tree removal occurs within a hibernacula site or when tree removal activities: 1) occur within a quarter-mile of a known hibernacula; or 2) cut or destroy known occupied maternity roost trees, or any other trees within 150 feet of that maternity roost tree during the pup-rearing season (June 1–July 31). Currently, there are no known maternity roost trees in the state of Mississippi and one known hibernaculum located in Tishomingo County near Pickwick Lake.

If tree clearing is not proposed then the Service has determined the proposed project will have "no effect" on NLEB. If tree clearing is proposed, then this project "may affect" the NLEB. If this project is federally funded or requires a federal permit, then we encourage the lead federal agency or its designated non-federal representative to rely upon the findings of the 2016 programmatic biological opinion for the final 4(d) rule to fulfill their project-specific section 7 responsibilities. A federal agency or its designated non-federal representative may use the NLEB 4(d) Rule Streamlined Consultation Form (https://www.fws.gov/midwest/endangered/mammals/nleb/pdf/StreamlinedConsultationForm29F eb2016.docx) to notify the Service that it proposes an action that may rely on the 4(d) rule biological opinion. If this is a non-federal activity, then incidental take from tree removal is not prohibited and no permits or further coordination is required with the Service.

Counties: Alcorn, Attala, Benton, Bolivar, Calhoun, Carroll, Chickasaw, Choctaw, Clay, Coahoma, Desoto, Grenada, Hinds, Holmes, Humphreys, Issaquena, Itawamba, Kemper, Lafayette, Lauderdale, Leake, Lee, Leflore, Lowndes, Madison, Marshall, Monroe, Montgomery, Neshoba, Newton, Noxubee, Oktibbeha, Panola, Pontotoc, Prentiss, Quitman, Rankin, Scott, Sharkey, Sunflower, Tallahatchie, Tate, Tippah, Tishomingo, Tunica, Union, Warren, Washington, Webster, Winston, Yalobusha, and Yazoo.

West Indian Manatee (*Trichechus manatus)*

The threatened West Indian manatee *(Trichechus manatus)* is an aquatic mammal that occurs in rivers, estuaries, and coastal areas of the Gulf of Mexico.Manatees have large, seal-shaped bodies with paired flippers and a round, paddle-shaped tail. Most manatee sightings in Mississippi occur in tidal rivers such as the Pascagoula and Jordan Rivers. Manatees have also been spotted in Biloxi Bay, Bay St. Louis, and near shore in the Gulf of Mexico. Most of the sightings in Mississippi occur during the months of June through November; however, winter sightings do occur.

Counties: Hancock, Harrison, and Jackson

BIRDS

Bald Eagle (*Haliaeetus leucocephalus)*

Although the bald eagle (*Haliaeetus leucocephalus*) was officially removed from the List of Endangered and Threatened Species as of August 8, 2007, it continues to be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (BGEPA). Bald eagles nest in Mississippi from December through mid-May in mature trees (e.g., bald cypress, sycamore, willow, etc.) near fresh to intermediate marshes or open water. Nest sites typically include at least one perch with a clear view of the water or area where the eagles usually forage. Bald eagles are vulnerable to disturbance during courtship, nest building, egg laying, incubation, and brooding. The Service developed the National Bald Eagle Management (NBEM) Guidelines to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute “disturbance,” which is prohibited by the BGEPA. A copy of the NBEM Guidelines is available at https://catalog.data.gov/dataset/national-bald-eagle-management-guidelines.

Counties: All

Eastern Black Rail (*Laterallus jamaicensis jamaicensis)*

The eastern black rail (*Laterallus jamaicensis jamaicensis)* was proposed for listing as a threatened species under the ESA on October 9, 2018. The eastern black rail is a small, secretive marsh dependent bird. One of four subspecies of black rails, it occurs in 36 states and multiple territories along the U.S. Atlantic and Gulf coasts, in the U.S. interior east of the Rocky Mountains, and in Mexico, Central America, and the Caribbean. Although historically uncommon in Mississippi, the species may be found in coastal marshes during the winter months (i.e., non-nesting season). While it can be found in salt, brackish, and freshwater

marshes, it has a very specific niche habitat, requiring dense herbaceous vegetation (i.e. rushes, grasses, sedges) to provide shelter and cover.

Counties: Hancock, Harrison, Jackson

Interior Least Tern (*Sterna antillarum)*

The endangered interior least tern (*Sterna antillarum*) is a migratory shorebird that breeds, nests, and rears its young on sparsely or non-vegetated portions of sand or gravel bars located mid-stream or along the shoreline in the Mississippi, Missouri, Arkansas, Ohio, Red and Rio Grande river systems and the rivers of central Texas. On the lower Mississippi River, the interior least tern is a common summer resident between Cairo, Illinois, and Baton Rouge, Louisiana. The breeding season for terns is approximately May through July. Avoidance of non-vegetated islands or point bars during the breeding season would prevent adverse impacts to this species.

Counties: Adams, Bolivar, Claiborne, Coahoma, DeSoto, Issaquena, Jefferson, Tunica, Warren, Washington, and Wilkinson

Mississippi Sandhill Crane *Grus canadensis pulla*)

The endangered Mississippi sandhill crane *(Grus canadensis pulla*) is found only in Jackson County. Critical habitat has been designated for the species on and adjacent to the Mississippi Sandhill Crane National Wildlife Refuge. Primary habitat for the cranes is wet pine savanna grasslands with scattered longleaf pine, slash pine, and pond cypress. Crane nests are typically laid in an open area of grasses and sedges with perennial shallow water, but they may also nest in swamp or marsh edges. During fall, winter, and early spring, the cranes will feed in small corn and chufa fields and in pastures. Increasing commercial, industrial and residential development in the area surrounding the refuge is limiting the availability of off-refuge habitat for the crane and limiting the ability of the refuge to manage crane habitat through the use of prescribed burning. Because the cranes fly between nesting, foraging, and roosting areas that may be off-refuge or between refuge units, the increase in off-refuge motorized vehicular traffic increases the likelihood that a crane will be hit and killed.

County: Jackson

Piping Plover *(Charadrius melodus)*

The threatened piping plover *(Charadrius melodus)* is a small shorebird approximately seven inches long with sand-colored plumage on their backs and crown and white underparts. The piping plover breeds from central Canada south to Nebraska and Iowa, east along the Great Lakes and Newfoundland, and south along the Atlantic Coast to Virginia. Plovers depart for the

wintering grounds from mid-July through late October. Breeding and wintering plovers feed on exposed wet sand in wash zones; intertidal ocean beach; wrack lines; washover passes; mud-, sand-, and algal flats; and shorelines of streams, ephemeral ponds, lagoons, and salt marshes by probing for invertebrates at or just below the surface. They use beaches adjacent to foraging areas for roosting and preening. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. The piping plover does not nest in Mississippi but winters along the coastal beaches and barrier islands. Critical habitat has been designated along many sand beach areas along the Mississippi Gulf Coast. Major threats to this species along the Gulf of Mexico include the loss and degradation of beach habitat due to erosion and shoreline stabilization development, disturbance by humans and pets, and predation.

Counties: Hancock, Harrison, and Jackson

Red-cockaded Woodpecker (*Picoides borealis*)

The endangered red-cockaded woodpecker (*Picoides borealis*) excavates nesting cavities in mature pine trees (60+ years old). A mated pair of birds and all helper birds forms a group. A collection of cavity trees where the group nests and roosts is called a cluster. All cavity trees, active and inactive, are important to the group and should therefore be avoided. In addition, older (30+ years) pine stands within a half-mile of a colony should be considered suitable or potentially suitable foraging habitats and should not be adversely impacted without additional foraging habitat analysis.

Counties: Adams, Amite, Choctaw, Copiah, Forrest, Franklin, George, Greene, Harrison, Jackson, Jasper, Jefferson, Jones, Lincoln, Newton, Noxubee, Oktibbeha, Pearl River, Perry, Scott, Smith, Stone, Wayne, Wilkinson, and Winston

Red Knot (*Calidris canutus rufa*),

The red knot (*Calidris canutus rufa*), a threatened species, is a medium-sized shorebird about 9 to 11 inches in length with a proportionately small head, small eyes, short neck, and short legs. The red knot can be found in Mississippi during the winter months (generally October through March). In the southeastern United States, red knots forage along sandy beaches, tidal mudflats, salt marshes, and peat banks. Observations along the Texas coast indicate that red knots forage on beaches, oyster reefs, and exposed bay bottoms and roost on high sand flats, reefs, and other sites protected from high tides. In wintering and migration habitats, red knots commonly forage on bivalves, gastropods, and crustaceans. Coquina clams (*Donax variabilis*), a frequent and often important food resource for red knots, are common along many gulf beaches. Major threats to this species along the Gulf of Mexico include the loss and degradation of habitat due to erosion and shoreline stabilization development, disturbance by humans and pets, and predation.

Counties: Hancock, Harrison, and Jackson

Wood Stork (*Mycteria americana*)

Wood storks (*Mycteria americana*) are large, long-legged wading birds, about 50 inches tall, with a wingspan of 60-65 inches. The plumage is white except for black primaries and secondaries and a short black tail. The head and neck are largely unfeathered and dark gray in color. Two distinct populations of wood storks occur in the United States. One population breeds in Florida, Georgia, and South Carolina, and is federally protected (threatened). The other population breeds from Mexico to northern Argentina and is not federally protected. Wood storks from each of these populations occur seasonally in Mississippi during the non-breeding season (May-October) and are not distinguishable from one another. The major threat to this species is a reduction in food base (primarily small fish) due to habitat loss, modification, and fragmentation. Typical foraging sites include freshwater marshes, swales, ponds, hardwood and cypress swamps, narrow tidal creeks or shallow tidal pools, and artificial wetlands (such as stock ponds; shallow, seasonally flooded roadside or agricultural ditches; and impoundments).

Counties: All

FISH

Bayou Darter (*Etheostoma rubrum*)

The threatened bayou darter (*Etheostoma rubrum*) is found only in the Bayou Pierre River and its tributaries: White Oak Creek, Foster Creek, and Turkey Creek. The darter prefers stable gravel riffles or sandstone exposures with large sized gravel or rock. Habitat loss or degradation has been a major contributor to the reduction in bayou darter numbers. Historical in-stream-bed gravel mining has caused various head-cuts throughout the last 50 years. Along with severe erosion rates from adjacent farm fields and bankside collapse, the river is becoming more shallow and wider. Tributaries are less impacted but also have various threats such as gravel mining, stream fords, ATV traffic and non-point and point source pollution.

Counties: Claiborne, Copiah, Hinds, and Lincoln

Gulf Sturgeon (*Acipenser oxyrinchus (=oxyrhynchus) desotoi*)

The threatened Atlantic sturgeon, Gulf subspecies (*Acipenser oxyrinchus (=oxyrhynchus) desotoi*) is found in the coastal rivers of the northeastern Gulf of Mexico generally from Lake Pontchartrain in Louisiana to the Suwanee River in Florida. Critical habitat has been

designated for the species in Mississippi to include portions of the Bogue Chitto, Bouie, Chickasawhay, Leaf, Pascagoula and Pearl Rivers and the Gulf of Mexico. Gulf sturgeons are primitive, anadromous fish that annually migrate from the Gulf of Mexico into freshwater streams to spawn. Subadults and adults spend eight to nine months each year in rivers. Adult and subadult holding areas have been identified in the Pascagoula River. The decline of the Gulf sturgeon is primarily due to limited access to riverine migration routes and historic spawning areas, habitat modification, and water quality degradation.

Counties: Clarke, Copiah, Forrest, George, Greene, Hancock, Harrison, Hinds, Jackson, Jones, Lawrence, Marion, Pearl River, Perry, Pike, Rankin, Simpson, Walthall, and Wayne

Pallid Sturgeon (*Scaphirhynchus albus*)

The endangered pallid sturgeon (*Scaphirhynchus albus*) is found throughout the lower Mississippi River. These fish require large, turbid, free-flowing riverine habitats, and feed on aquatic invertebrates and small fish. They are usually found near the bottom of rivers on sand flats or gravel bars. Little information is known on spawning or migration habits of these fish, although spawning likely occurs in the spring and summer months. Pallid sturgeon may be entrained into water intake structures or by dredging.

Counties: Adams, Bolivar, Claiborne, Coahoma, DeSoto, Issaquena, Jefferson, Tunica, Warren, Washington, and Wilkinson

Pearl Darter *(Percina aurora)*

The threatened pearl darter *(Percina aurora)* was historically found in the Pearl and Pascagoula River systems. However, it is currently found only in the Pascagoula River system. The darter prefers stable gravel riffles or sandstone exposures with large sized gravel or rock. The pearl darter is vulnerable to non-point source pollution, urbanization, and changes in river geomorphology due to its localized distribution within one river drainage and its apparent low population sizes.

Counties: Clarke, Covington, Forrest, George, Greene, Jackson, Jones, Lauderdale, Newton, Perry, Stone, and Wayne

Snail Darter (*Percina tanasi*)

The threatened snail darter (*Percina tanasi*) was recently (2015) discovered within Bear Creek in Tishomingo County. The previous distribution included the upper Tennessee River drainage

of eastern Tennessee, northern Georgia, and Alabama. Snail darters inhabit gravel or sandy shoals in large creeks and rivers with low degrees of turbidity or siltation. Threats to this species include non-sustainable agricultural practices, environmental contamination and pollution, pesticides, channel modification, habitat inundation (reservoirs), and siltation.

County: Tishomingo

REPTILES

Alabama Red-bellied Turtle *(Pseudemys alabamensis)*

The endangered Alabama red-bellied turtle *(Pseudemys alabamensis)* is found in the lower Pascagoula River and its tributaries and bayous: Bayou Chemise, Bluff Lake, Dead River, Escatawpa River, Farragut Lake, John's Bayou, King's Bayou, Little Bear Bayou, Mary Walker Bayou, Page Bayou, and Sioux Bayou. It is also found in the Back Bay of Biloxi, Bayou Cassotte, Bayou Cumbest, Biloxi River, Old Fort Bayou, and the Tchoutacabouffa River. Destruction of nesting areas along riverbanks; degradation of submerged aquatic vegetation feeding areas; and reduced water quality have impacted this species.

Counties: Harrison and Jackson

Black Pinesnake (*Pituophis melanoleucus lodingi*)

The threatened black pinesnake (*Pituophis melanoleucus lodingi*) prefers uplands with well-drained, sandy soils in pine-dominated forests, particularly longleaf pine. Using prescribed fire and other beneficial practices to maintain an open-canopied forest with abundant herbaceous groundcover is essential to maintain prey base and basking opportunities; additionally, leaving stumps intact during forestry activities is important so they may naturally burn or rot out and provide the root system refugia that pinesnakes utilize. Critical habitat is proposed for Forrest, George, Greene, Harrison, Jones, Marion, Perry, Stone, and Wayne Counties.

Counties: Covington, Forrest, George, Greene, Hancock, Harrison, Jackson, Jefferson Davis, Jones, Lamar, Lawrence, Marion, Pearl River, Perry, Stone, and Wayne

Green, Hawksbill, Kemp's Ridley, Leatherback, and Loggerhead Sea Turtles

There are five species of federally protected sea turtles that inhabit the Gulf of Mexico waters along the Mississippi coast: the leatherback *(Dermochelys coriacea)*, loggerhead *(Caretta caretta)*, green *(Chelonia mydas)*, hawksbill (*Chelonia mydas*) and Kemp's ridley *(Lepidochelys kempii)*. Although these are predominantly marine animals, they can come ashore to nest on barrier island and mainland beaches. Currently, only the loggerhead is known to nest in Mississippi. Mortality due to fishing nets and trawls, ingestion of inedible objects, and nest predation has reduced these species numbers. Critical habitat for the loggerhead includes Horn and Petit Bois Islands in Jackson County.

Counties: Hancock, Harrison, and Jackson

Gopher Tortoise (*Gopherus polyphemus*)

The threatened gopher tortoise (*Gopherus polyphemus*) occupies a wide range of upland habitat types; most frequently the longleaf pine ecosystem. The general physical and biotic features thought to characterize suitable tortoise habitat are: presence of well-drained, sandy soils, which allow easy burrowing; an abundance of diverse herbaceous ground cover; and an open canopy and sparse shrub cover, which allows sunlight to reach the ground floor. The gopher tortoise digs burrows for shelter, and groups of tortoises dig burrows in the same location, forming a colony. Some of the major threats to the species are habitat degradation (often attributed to fire suppression) and habitat fragmentation (often attributed to urbanization and agricultural/ silvicultural conversion), which can result in forage reduction, direct human impacts, and reproductive isolation.

Counties: Clarke, Covington, Forrest, George, Greene, Hancock, Harrison, Jackson, Jasper, Jefferson Davis, Jones, Lamar, Marion, Pearl River, Perry, Smith, Stone, Walthall, and Wayne

Ringed Map Turtle (*Graptemys oculifera*)

The threatened ringed map turtle (*Graptemys oculifera*) is found in the Pearl River. It prefers river stretches with moderate currents, abundant basking sites, and sand bars for nesting. Stream modification in the Pearl River for flood control and urban development has significantly contributed to the decline of the species. Threats to this species include removing forested habitat along the river banks (source of the deadwood used for basking) and/or removing instream deadwood used for basking and foraging (commonly referred to as desnagging). Water quality degradation has also posed a serious problem for the turtle.

Counties: Copiah, Hancock, Hinds, Lawrence, Leake, Madison, Marion, Neshoba, Pearl River, Pike, Rankin, Scott, Simpson, and Walthall

Yellow-blotched Map Turtle (*Graptemys flavimaculata*)

The threatened yellow-blotched map turtle (*Graptemys flavimaculata*) is found in the Chickasawhay, Leaf, and Pascagoula Rivers and their larger tributaries. The yellow-blotched map turtle prefers river stretches with moderate currents, abundant basking sites, and sand bars. Threats to this species include removing forested habitat along the river banks (source of the deadwood used for basking) and/or removing instream deadwood used for basking and foraging (commonly referred to as desnagging). Water quality degradation has also posed a serious problem for the turtle.

Counties: Clarke, Covington, Forrest, George, Greene, Jackson, Jefferson Davis, Jones, Lauderdale, Perry, Smith, and Wayne

AMPHIBIANS

Dusky Gopher Frog *(Rana sevosa)*

The endangered dusky gopher frog *(Rana sevosa)*, formerly called the Mississippi gopher frog, historically was widely distributed in the southern counties of Mississippi. Dusky gopher frog habitat includes both upland sandy sites historically forested with longleaf pine and isolated temporary wetland breeding sites embedded within the forested landscape. Adult and subadult dusky gopher frogs spend the majority of their lives underground, primarily in stump holes and small mammal burrows, but they will also use gopher tortoise burrows. Breeding sites are small, relatively shallow, isolated, depressional ponds (not connected to any other water body) that dry completely on a cyclic basis. Emergent herbaceous vegetation is important for egg attachment. The dominant source of water to the ponds is rainfall within their small, localized watersheds. Approximately 4,933 acres are designated as critical habitat in Forrest, Harrison, Jackson, and Perry Counties, Mississippi.

Counties: Forrest, George, Greene, Hancock, Harrison, Jackson, Jones, Lamar, Pearl River, Perry, Stone, and Wayne

MUSSELS

Alabama Moccasinshell, Black Clubshell, Heavy Pigtoe, Orange-nacre Mucket, Ovate Clubshell, Southern Clubshell, and Southern Combshell mussel

Seven federally listed mussel species are found within top bank of the Tombigbee, Luxapallila, and Buttahatchie Rivers; and Bull Mountain Creek. Two of these species (southern clubshell and southern combshell) may be found in the Noxubee River. The endangered heavy pigtoe mussel (*Pleurobema taitianum*), the endangered southern combshell mussel (*Epioblasma penita*), the endangered southern clubshell mussel (*Pleurobema decisum*), the endangered ovate clubshell mussel (*Pleurobema perovatum*), the endangered black clubshell mussel (*Pleurobema curtum*), the threatened Alabama moccasinshell *(Medionidus acutissimus)*, and the threatened orange- nacre mucket (*Lampsilis perovalis*) all require clean, swiftly moving stable streams with pools and riffles. Work activities that affect channel geometry (depth, width) or that increase sedimentation and water turbidity could have adverse impacts on these species. Also, be advised that in-stream activities can affect channel geometry both up- and downstream. Critical habitat has been designated for the Alabama moccasinshell, orange-nacre mucket, ovate clubshell, and southern clubshell in Itawamba, Lowndes and Monroe Counties.

Counties: Clay, Itawamba, Kemper, Lauderdale, Lowndes, Monroe, and Noxubee

Cumberlandian Combshell, Oyster Mussel, Slabside Pearlymussel and Snuffbox mussel

The endangered Cumberlandian combshell mussel *(Epioblasma brevidens)*, oyster mussel (*Epioblasma capsaeformis*), slabside pearly mussel *(Lexingonia dolabelloides),* and snuffbox mussel *(Epioblasma triquetra)* are found in the Bear Creek watershed. Work activities that alter flow, channel geometry or increase sedimentation and water turbidity could have adverse impacts on these species. All of Bear Creek in Tishomingo County is designated as critical habitat for the cumberlandian combshell, oyster mussel, and slabside pearlymussel.

County: Tishomingo

Fat Pocketbook *(Potamilus capax)*

The endangered fat pocketbook mussel *(Potamilus capax)* is found in the Mississippi River and associated tributaries. It is a broad, rounded, and slightly angular mussel with a smooth, yellowish exterior color that is frequently clouded with brown. Fat pocketbooks occur primarily in sand and mud substrates, although the species has been found in fine gravel and hard clay occasionally. Water depth ranges from a few inches to several feet. The fish host for this species

is freshwater drum. Fat pocketbook mussels may be affected by dredging or channel clearing activities, excessive sedimentation, channel erosion, and pollutants.

Counties: Adams, Bolivar, Claiborne, Coahoma, DeSoto, Issaquena, Jefferson, Tunica, Warren, Washington, and Wilkinson

Inflated Heelsplitter *(Potamilus inflatus)*

The threatened inflated heelsplitter mussel *(Potamilus inflatus)* is found in the lower Pearl River and Tombigbee watersheds. It inhabits areas with moderate to swift currents, and prefers riffle or shoal areas with stable bottoms composed of sandy gravel or firm mud gravel and cobble. Work activities that increase sedimentation and water turbidity, or alter channel geometry or flow could have adverse impacts on this species.

Counties: Clay, Hancock, Itawamba, Lowndes, Monroe, Noxubee, and Pearl River

Rabbitsfoot (*Quadrula cylindrica cylindrica*)

The rabbitsfoot mussel (*Quadrula cylindrica cylindrica*), a threatened species, is a historical resident of the Bear Creek, Big Sunflower River and Big Black River watersheds. Population declines can be attributed to channel erosion, water-quality degradation, loss of stable substrates, sedimentation, channelization, gravel mining, dredging, impoundments, and competition of exotic mussel species. Critical habitat has been designated for the Big Black River in Hinds and Warren Counties (from Porter Creek to Highway 27), the Big Sunflower River in Sunflower County (from Highway 442 to the Quiver River), and Bear Creek in Tishomingo County (from state line to state line).

Counties: Bolivar, Claiborne, Hinds, Humphreys, Madison, Sharkey, Sunflower, Tishomingo, Warren, Washington, and Yazoo

Sheepnose (*Plethobasus cyphyus*)

The endangered sheepnose mussel (*Plethobasus cyphyus*) is a larger stream species occurring primarily in shallow shoal habitats with moderate to swift currents over coarse sand and gravel. A population of sheepnose survives in the Big Sunflower River, which may be limited to a 12 to 15-mile reach upstream of Indianola in Sunflower County. Although no juvenile mussels have been found in recent sampling efforts, variably sized individuals indicate some, possibly very low, level of recruitment in the population (Jones 2008, pers. comm.). The species is believed to be extirpated from the Hatchie and Big Black Rivers.

Counties: Bolivar, Humphreys, Sharkey, Sunflower, and Washington

INSECTS

Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*)

The endangered Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) is a medium sized butterfly with an overall rich brown color. A distinctive series of orange-ringed black circular eyespots with silvery centers are located on the lower surfaces of both pairs of wings. It occurs in wetlands where low nutrient systems receive carbonate-rich ground water from seeps and springs. In Mississippi, Mitchell's satyr has been found in small upland wetlands created by beaver dams and in wetlands formed by road culverts. The greatest threat to the Mitchell's satyr is habitat destruction caused by beaver control, draining and filling of wetlands, invasion from exotic weeds, and contamination of wetlands by pesticides, fertilizer, and nutrient runoff from adjacent agriculture.

Counties: Alcorn, Itawamba, Monroe, Prentiss, and Tishomingo

PLANTS

Louisiana Quillwort (*Isoetes louisianensis*)

The endangered Louisiana quillwort (*Isoetes louisianensis*) is a small, nonflowering grass-like semi-aquatic to aquatic plant. Mature plants are six to ten inches long, mostly evergreen, with spore-bearing structures below ground. Surveys need to be conducted during the appropriate field season when the plants are visible, typically November into May. Timing varies depending upon rainfall, as plants completely die back and are not visible when the intermittent streams, which are habitat for this species, have dried-up. As such, it is recommended that known sites be visited prior to initiating surveys to determine if plants will likely be visible. Threats include activities that increase stream sedimentation, reduce stream flow, and reduce the overstory canopy cover.

Counties: Forrest, George, Greene, Hancock, Harrison, Jackson, Jones, Lamar, Pearl River, Perry, Stone, and Wayne

Pondberry (*Lindera melissifolia*)

The endangered pondberry (*Lindera melissifolia*) is a member of the laurel family (Lauraceae) and is a deciduous aromatic shrub that averages two to six feet tall. It occurs in seasonally flooded wetlands, sandy sinks, pond margins, and swampy depressions. It is best to conduct surveys for this species during the flowering season, when the species is highly visible (February to March); however surveys are still possible later in the season following leaf-out and into the fruiting season (late summer-fall). Fruits turn bright red as they mature in the late fall before being dropped in the early winter (December). Since pondberry is a deciduous shrub, it is recommended that a nearby known site be visited prior to initiating any surveys, to confirm adequate visibility of the species for a determination of its presence or absence at a project site. Threats included habitat destruction, population fragmentation, altered hydrologic regimes, competition from encroaching vegetation, and disturbance by wild hogs and domestic cattle.

Counties: Bolivar, Carroll, Coahoma, DeSoto, Grenada, Holmes, Humphreys, Issaquena, Leflore, Panola, Quitman, Sharkey, Sunflower, Tallahatchie, Tunica, Warren, Washington, and Yazoo

Price's Potato Bean (*Apios priceana*)

The threatened Price's potato bean (*Apios priceana*) is a perennial, herbaceous, twining vine in the pea family (Fabaceae [=Leguminosae]). It is found on slopes or bluffs with open woods that often grade into creek and river bottoms. The species may also be found along forested margins of power-line and road rights-of-ways. These areas are typically underlain by alkaline soils and calcareous parent rock. Surveys should be conducted when the species is in flower or fruit, typically mid-June into October. Price's potato bean is readily confused with its more common relative groundnut (*Apios americana*) and surveys should be conducted by individuals familiar with both species. Threats include excessive shading from forest canopy closure, incompatible right-of-way maintenance (e.g., indiscriminate herbicide spraying), and competition from non-native, invasive plants.

Counties: Alcorn, Calhoun, Chickasaw, Clay, Kemper, Lee, Lowndes, Monroe, Noxubee, Oktibbeha, Pontotoc, Prentiss, Tippah, Union, Webster, and Winston

White Fringeless Orchid (*Platanthera integrilabia*)

The threatened white fringeless orchid (*Platanthera integrilabia*) is a perennial herbaceous plant with a light green stem (growing to over 2 feet tall) arising from a tuber. Leaves decrease in size from the base to the top of the stem, have alternate arrangement, are narrowly elliptic to lanceolate in shape, and have entire margins. Flowers are white and borne in a loose cluster at

the end of the stem. The flower's lower petal (the lip) does not have a conspicuous fringe along the margin, but may be slightly toothed. A prominent green to white spur (growing to nearly 2.5 inches) protrudes from the underside of each flower. Flowering occurs from July to September and fruiting capsules mature in October. The species can be found in forested wetlands, wet, boggy areas at the heads of streams and on seepage slopes that are partially shaded. Plants are often associated with *Sphagnum* (peat) moss and other orchids. Surveys should be conducted when plants are in bloom, as the species is difficult to distinguish from more common *Platanthera* species without flowers. Threats include habitat destruction and modification from development, incompatible forestry practices, alteration of hydrologic regimes, incompatible right-of-way maintenance, invasive species competition, and disturbance by feral hogs. Other threats include herbivory by deer and feral hogs as well as over-collection.

Counties: Alcorn, Itawamba, Lowndes, Monroe, Prentiss, and Tishomingo

Whorled Sunflower (*Helianthus verticillatus*)

The endangered whorled sunflower (*Helianthus verticillatus*), a member of the aster family (Asteraceae [=Compositae]), is a tall (growing to over 15 feet tall), rhizomatous, perennial herbaceous plant. The firm, linear to lanceolate leaves have a prominent mid-vein, lack prominent lateral veins, are short-petioled to nearly sessile, and can grow to over 7 inches long. Leaf arrangement is opposite on the lower stem, whorled (verticillate) in groups of 3 or 4 (to 6) along the mid-stem, and alternate or opposite near the top. The stem is smooth, waxy (glaucus), and has a bluish tint during the growing season. Flowering occurs from mid- to late August into October. Flowers are arranged in branched inflorescences (cymes) of 3 to 7 heads. Heads consist of deep yellow ray flowers and lighter yellow disk flowers. The species can be confused with its more common close relatives, *H. angustifolius* (narrowleaf sunflower), *H. giganteus* (giant sunflower), and *H. grosseserratus* (sawtooth sunflower). Plants are found on moist soils in open, grassy areas (such as wet prairies, road and utility rights-of-way, and along margins of agricultural fields) with little to no overstory canopy and are often associated with floodplains of small streams. Threats include indiscriminate herbicide application, incompatible mowing regimes, habitat destruction, and encroachment of woody vegetation.

Counties: Alcorn, Benton, Marshall, Tishomingo

Puerto Rico and U.S. Virgin Islands

Federally Listed Threatened and Endangered Species

Birds

Yellow-shouldered Blackbird (*Agelaius xanthomus)*

The yellow-shouldered blackbird (*Agelaius xanthomus*), also known as "la mariquita de Puerto Rico", is a diurnal blackbird endemic to Puerto Rico. It was listed as endangered in November 19, 1976 (USFWS 1976). The species was once common in the coastal forests, but during the early 20th century, the majority of Puerto Rico's coastal forests were destroyed for the establishment of sugar cane plantations. Following the demise of the sugar industry, most of these former plantations were subsequently developed for housing or converted into livestock pastures. Currently, the yellow-shouldered blackbird is mainly limited to four areas: Mona Island, Monito Island, and three populations in the eastern, southern and southwestern regions of Puerto Rico (Liu 2015, USFWS 2018). The yellow-shouldered blackbird breeding season commonly spans from April to August, but breeding activity has been observed from February to November. The beginning of the species' breeding season coincides with the onset of the rainy season, which explains the fluctuation in the start and end of the breeding season. These populations can nest in mangroves associated with mud flats and salt flats, offshore red mangrove (*Rhizophora mangle*) cays, coastal black mangrove (*Avicennia germinans*) forests, upland lowland dry coastal pastures, suburban areas (including buildings), coconut (*Cocos nucifera*) plantations, and coastal cliffs (Lewis et al. 1999). The total numbers of yellow-shouldered blackbird have shown a slight increase over the past 25 years; however, the size of individual disjunct populations continues to remain relatively low (USFWS 2018). Recent surveys estimated population numbers near 1,000 in the southwestern region of Puerto Rico, 80 individuals in the southern region of Puerto Rico, 150 individuals in the Mona Island, and 10 individuals in the eastern region of Puerto Rico (USFWS 2018).

The primary threats to the species are habitat loss and degradation due to development and human recreational activities, predation by other species (e.g., rats, feral cats, raptors), and nest parasitism by the invasive shiny cowbird (*Molothrus bonariensis*) (USFWS 2018). However, the yellow-shouldered blackbird will be vulnerable to impacts from the increases in the rate of sea level rise and storm activity that are expected to occur over the coming decades (Paris et al. 2012). The climatic influences such as storms and floods may force the birds to renest, which prolongs the nesting season and results in substantial yearly variation in reproductive success and affect the vegetation surrounding the nesting sites, especially black mangrove (*Avicennia germinans*), exposing the fledglings and adults to greater predation and possible decrease in food sources (USFWS 2018). Moreover, sea level rise may affect the availability of suitable nesting sites in the off shore cays composed of red mangrove (*Rhizophora mangle*) and cause a substantial reduction in reproductive success.

Counties / Municipalities: Cabo Rojo, Lajas, Ceiba, Guayama, Salinas, Mona Island, San German.

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Piping Plover (*Charadrius melodus)*

The piping plover is a small light, grayish, sand-like color bird, with a length of approximately 6 to 7.5 inches. Piping plovers are swift runners, and have the peculiar habit of running for short distances and stopping abruptly. When it remains still, the piping plover easily blends in with the pale sandy background. It is an incidental winter visitor to the Puerto Rico and the U.S. Virgin Islands, although it has been observed in the southwestern coast of the island (e.g., Cabo Rojo Salt Flats), the San Juan's Caño Martín Peña, the Jobos Bay in Guayama and in San Jacinto, in Guayanilla (USFWS 2019).

Suitable plover habitat located on coastal beaches, islands or spits may be affected by sea level rise and increased stormy conditions (Paris et al. 2012). These dynamic geomorphic features can experience major changes in ecology because of severe storms. Sea level rise and flooding may inundate coastal salt and mud flats habitat used by the piping plover in Puerto Rico and the Virgin Islands affecting suitability of habitat for plovers. In addition, wintering habitat for this species may also be adversely affected by shoreline hardening, if implemented as a measure to mitigate for increased erosion. These measures could potentially disrupt island sediment movement.

Counties / Municipalities: Coastal counties in Puerto Rico and USVI, including Cabo Rojo, San Juan, Guayama, Guayanilla

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Puerto Rican nightjar (*Caprimulgus noctitherus*)

The Puerto Rican nightjar, *Caprimulgus noctitherus*, is a robin-sized (24 cm) nocturnal bird with long bristles about the bill. Its fluffy plumage is mottled with dark brown, black, and gray; and there is a white band across the throat and white spots at the end of the tail feathers (Kepler and Kepler 1973). The Puerto Rican nightjar is distributed through three main regions of coastal dry and lower cordillera forests of southwestern Puerto Rico. These included; Guánica-Ensenada, Susúa-Maricao, and Guayanilla-Peñuelas (USFWS 2018). In addition, there are nightjar records reported for the Parguera Hills and Sierra Bermeja, located in the southwestern tip of Puerto Rico (Vilella and Zwank 1993). Large areas of continuous closed-canopy, semi-deciduous and evergreen forests in coastal zones characterize the nightjar habitat. Outside the southwestern region of Puerto Rico, nightjar habitat is characterized by small fragments of forest distributed across the southern coast of the island (González 2010). Conservation of the nightjar greatly depends on the continued protection of the coastal dry and lower cordillera forests of Guánica and Susúa Commonwealth Forests. These forests, managed by the Puerto Rico Department of the Natural and Environmental Resources (DNER), encompass some of the best nightjar habitat remaining as well as unique floristic associations. The primary threats to the species are habitat loss and degradation due to development and human recreational activities and predation by other species (e.g., rats, feral cats, raptors) (USFWS 2018).

Forested habitats in coastal areas inhabited by the Puerto Rican nightjar may be vulnerable to impacts from the increases in the rate of sea level rise and storm activity that are expected to occur over the coming decades. The climatic influences such as storms and floods may force the birds to renest, which prolongs the nesting season and results in substantial yearly variation in reproductive success and affect the vegetation surrounding the nesting sites. Moreover, sea level rise increases may affect the availability of suitable nesting sites for the species.

Counties/ Municipalities: Lajas, Guanica, Guayanilla, Peñuelas, Ponce, Yauco

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Roseate tern (*Sterna dougallii dougallii*)

The roseate tern is a medium-sized, black-capped sea tern about 15 inches long (38 cm) and weighs about 4 ounces (Gochfeld et al. 1998). Its plumage superficially resembles that of the common tern (*Sterna hirundo*), among which, it invariably nests in the Northeast. On November 2, 1987, the Service determined the population that nests in the Northeast to be endangered, and the population that nests in the Caribbean to be threatened (USFWS 1987). The roseate tern is a common breeding resident in the Virgin Islands, and in Puerto Rico. In Puerto Rico, it nests in low lying offshore cays, which are vulnerable to sea level rise. Nesting occurs primarily from April to September, but can be seen rarely in other months (Raffaele et al. 1989). Breeding populations of the roseate tern are susceptible to stochastic events, including erosion of nesting habitat, storms, over-washing of nests, and prey food shortages that can be caused by climate change and sea level rise (USFWS 2010).

Counties / Municipalities: Virgin Island, Lajas, Culebra Island.

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Red knot (*Calidris canutus rufa*)

The rufa red knot is a migratory shorebird that breeds in the Canadian Arctic, winters in parts of the United States, the Caribbean, and South America, and primarily uses well known spring and fall stopover areas on the Atlantic coast of the United States, although some follow a mid-

continental migratory route (USFWS 2012). The species is generally rare in Puerto Rico and the Virgin Islands during its southbound migration. It occurs even less frequently while migrating northward. The species is threatened by habitat destruction due to beach erosion and various shoreline protection and stabilization projects that are affecting areas used by migrating knots for foraging, the inadequacy of existing regulatory mechanisms, human disturbance, and competition with other species for limited food resources that can be exacerbated by sea level rise and storms (USFWS 2014).

Counties: Coastal counties in Puerto Rico and USVI

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Reptiles

Mona boa (*Epicrates monensis monensis)* also known as *Chilabothrus monensis monensis*

The Mona boa is a nonvenomous snake that grows to about 3 feet in length. When mature, its ground color is light brown dorsally, with 44 dark brown markings; and its underside is beige with a few scattered spots. The dorsal pattern of the body consists of two rows of spots that extend to the end of the tail, with spots varying in number from 51 to 57. The Mona boa was listed as threatened in February 3, 1978 due to threats of habitat modification and the effects of feral mammals on populations of this species (USFWS 1978). This reptile is restricted to the island of Mona; an isolated island located in the Mona Passage, about 42.3 miles west of Puerto Rico, and 37.3 miles east of Hispaniola (Frank and Benson 1998). The bulk of the island forms a flat-topped, raised platform that dips gently to the south to form a 9 to 19 feet high coastal, mostly sandy flat (Frank et al. 1998). The Mona boa has been observed at three major sites in the xeric plateau above Playa Sardinera, Playa Uvero and Playa Pájaros (USFWS 2014). Current population numbers for the Mona boa are unknown.

Storms events may affect the Mona boa habitat by modifying the vegetation structure, which provide foraging resources to the species, and this habitat modification may increase vulnerability of adults to terrestrial predators (USFWS 2014). In addition, increases in sea level could eliminate the coastal scrub/shrub forest and limit suitable habitat to the island plateau.

Counties: Mona Island

Literature Cited

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Mona ground iguana (*Cyclura stejnegeri)*

Mona ground iguana is the largest Puerto Rican lizard and it was listed as threatened in February 3, 1978 (USFWS 1978). It measures 3 to 4 feet total length, has a heavy body, a large head, and a stout, laterally compressed tail. The lizard has a large jowl under the angle of the jaw, a large median dewlap that is joined posteriorly by a transverse fold, and a small horn on the snout just in front of the eyes. A dorsal crest is present, extending from head to tail. The general color is olive to olive gray, sometimes with brown and/or blue lines (USFWS 2015). The Mona ground iguana is restricted to the island of Mona; an isolated island located in the Mona Passage, about 42.3 miles west of Puerto Rico, and 37.3 miles east of Hispaniola. The bulk of the island forms a flat-topped, raised platform that dips gently to the south to form 9.8 to 19.7 feet high coastal, mostly sandy flat. The Mona iguanas are most common along major escarpments and cliffside talus slopes and less common on the southwestern coastal plain, except during the summer nesting season (USFWS 2015).

The breeding season begins in mid-June, when all mating occurs, and ends by November, when eggs hatch. After mating, females migrate to nesting grounds on the plateau or the southwestern coastal plain, where most of the favorable nesting sites occur (USFWS 2015). The majority of the nests occurs in the coastal area including Sardinera, Punta Arenas, and the coastal plain. Since the most important nesting area for the Mona iguana lies within the limited sandy coastal plains of Mona Island, the species may be threatened by climate change related sea-level rise. The nesting sites associated with the coastal scrub/shrub forest would be susceptible to flooding and this could affect nesting habitat suitability (USFWS 2015). Hurricanes and tropical storms also may affect nesting habitat suitability by modifying the structure of the habitat and by flooding available nests and thus, reducing reproductive output and restricting nesting areas to the island plateau.

Counties: Mona Island

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Puerto Rican boa (*Epicrates inornatus)* also known as *Chilabothrus inornatus*

The Puerto Rican boa is the largest endemic snake inhabiting the Puerto Rico Island. The species color is somewhat variable but usually ranges from pale to dark brown, sometimes grayish, with 70 to 80 darker colored blotches along the back from neck to vent. These dorsal blotches are generally dark-bordered with the centers of a lighter hue. Maximum size is approximately 6 and half feet. Observations of captive specimens suggest that under natural conditions the diet of sub-adults and adults consists of birds, small mammals, and lizards. The species has been documented to be widely distributed across the island of Puerto Rico; however, its abundance is not uniform across the island. It is more often found in the northern limestone karst region, known from both protected areas and private lands (USFWS 2011). Although habitat destruction and modification is a threat to the Puerto Rican boa, the species appears to be widely distributed and utilizes a wide variety of habitats, ranging from mature forest to plantations and disturbed areas (Wiley 2003, USFWS 2011). The species has also been reported to be very common along streams on tree branches. The species is currently threatened by habitat destruction and modification, competition with introduced species, and predation by invasive vertebrates, and other natural or manmade factors such as malicious killings, road constructions, and road mortalities. Storm events may affect the vegetation structure used by the Puerto Rican boa for foraging and may increase its vulnerability to terrestrial predators. In addition, sea level rise increases may affect the availability of suitable habitats in coastal municipalities of Puerto Rico.

Counties: All counties of Puerto Rico.

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Wiley, J.W. 2003. Habitat association, size, stomach contents and reproductive conditions of Puerto Rican boas (*Epicrates inornatus*) in a hurricane impacted forest. Caribbean Journal of Science 39(2): 189-194.

Virgin Islands tree boa (*Epicrates monensis granti*) also known as *Chilabothrus monensis*

The Virgin Island tree boa is a medium-length, slender and nonvenomous snake endemic to Puerto Rico and the Virgin Islands, that has been listed as endangered since 1970 due to its restricted and fragmented distribution, predation by invasive mammals, and habitat disturbance (USFWS 1970). There are seven populations known between Puerto Rico and the Virgin Islands. Five are wild populations (Rio Grande, Culebra Island, and Cayo Diablo in Puerto Rico, St. Thomas, USVI, and Tortola, British VI) and two are the product of a successful captive breeding, rat eradication and introduction efforts in Cayo Ratones (PR), and USVI Cay (Tolson et al. 2008). The Service estimated between 1,300-1,500 VI boas occur in PR and USVI (USFWS 2009), although some of the population sizes used for this estimate are considered somewhat speculative (USFWS 2018). The other known wild population occurs in Tortola, British Virgin Islands, but there is no data on the status of that population. Several other islands and cays have been searched, but the species has not been found and rats have overrun these areas (Tolson 1991). Threats to the Virgin Island boa mainly include habitat loss and fragmentation from human development, predation mainly from feral cats (*Felis catus*) and rats (*Rattus rattus*), and climate change, particularly increasing sea levels and frequency of major hurricanes (USFWS 2009). Increase in sea level may affect the species and its habitat in coastal areas and offshore islets. An estimate of 65% of the known population occurs on offshore islets (less than 2 acres) with a maximum elevation of 50 feet susceptible to sea level rise.

Counties / Municipalities: Humacao, Fajardo, Luquillo, Rio Grande, Culebra, St. Croix, St. John, St. Thomas.

Literature Cited

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St. Croix ground lizard (*Ameiva polops*)

The St. Croix ground lizard is a small species of Ameiva measuring 1 to 3 inches in snout-vent length. It has parallel longitudinal black, white, and light-brown stripes. The belly is light gray with lateral blue margins, and pinkish undersides of legs, throat, and chest. The tail also has alternating rings of blue and black. The species was listed as endangered in 1977 due to predation by the introduced mongoose and habitat modification (USFWS 1977). In addition, critical habitat was designated that same year at Protestant Cay, and Green Cay National Wildlife Refuge in St Croix, U.S. Virgin Islands. The St. Croix ground lizard currently occupies four offshore islands/cays in St. Croix; including one native population at Protestant Cay; an introduced population on Ruth Cay from individuals translocated from Protestant Cay; a second native population on Green Cay; and an introduced population on Buck Island Reef National Monument from individuals translocated from Green Cay. Population estimates for each island are between 100-300 individuals on Protestant Cay, 200-350 on Ruth Cay, 100-300 on Green Cay, and more than 1,000 individuals in Buck Island (USFWS, 2018). The St. Croix ground lizard is currently threatened by habitat destruction and modification, predation, and other natural or manmade factors (USFWS, 2018). Since the species was listed, the St. Croix ground lizard habitat on Protestant Cay has continually been modified by hotel landscape management practices (e.g., raking and removal of leaf litter, removal of undergrowth and woody vegetation, and planting of exotic vegetation). Habitat degradation has also been identified in Green Cay due to the presence of invasive vegetation and rats. Predation by rats also has been a concern on Protestant, Ruth, and Green cays. The species distribution is limited to offshore cays with low elevations. Effects of hurricanes and sea level rise are identified as threats to all coastal areas where the species occurs and the low-lying Protestant, Ruth and Green cays (USFWS 2019). The lowest lying cays (Ruth, Green and Protestant) were severely impacted by storm surge from hurricanes Irma and Maria; impacts to species populations are unknown. Projected sea level rise may reduce the available habitat for the species. In addition, these low-lying cays are vulnerable to storm surges caused for example by the recent hurricanes Irma and Maria. Ruth Cay is believed to have been completely inundated due to the effects of these hurricanes and the post-hurricane status of the Ruth Cay SCGL population is unknown (USFWS, 2019).

Counties: St. Croix

Literature Cited

U.S. Fish and Wildlife Service (USFWS). 1977. Final Determination of Endangered Status and Critical Habitat for St. Croix Ground Lizard; 42 FR 28543 28545 (*Ameiva polops*). US Fish and Wildlife Service, Washington, DC. 3 pp.

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Sea turtles

In Puerto Rico, sea turtle nesting is primarily composed of the green sea turtle (*Chelonia mydas*), the hawksbill sea turtle (*Eretmochelys imbricata*) and the leatherback sea turtle (*Dermochelys coriacea*). The loggerhead sea turtle (*Caretta caretta*) has been reported in the Caribbean; however, there are no known nesting sites in Puerto Rico, or in the US Virgin Islands. In fact, the only sightings of the loggerhead sea turtle in Puerto Rico have been limited to the waters northeast and southeast of the Island (USFWS, 2007). In the U.S. Caribbean, all coastal counties with mixed sand gravel, coarse-grained sand and fined medium grain sand beaches are potential nesting habitat for sea turtles (NOAA 2000). However, only some beaches with high nesting activity are monitored during the nesting season.

The green sea turtle (*Chelonia mydas*) grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. Color is variable. Hatchlings generally have a black carapace, white plastron, and white margins on the shell and limbs. The adult carapace is smooth, keelless, and light to dark brown with dark mottling; the plastron is whitish to light yellow. Adult heads are light brown with yellow markings. Identifying characteristics include four pairs of costal scutes, none of which borders the nuchal scute, and only one pair of prefrontal scales between the eyes (USFWS, 2007). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae. The nesting season varies with the locality. In the Puerto Rico and the Virgin Islands, it is roughly August through November (DRNA 2018). Nesting occurs nocturnally at 2, 3, or 4-year intervals. Only occasionally do females produce clutches in successive years. A female may lay as many as nine clutches within a nesting season (overall average is about 3.3 nests per season) at about 13-day intervals. Clutch size varies from 75 to 200 eggs, with an average clutch size of 136 eggs reported. Incubation ranges from about 45 to 75 days, depending on incubation temperatures. Hatchlings generally emerge at night. Age at sexual maturity is believed to be 20 to 50 years (USFWS 2007). The Vieques Island is the most important nesting area for green turtles in Puerto Rico, since every year more than 100 nests are counted. In addition, nesting activity has been reported in Humacao, Maunabo, and Mona Island (DRNA 2018).

The hawksbill sea turtle (*Eretmochelys imbricata*) is a small to medium-sized marine turtle having an elongated oval shell with overlapping scutes on the carapace, a relatively small head with a distinctive hawk-like beak, and flippers with two claws. General coloration is brown with numerous splashes of yellow, orange, or reddish-brown on the carapace. The plastron is yellowish with black spots on the intergular and post anal scutes (USFWS 2013). Juveniles are black or very dark brown with light brown or yellow coloration on the edge of the shell, limbs,

and raised ridges of the carapace. As an adult, the hawksbill may reach up to 3 feet in length and weigh up to 300 pounds, although adults more commonly average about 2 and a half feet in length and typically weigh around 176 pounds or less. It is the only sea turtle with a combination of two pairs of prefrontal scales on the head and four pairs of costal scutes on the carapace. The hawksbill feeds primarily on sponges and is most often associated with the coral reef community. The nesting season varies with locality, but in most locations, nesting occurs sometime between April and November. Hawksbills nest at night and, on average, about 4.5 times per season at intervals of approximately 14 days. In the U.S. Caribbean, clutch size is approximately 140 eggs, although several records exist of over 200 eggs per nest. Remigration intervals of 2 to 3 years predominate. The incubation period averages 60 days. Age at sexual maturity has been estimated as 20 or more years in the Caribbean (USFWS 2013). The beaches with high nesting activity are located in the municipalities of Mayaguez, Añasco, Rincón, Aguada, Isabela, Yabucoa, Maunabo, Patillas, Fajardo, Luquillo, Arecibo, Barceloneta, Dorado, and the islands of Culebra, Vieques, Caja de Muertos and Mona (DRNA 2018).

The leatherback sea turtle (*Dermochelys coriacea*) is the largest, deepest diving, and most migratory and wide ranging of all sea turtles. The adult leatherback can reach 4 to 8 feet in length and 500 to 2000 pounds in weight. Its shell is composed of a mosaic of small bones covered by firm, rubbery skin with seven longitudinal ridges or keels. The skin is predominantly black with varying degrees of pale spotting; including a notable pink spot on the dorsal surface of the head in adults. A tooth like cusp is located on each side of the gray upper jaw; the lower jaw is hooked anteriorly. The paddle-like clawless limbs are black with white margins and pale spotting (USFWS 2013). Hatchlings are predominantly black with white flipper margins and keels on the carapace. Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. In the Caribbean, nesting occurs from about March to July. Female leatherbacks nest an average of 5 to 7 times within a nesting season, with an observed maximum of 11 nests. The average nesting interval time is about 9 to 10 days. The nests are constructed at night in clutches with an average of 80 to 85 eggs. The white spherical eggs are approximately 2 inches in diameter. Typically, incubation takes from 55 to 75 days, and emergence of the hatchlings occurs at night. Most leatherbacks remigrate to their nesting beaches at 2 to 3-year intervals. Leatherbacks are believed to reach sexual maturity in about 16 years (USFWS 2013). The beaches with high nesting activity are located in the municipalities of Luquillo, Fajardo, Maunabo, Culebra, Vieques, Yabucoa, Añasco, Isabela, Dorado, Patillas, Humacao, Mayaguez, Arecibo, Barceloneta and San Juan (DRNA 2018), and Sandy Point in St. Croix.

Sea level rise is a potential threat to sea turtle species, particularly for areas with low-lying beaches, where the sea may inundate nesting sites and decrease available nesting habitat. The loss of habitat can also be accelerated due to a combination of other environmental and oceanographic changes such as increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion and flooding (USFWS 2007).

Counties: All coastal counties with mixed sand gravel, coarse grained sand and fined medium grain sand beaches.

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Amphibians

Llanero Coqui (*Eleutherodactylus juanariveroi*)

The coqui llanero is a small frog endemic to Puerto Rico. In 2007, it was described as a new species of the genus *Eleutherodactylus*, family Leptodactylidae. Males measure approximately 0.58 inches, and females 0.62 inches. It has the smallest clutch size of all *Eleutherodactylus* species on the Island, and a high frequency call. Surveys indicate a mean population density of 473.3 individuals per acre. In October 4, 2012, the coqui llanero was federally listed as an endangered species with a designation of 615 acre (249 ha) of critical habitat in the municipality of Toa Baja, Puerto Rico (USFWS 2012). The coqui llanero is currently known to be restricted to one freshwater herbaceous wetland in the municipality of Toa Baja. The herbaceous vegetation in the wetland consists of *Blechnum serrulatum* (toothed midsorus fem), *Thelypteris interrupta* (willdenow's maiden fem), *Sagittaria lancifolia* (bulltongue arrowhead), *Cyperus sp.* (flatsedges), *Eleocharis sp.* (spike rushes), and vines and grasses (Rios-Lopez and Thomas 2007). The species is currently threatened by the combined influences of urban development,

activities associated with the operation and future closure of the Toa Baja municipal landfill, water channel clearing activities for flood control, and invasive wetland plant species. In addition, other threats include restricted distribution and highly specialized ecological requirements of the species; which may exacerbate other potential threats like landfill leachate pollution, the use of herbicides, brush fires, competition, and environmental effects resulting from climate change (USFWS 2019).

According to Davila (2013), sea level rise is a major threat to this species based on results from a Sea Level Affecting Marshes Model. The model suggested the gradual but inevitable demise by 2100 of the only known occupied habitat for the coquí llanero. Since there is limited suitable habitat for this species within Puerto Rico, this threat could risk the entire species existence. Sea level rise would impart more pressure towards the species and in its habitat since the possible sea (salt) water intrusion would consequently change the physical and ecological characteristics of the freshwater wetland, changing the vegetation and affecting the reproduction since this species is dependent on a specific freshwater plant. Since the known occupied habitat of the coquí llanero is only about 50 feet in elevation, the possible predicted sea level rise may have detrimental effects on the species. Moreover, potential suitable habitats identified within Puerto Rico by Davila (2013) are near coastal areas that may suffer from the same salt-water intrusion, affecting the possible suitable habitats available for the species.

Counties: Toa Baja

Literature Cited

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Puerto Rican crested toad (*Peltophryne lemur*)

The Puerto Rican crested toad (PRCT), commonly known in Spanish as “sapo concho puertorriqueño” is the only native bufonid of Puerto Rico and Virgin Islands. The species was listed as threatened in August 4, 1987 (USFWS 1987). The Puerto Rican crested toad is a medium-sized toad, 2.5 to 4.5 inches in snout — vent length, yellowish-olive to blackish —

brown in color, with prominent supraorbital crests and a distinctive long, upturned snout. Males are considerably smaller than females, and exhibit less prominent crests. Sexual dichromatism (males being more yellow than females) exists and is most apparent immediately prior to and during reproduction. The PRCT has been described as a rare species throughout its entire range because the low number of collections. The PRCT known populations are within the northern karst region the southern karst region of Puerto Rico through the municipalities of Arecibo, Ciales, Coamo, Florida, Guánica, Guayanilla, Manati, Peñuelas, Santa Isabel and Yauco (USFWS, 2016). The species emerges to breed after heavy rains concentrated in a very short period. When rainfall and surface water are adequate, breeding events occurs in ponds resulting in water accumulation of no less than 2 inches if the soil is saturated.

The PRCT is currently threatened by destruction and modification of its habitat, disease, predation, and other natural and human factors, such as sea level rise (USFWS 2016). The natural breeding populations located at Guayanilla and Guanica are extremely vulnerable to storm surges cause by hurricanes and to saltwater intrusion by sea level rise due to its proximity to the sea. Increase in sea level may affect the species and the habitat on which the species depend for reproduction at these two sites (citation). The two breeding ponds are located on coastal areas with a maximum elevation of less than 3 feet, and are less than 328 feet from the sea. Breeding ponds, hence populations, could easily be lost if the narrow sandy beach barrier is destroyed by storm surge and pools are flooded with sea water during severe hurricanes and tropical storms, which also usually set the conditions that triggers breeding events.

Counties / Municipalities: Arecibo, Ciales, Coamo, Florida, Guanica, Guayanilla, Manati, Peñuelas, Santa Isabel, Yauco

Literature Cited

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Guajon (*Eleutherodactylus cooki*)

The guajón (*Eleutherodactylus cooki*) is a petricolous (i.e., inhabiting rocks) frog species endemic to the southeastern part of Puerto Rico. This species is one of sixteen species of the genus *Eleutherodactylus*, commonly known as “coquíes” that inhabit the island. The guajón has a solid brown coloration in the dorsal area, white-rimmed eyes, and large, truncate disks (i.e., partially cut) on its feet (Rivero 1998). The species exhibits sexual dimorphism (separate female and male morphs) regarding size, vocalization, and coloration (Burrowes 2000 and 1997). Females are larger than males; the mean size (snout-vent length) for females is 2.01 inches and 1.71 inches for males. The ventral coloration of females is uniformly white, while males are

yellow extending from the vocal sac to the abdomen and flanks. Males call for mates by producing 3-7 similar notes (Drewry and Rand 1983). Females produce only a short, acute call when distressed (Burrowes 2000). Juveniles are brown in color with a dorsal pattern of dark brown inverted parentheses.

The coqui guajón was listed as threatened in 1997 mostly due to modification and destruction of its limited specialized habitat. A total of 17 critical habitat units were designated in 2007 for this species (citation). The guajón occurs at low and intermediate elevations from 18 to 1,183 feet above sea level where they inhabit caves formed by large boulders of granite rock known as “guajonales” or streams with patches of rocks without cave systems. The species is considered a habitat specialist since populations only occur within "guajonales" and/or streams with patches of rocks (USFWS 2004). The unique hydrological and geological combination of these habitats is considered one of the most important attributes for a coqui guajón population occurrence and persistence. The species also is known to occur within somewhat disturbed and modified habitats such as adjacent to rural roads, culverts and aqueduct pump stations (USFWS 2017). The coqui guajon's range is limited to only seven municipalities in southeast Puerto Rico (USFWS 2004) and mostly within private lands (USFWS 2017).

Since the species is dependent on “guajonales” associated to streams and culverts, sea level rise and storms may affect the species and the habitat on which the species depend. Major storms and hurricanes may put the habitat and populations of the guajón at risk through flash flooding, erosion and sedimentation.

Counties / Municipalites: Maunabo, San Lorenzo, Yabucoa, Patillas, Humacao, Las Piedras.

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Insects

Puerto Rico harlequin butterfly (*Atlantea tulita*)

The Puerto Rico harlequin butterfly (PRHB) is endemic to the island of Puerto Rico and is one of the four species endemic to the Greater Antillean genus *Atlantea*. The PRHB is a candidate under the Endangered Species Act. The harlequin butterfly has a wing span of about 2-2.5 inches wide. Both female and male harlequin butterflies are similar in color patterns and size. This butterfly is brownish black at the dorsal area with deep orange markings and confused black markings at the half basal anterior wing. The posterior wing has a wide black border enclosing a set of reddish bronze sub-marginal points. The ventral side of the anterior wing is similar to the dorsal anterior wing, and the posterior is black with orange basal spots and a complete postdiscal beige band with a band of reddish spots distally and sub marginal white half-moons. The costa, the anterior (leading) edge of a wing, in males is gray and wide. Females are multivoltine ovipositors (produce several broods in a single season) (Carrion-Cabrera 2003). The harlequin butterfly has only been observed utilizing the prickly bush (*Oplonia spinosa*) as its host plant (plant used for laying eggs and serves as a food source for the development of larvae). Carrion-Cabrera (2003) states that the dispersion of the species is limited by the monophagus habit of the larvae (only utilizes the prickly bush). Additionally, the butterfly flies slowly and is weak and fragile; the species is considered sedentary (not able to move or disperse in a given environment).

The species occurs within the subtropical-moist-forest life zone in the northern karst region (i.e., municipality of Quebradillas) of Puerto Rico, and in the subtropical-wet-forest life zone (i.e., Maricao Commonwealth Forest, municipality of Maricao). The primary threats to the Puerto Rican harlequin butterfly are development, habitat fragmentation, and other natural or manmade factors such as human-induced fires, use of herbicides and pesticides, vegetation management, and climate change (USFWS 2019). The species is not associated with coastal scrub shrub habitat, however its host plant is sometimes found in coastal areas. Sea level rise may not directly affect the species but can affect the host plant, limiting the availability of habitat in coastal areas.

Counties/ Municipalities: Quebradillas, Sabana Grande, Maricao, Yauco, Arecibo, Isabela, Ciales, Camuy.

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Plants

Chamaecrista glandulosa var. mirabilis

Chamaecrista glandulosa var. mirabilis is a small shrub endemic to the white silica sands of the northern coast of Puerto Rico. It was listed on April 5, 1990 as endangered. *C. glandulosa var. mirabilis* is a prostrate, ascending, or erect shrub, which may reach up to 3 feet in height. The branches are slender, straight, and wire-like. Leaves are alternate, evenly one-pinnate, 1 to 3 inches long, 0.5 to 1 inches wide, with some scattered whitish hairs. The stipules are persistent, striate, and about 1 inch long. The leaflets are mernbranaceous, usually in 18 pairs, 3 to 6 inches long and 0.5 to 1.5 inches wide. The petioles have one to two stipitate glands. The flowers are solitary, with a pedicel about as long as the leaves. The corolla is yellow, about 1 inch in diameter, with one petal much larger than the others. Mature fruits (legumes) are glabrous, linear, 2.5 to 4 inches long, 3 to 4 inches wide, flat, elastically dehiscent, and 12 to 15 seeded. *Chamaecrista glandulosa var. mirabilis* is known only from the silica sands of the north coast of Puerto Rico (USFWS, 2015). These sands occur between Vega Baja and Manati, at elevations near sea level.

The species is limited to coastal habitats consisting on white siliceous sands adjacent to wetland areas. Climate change is predicted to increase the frequency and strength of tropical storms andalso to lead to a gradual rise in sea level. Vulnerability to climate change impacts is a function of sensitivity and exposure to those changes, and the adaptive capacity of the species (Glick et al., 2011). Therefore, shifts of vegetation communities are expected as temperatures and moisture regimes are altered by climate change. Under this scenario, the populations of *C. glandulosa var. mirabilis* may be displaced or outcompeted by native or exotic species with wider environmental plasticity. Even a small rise in sea level could represent very serious threat to the taxon. The known populations and suitable habitat occurs adjacent to coastal wetlands adjacent to the Tortuguero Lagoon. Sea level rise will also compromise natural recruitment by affecting seed germination and/or the survival of seedlings. Due to its limited range and limited substrate availability, flooding, climate change and sea level rise, will have an adverse impact on the species.

Counties/ Municipalities: Dorado, Vega Baja, Vega Alta, Manati.

Literature Cited

Glick P., H. Chmura, and B. A. Stein. 2011. Moving the conservation goalpost: A review of climate change adaptation literature. National Wildlife Federation. 25 pp.

U.S. Fish and Wildlife Service (USFWS). 2015. *Chamaecrista glandulosa var. mirabilis* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boqueron, Puerto Rico. 14 pp.

Cobana negra (*Stahlia monosperma*)

Stahlia monosperma (cobana negra) is a medium-sized, evergreen tree that reaches 25 to 50 feet in height, and 1 to 1.5 feet in diameter that was listed as threatened on April 5, 1990. It is a member of the Family Fabaceae, easily identified by (1) pinnately compound leaves with 6 to 12 opposite, lance-shaped to ovate leaflets on red stalks and with scattered black raised dots on lower surface; (2) clusters of pale yellow flowers about one-half of an inch across the five petals; (3) odd elliptic, thick and fleshy, red pods 2 inches or less in length; and (4) yellow-green and slightly pendulous foliage (Little and Wadsworth 1964). Flowers are yellow and are produced between March and May, depending on rainfall. Flower clusters are terminal, 3 to 6 inches long, and unbranched. The slightly hairy flowers have a funnel-shape, broad base, 10 stamens and a one-celled, slender and curved ovary. A thin, red, fleshly fruit is produced during late June and mid-July. Fruit pods are about 1.5 inches broad and three-fourths of an inch thick, with an odor of ripe apples, light brown tasteless flesh, and one large seed (Little and Wadsworth 1964). Fruits mature in summer and fall. The sapwood is light brown, and the heartwood is dark brown. The wood is very hard, heavy, strong, durable, and resistant to attack by dry wood termites.

Wild *Stahlia monosperma* grows in brackish, seasonally flooded wetlands in association with mangrove communities, although cultivated plants have been reported from inland areas such as the nursery at Cambalache State Forest in Puerto Rico. Its associates are usually "úcar" (*Bucida buceras*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*). Individuals are also found on pasturelands adjacent to mangrove forests, as well as in some urban areas of Boquerón, Cabo Rojo. Nearly all of the known trees are growing at the edge of salt flats or shallow lagoons, which are inundated during the wet season. Currently, there are nine natural known populations located sparsely around Cabo Rojo, Lajas, Guayanilla, Río Grande and Vieques Island. Introduced individuals may be found at least 18 municipalities around the island of Puerto Rico and in three areas in the Dominican Republic (Macao, Higüey, and San Pedro de Macoris) (USFWS, 2014).

Disturbances such as hurricanes may affect small relic populations of Cóbana negra. These populations are very important as they may harbor an important genetic stock of the species. Cóbana negra may be further threatened by climate change, which is predicted to increase the frequency and strength of tropical storms and can cause severe droughts (Hopkinson et al. 2008). Even if Cóbana negra resists adverse effects of hurricanes, the cumulative effects of severe storms, soil erosion and increased sediment runoff may compromise the establishment of seedlings along drainages, which usually provide suitable habitat for the species. In addition, sea level rise may modify species' natural habitat, resulting in irreversible damages to the species. Hence, decreasing the number of individuals in already small populations.

Counties / Municipalities: Santa Isabel, Juana D□íaz, Guánica, Arecibo, Loíza, Adjuntas, Guayanilla, Peñuelas, Yauco, Sabana Grande, Cabo Rojo, Vega Alta, Dorado, Humacao, Lajas, Cayey, Mayagüez, Culebra, Vieques, Rio Grande.

Literature Cited

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Mitracarpus polycladus and ***Mitracarpus maxwelliae***

Mitracarpus polycladus is a small shrub known to occur in Puerto Rico, Saba Island in Lesser Antilles, and Anegada Island in British Virgin Islands (BVI) that was listed as endangered on September 9, 1994 (USFWS 2018). *Mitracarpus polycladus* was first discovered growing on coastal rocks near Caña Gorda, Guánica, Puerto Rico, in 1886 by Paul Sintenis. It is a suffrutescent perennial, branched near the base, and the erect or spreading stems may reach up to 17 inches in height. The branches are 4-angled and glabrous. Leaves are opposite, linear to linear-lanceolate, 1 to 1.5 inches long, glabrous and often with an inrolled margin and decurrent base. The inflorescence is terminal and capitate, 3 to 5 inches in diameter, many flowered and subtended by 3 branch-like leaves. The corolla is white, about 1 inch long, with ovate leaves. The seed capsule is 0.5 inches in diameter, splitting open transversely below the middle, and contains black seeds. In Puerto Rico, *M. polycladus* occurs in the southern karst region in the municipalities of Guánica, Yauco, and Guayanilla (USFWS 2018). The latest account of *M. polycladus* resulted in approximately 12,470 mature individuals and more than 11,450 seedlings, distributed throughout the Guanica Commonwealth Forest (GFC), San Francisco Wind Farm (a private property adjacent to the eastern boundary of the GCF), and the Ballena Beach area, a private property located adjacent to the southern boundary of the GCF managed for conservation by Para La Naturaleza (USFWS, 2018).

Mitracarpus maxwelliae is a low, densely branching, mound like shrub, which may reach approximately 8 inches in height that was listed as endangered on September 9, 1994. The somewhat woody branches are striate and sharply 4-angled. The leaves are opposite, sessile, linear or linear-lanceolate, densely scabrous, and from 1 to 3 inches long and 1 to 2 inches wide. The flower heads are terminal, dense, sub-globose, and from 0.5 to 1 inch in diameter. The corolla is white; narrowly funnel form, minutely glandular-papillose, and 1 to 3 inches long. The capsule is about 0.5 inch in diameter, opening by a transverse circular split at about the middle. The seeds are ellipsoid, brownish-black, and 0.5 inch long and 0.5 inch wide (USFWS 2018). *Mitracarpus maxwelliae* occur only in Puerto Rico, with a very limited distribution. Only two populations of this species are currently known: one at Monte de la Brea and another at Monte

Las Pardas, both located at La Montalva Ward in the municipality of Guanica. The population at Monte de la Brea is within the boundaries of the GCF, whereas the population at Monte Las Pardas occurs in a public land slated for development. The latest inventory of *M. maxwelliae* indicates that the overall abundance of the species is approximately 2,170 mature individuals and more than 1,430 seedlings (USFWS 2018).

Both species are threatened by destruction and modification of it habitat. Sea level rise and storms pose a threat to both species since these plants are found growing in sandy and rocky areas in the coast. As sea level rise augment, less habitat may be available for the species.

Counties / Municipalities: Guánica, Yauco, and Guayanilla.

Literature Cited

U.S. Fish and Wildlife Service (USFWS). 2018. *Mitracarpus maxwelliae / (*no common name*)* and *Mitracarpus polycladus / (*no common name*)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. 29 pp.

Vahl's boxwood (*Buxus vahlii*)

Buxus vahlii is an evergreen shrub or small tree reaching 16 feet in height, with a stem diameter of 5 inches that was listed as endangered on August 13, 1985. The leaves are simple, opposite, and oblong to obovate. One diagnostic character is the presence of two grooves in the stem below each node. The species generally flowers and sets seed between December and April. The flowers are small and unisexual, borne together in a cluster (an axillary raceme) on the same plant. The fruit is a three-horned capsule approximately 0.25 inches long (USFWS 1987). The known populations of the Vahl's boxwood in Puerto Rico and St. Croix occur primarily within the subtropical dry forest life zone and to a lesser extent the subtropical moist forest life zone.

The species is threatened by habitat destruction or modification since there are several proposed developments in the areas where the species occurs (tourism and urban development), which could result in further encroachment of populations and the modification of suitable habitat, limiting the expansion of the existing populations. In addition, an evaluation of the species after Hurricane María made by the Service, stated that plants that were observed partly or wholly dead at the municipality of Rincón had trunks that were split longitudinally partway, or were “reclining” (not erect), which suggest damage caused by hurricanes (USFWS 2019). Hence, cumulative effects of severe tropical storms may affect the Rincón population. Vahl’s boxwood may be further threatened by sea level rise, which could possibly affect the Rincón and Sandy Point “St. Croix” populations. The cumulative effect of coastal erosion due to severe hurricanes, sea level rise, and the habitat modifications for urban and tourism development can further diminish the availability of suitable habitat, and therefore, limit the population expansion and colonization of new areas at Rincón and St. Croix (USFWS 2018).

Counties / Municipalities: Bayamón, Isabela, Peñuelas, Ponce, Rincón at Puerto Rico. Christiansted and Frederiksted at St. Croix.

Literature Cited

U.S. Fish and Wildlife Service (USFWS). 1987. Vahl's boxwood *(Buxus vahlii)* Recovery Plan. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. 46 pp.

U.S. Fish and Wildlife Service (USFWS). 2018. Vahl's boxwood *(Buxus vahlii)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. 28 pp.

Agave eggersiana

Agave eggersiana is a flowering plant of the family Agavaceae (century plant family) endemic to the island of St. Croix in the U.S. Virgin Islands that was listed as endangered on October 9, 2014 (USFWS 2014). *A. eggersiana* was originally described in 1913 by Trelease from material collected on St. Croix, and is distinguished from other members of the Agavaceae family by its acaulescent (without an evident leafy stem), non-suckering growth habit (vegetative reproduction that does not form offshoots around its base), and fleshy, nearly straight leaves with small marginal prickles 0.04 inches long that are nearly straight (Proctor and Acevedo-Rodríguez 2005). Its flowers are deep yellow 1.95 to 2.34 in long. After flowering, the panicles (inflorescence) produce numerous small vegetative bulbs (bulbils), from which the species can be propagated (Proctor and Acevedo- Rodríguez 2005, p. 118). *A. eggersiana* is not known to produce fruit. Furthermore, based on observations of cultivated plants, *A. eggersiana* requires at least 10 to 15 years to develop as a mature individual and to produce an inflorescence (David Hamada, St. George Botanical Garden, 2010, pers comm.). *A. eggersiana*, like other Agave species, is monocarpic, meaning the plant dies after producing the spike or inflorescence.

Approximately 450 individuals in 10 localities are known to exist around this island (USFWS 2014). The species currently occurs in six areas that appear to be remnants of wild populations. The other four populations are introduced individuals planted for conservation. The primary threats to *Agave eggersiana* are from habitat modification and from natural or manmade factors. The species occurs in areas either threatened by development pressure, or currently affected by landscape practices and competition with exotic species, resulting in detrimental effects to its reproduction and recruitment (USFWS 2014). In addition, a 17.96 ac critical habitat for *Agave eggersiana* was designated in 2014.

As an endemic species to the island of St. Croix, *A. eggersiana* would be expected to be well adapted to tropical storms. However, the low number of individuals found on the island and the reproductive biology of the species (dependence on asexual reproduction and the plant dying after flowering) increases the likelihood of stochastic events such as hurricanes extirpating a

population. In addition, landslides and coastal erosion associated with hurricanes may affect the populations located along the coastal areas of St. Croix (Ha'penny Beach, South Shore, and Protestant Cay) due to their proximity to cliffs and the shoreline. Sea level rise, the cumulative effect of coastal erosion due to severe hurricanes, storm surges, plus the habitat modification for urban and tourism development can further diminish the availability of suitable habitat and, therefore, limit population expansion and colonization of new areas.

Counties / Municipalities: Ha'penny Beach, South Shore, and Protestant Cay at St. Croix.

Literature Cited

Proctor, G. R. and P. Acevedo-Rodríguez. 2005. Agavaceae, p.118. in, P. Acevedo-Rodríguez & M. T. Strong (eds.) Monocotiledons and Gymnosperms of Puerto Rico and the Virgin Islands. Contribu. U. S. Natl. Herb. Vol. 52: 1-415.

U.S. Fish and Wildlife Service (USFWS). 2014. Endangered and Threatened Wildlife and Plants; Endangered Species Status for *Agave eggersiana* and *Gonocalyx concolor*, and Threatened Species Status for *Varronia rupicola*. U.S. Fish and Wildlife Service, Washington, DC. 13 pp.

Marron bacora (*Solanum conocarpum*)

Solanum conocarpum is a dry forest shrub in the island of St. John, U.S. Virgin Islands. Currently, it is a candidate under the Endangered Species Act. Its leaves are oblong-elliptic or oblanceolate (broader at the distal third than the middle), ranging from 3.5-7 cm (0.62-1.5 in) wide. The leaves are coriaceous (leathery texture) and glabrous (no hairs), and have a conspicuous yellowish mid-vein (USFWS 2016). The flowers are usually paired in nearly sessile (not stalked) lateral or terminal cymes (flat-topped flower cluster). The corolla consists of five separate petals that are light violet, greenish at the base, and about 2 cm (0.78 in) wide. The fruit, a berry, is ovoid-conical (teardrop shaped), 2-3 cm (0.78-1.2 in) long, and turns from green with white striations to golden yellow when ripe (Acevedo-Rodríguez 1996). Its current distribution includes eight localities in the island of St. John, each ranging from 1 to 144 individuals (USFWS 2016). The species has been reported to occur on dry, poor soils. It can be locally abundant in exposed topography on sites disturbed by erosion, areas that have received moderate grazing, and around ridgelines as an understory component in diverse woodland communities. A habitat suitability model suggests that the vast majority of *Solanum conocarpum* habitat is found in the lower-elevation coastal-scrub forest (USFWS, 2016). Efforts have been conducted to propagate the species to enhance natural populations, and planting of seedlings has been conducted in the island of St. John. *Solanum conocarpum* is threatened by the lack of natural recruitment, absence of dispersers, fragmented distribution, lack of genetic variation, climate change, and habitat destruction or modification by exotic mammal species. The reduced number of individuals, low number of populations, and lack of connectivity between populations evidence these threats. Overall, the threats are of high magnitude because they are leading to

population declines for a species that already has low population numbers and fragmented distribution; the threats are also ongoing and therefore imminent.

The cumulative effects of severe tropical storms and increased sediment runoff may jeopardize the establishment of seedlings along drainage areas usually associated with suitable habitat for *S. conocarpum* (Ray, 2005; O. Monsegur, USFWS, pers obs., 2010). Due to the low number of adult individuals and the problems associated to the natural recruitment of the species, severe tropical storms may have an adverse impact on the species. In addition, *Solanum conocarpum* may be further threatened by sea level rise inundating the suitable habitat associated with drainages near the coast. The cumulative effect of coastal erosion due to severe hurricanes, plus the habitat modification for urban and tourist development can further diminish the availability of suitable habitat for *S. conocarpum*, and therefore, limit population expansion and colonization of new areas. These cumulative factors may reduce the number of individuals and further reduce populations.

Counties: St. John Island

Literature Cited

Ray, G. and A. Stanford. 2005. Population Genetics, Propagation and Reintroduction of *Solanum conocarpum*, A Rare Shrub of St. John, US Virgin Islands. Final Report to the National Park Service, Project PMIS # 49192, Virgin Islands National Park. 19 pp.

U.S. Fish and Wildlife Service (USFWS). 2016. *Solanum conocarpum* Candidate Assessment. U.S. Fish and Wildlife Service Southeast Region Caribbean Ecological Services Field Office, Boquerón, Puerto Rico. 19 pp.

Leptocereus grantianus

Leptocereus grantianus is a sprawling, sub erect, nearly spineless cactus, which may reach up to 6 feet in height and 1 to 2 inches in diameter. It was listed as endangered on February 26, 1993 (USFWS 1995). The elongated stems have 3 to 5 prominent ribs with broadly scalloped edges. Ribs of young joints are thin, and the small areoles may bear one to three minute, nearly black spines which disappear as the joints grow older and the ribs become thicker. The flowers are solitary at the terminal areoles, 1 to 2 inches long, and nocturnal. The ovary and flower tube bear distinct areoles. The outer perianth segments are linear, green, and tipped by an areole like those of the tube and ovary. The inner perianth segments are numerous, cream-colored, oblong-ovate, obtuse and about 0.5 inch long. Stamens are many and have yellow anthers. The stigma lobes are several and short. The fruit is sub globose to ellipsoid and about 0.5 inch in diameter (Britton 1933; Proctor 1991).

Leptocereus grantianus occurs within the subtropical dry forest life zone, the driest life zone in Puerto Rico (USFWS, 1995). This life zone occurs along the south coast of Puerto Rico, Vieques Island, Culebra, and St Croix, and includes all the small islands surrounding Puerto Rico (Ewel

and Whitmore, 1973). The species grows on rocky outcrops, steep and unstable slopes adjacent to narrow beach and on remnants of small-forested patches of native vegetation located along the southwest coast of the main island of Culebra (O. Monsegur and C. Pacheco, Service unpubl. data, 2009). There is no evidence or record of the species occurring in other types of habitat. The species is currently threatened by destruction, modification, or curtailment of it habitat or range, disease and predation, and human-induced fires, physical damage caused by human trampling, hurricanes and storms also are considered threats to this species. As a species endemic to the Lesser Antilles, *L. grantianus* should be adapted to hurricanes. However, its occurrence on coastal cliffs with highly erodible soils subjected to significant water surge during heavy sea waves may place it at increased risk, especially as climate change is predicted to increase the frequency and strength of hurricanes, and increase the sea level (Paris et al. 2012). High rainfall associated with tropical storms and hurricanes, sometimes about 24 inches (2 feet) of rain in a single storm event, can cause floods, and interacting with topography and substrate may induce mass wasting events (e.g., land, mud and debris slides) posing a threat to *L. grantianus*.

Counties / Municipalities: Culebra

Literature Cited

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Ewel, J.J. and J.L. Whitmore. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. Forest Serv. Research Pap. ITF-8, USDA. 72 pp.

Paris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global sea level rise scenarios for the U. S. National Climate Assessment. NOAA Tech Memo OAR CPO-1, 37 p.

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Varronia rupicola

Varronia rupicola is a small shrub that has been described from southwestern Puerto Rico, Vieques Island, and Anegada Island (British Virgin Islands). It was listed as threatened in 2014 (USFWS 2014). Currently, approximately 227 individuals are known from four locations: Peñuelas, Yauco, Guánica Commonwealth Forest, and Vieques National Wildlife Refuge. In addition, a 17.96 ac of critical habitat has been designated for *Varronia rupicola* within the municipalities of Guanica, Guayanilla, Ponce, Peñuelas, and the Vieques National Wildlife Refuge in Puerto Rico. All these sites lay within the subtropical dry forest life zone overlying a limestone substrate. The species is threatened by maintenance of trails and power line rights-of-way in the Guánica Commonwealth Forest, and residential and commercial development in Penñuelas, Yauco, and Anegada Island. *Varronia rupicola* is also vulnerable to natural (e.g.,

hurricanes) or manmade (e.g., human-induced fires) threats. Furthermore, the population on Anegada Island, which is considered the healthiest population, is expected to be affected by sea-level rise as most of the suitable habitat for the species is less than 10 feet above sea level. Therefore, even a small rise in sea level could devastate the healthiest population, and lead to a significantly greater likelihood of extinction (USFWS 2014).

Counties / Municipalities: Peñuelas, Yauco, Guánica, BVI.

Literature Cited

U.S. Fish and Wildlife Service. 2012. Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions. Washington, DC. 68 pp.

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Mammals

Trichechus manatus manatus

The Antillean manatee is slow moving aquatic mammal ranging in color from gray to brown. The manatees' reaches adulthood at about six years of age and the oldest in captivity reached over 60 years of age. Adult manatees in Puerto Rico measure about 10 feet in length and weigh between 1,200 to 2,000 pounds. At birth, calves measure over 3 feet and weigh between 35 and 60 pounds (Drew et al. 2012).

Manatees in Puerto Rico inhabit mostly shallow coastal areas (USFWS 2007). They may be encountered in canals, rivers, estuaries (the river mouth) and saltwater bays. In Puerto Rico, manatees are more common along the east and south of Puerto Rico. Surveys show concentrations in several "hot spots" including Ceiba, Vieques Island, Jobos Bay in Salinas and Boquerón Bay. Other important areas are the San Juan Bay, Luquillo, Guayanilla, Lajas, Cabo Rojo and Mayagüez. Manatees in Puerto Rico are least abundant along the north coast, between Rincón and Dorado. Manatees have also been reported, although only in few instances, around Culebra Island. No records exist from Mona or Desecheo Islands. Manatees are virtually non-existent in the U.S. Virgin Islands; sightings and stranding in this area are extremely rare (USFWS 2007).

Most threats to manatees are mostly anthropogenic in origin; manatees have survived several cycles of climate change, with fossil manatee bones found high in the karst region of Puerto Rico

(Felix Lopez, Caribbean ES Field Office, 2019, pers comm.) Sea level rise, increased storms and flooding will probably not affect the manatee and in the case of sea level rise, may actually create more shallow water habitat with submerged aquatic vegetation for them.

Counties / Municipalities: All coastal counties in Puerto Rico

Literature Cited

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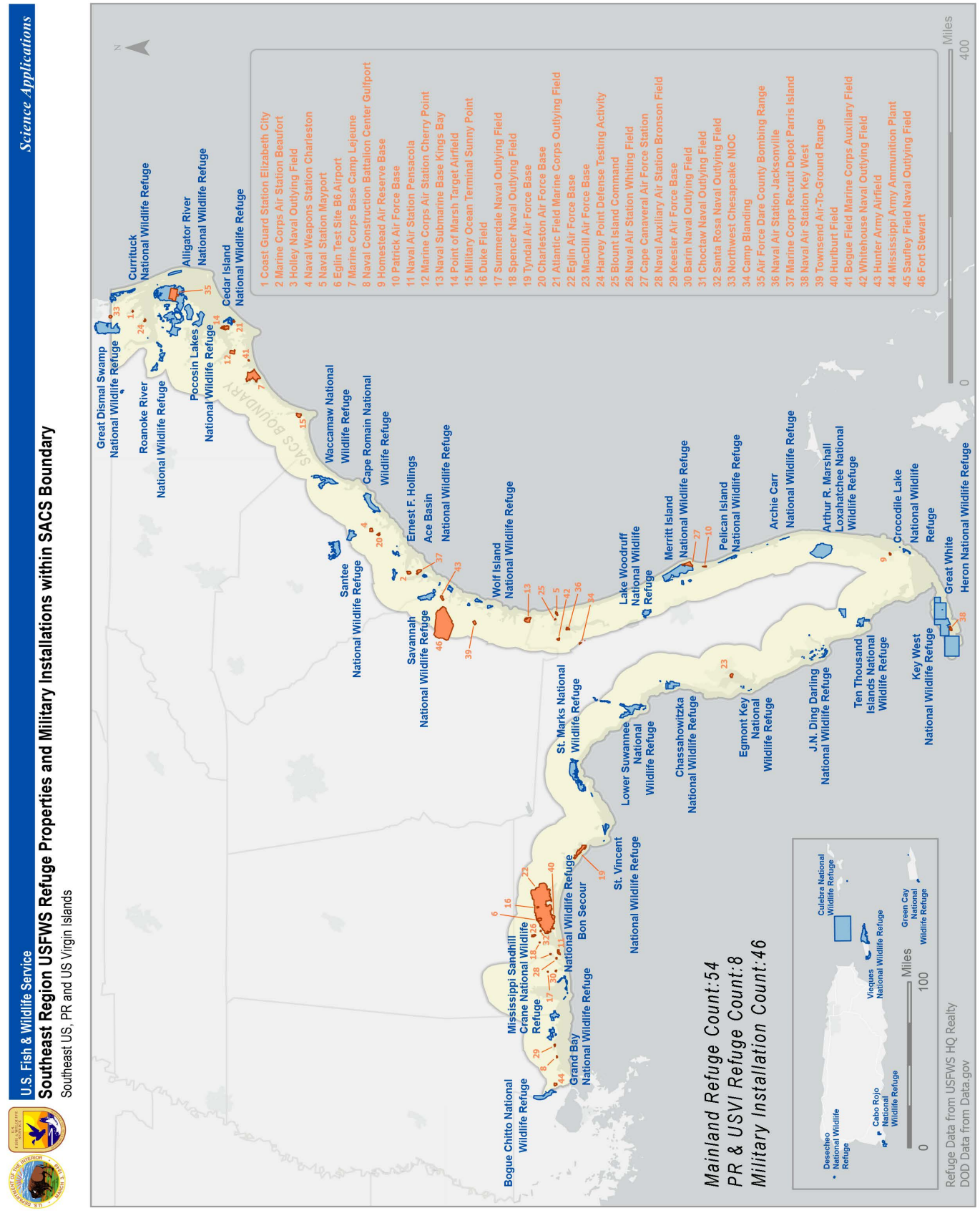
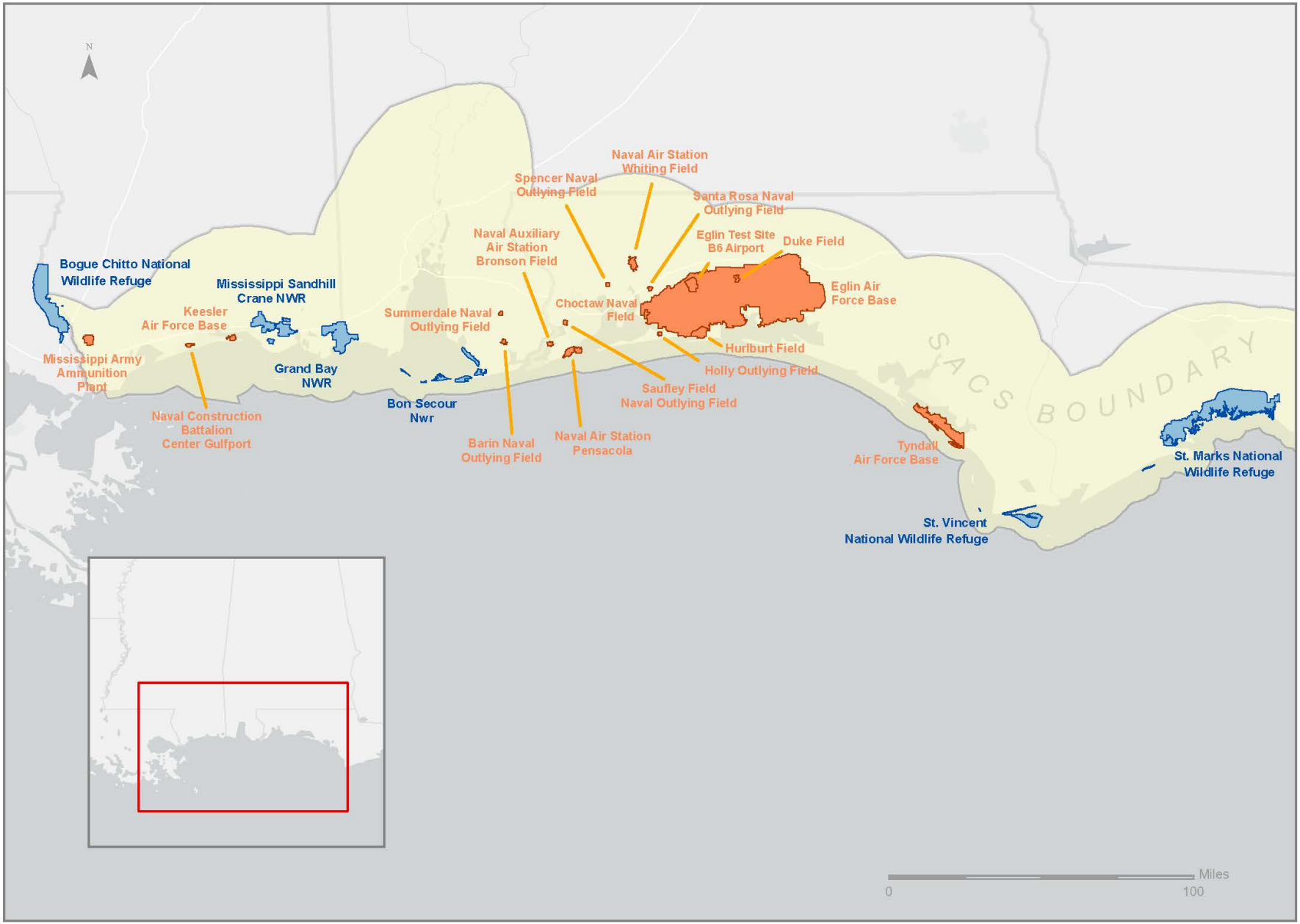
Appendix A. Figures



Southeast Region USFWS Refuge Properties and Military Installations within SACS Boundary

LA, MS, AL, FL, USA

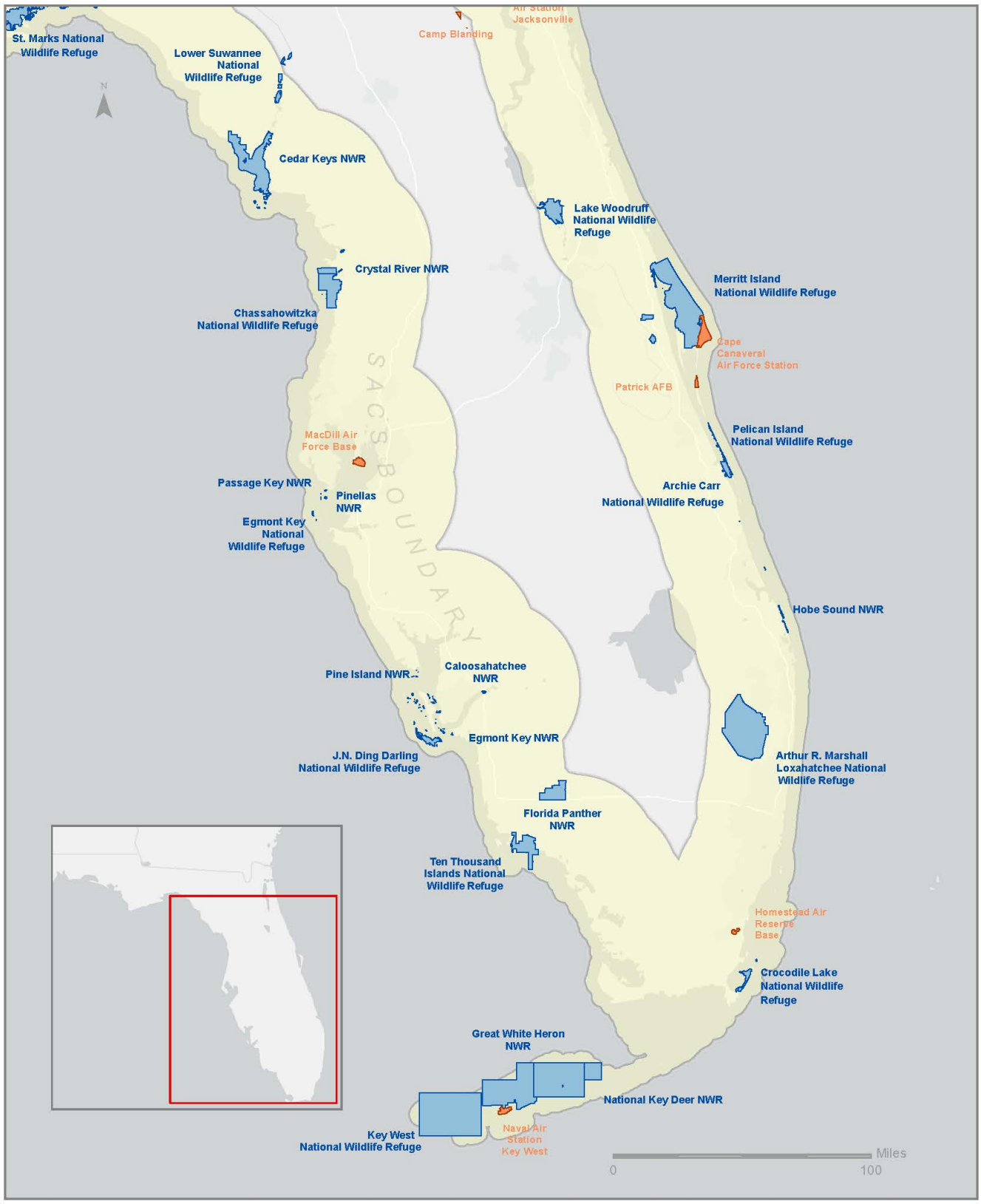


U.S. Fish & Wildlife Service

Science Applications

Southeast Region USFWS Refuge Properties and Military Installations within SACS Boundary

South FL, USA




U.S. Fish & Wildlife Service
Science Applications
Southeast Region USFWS Refuge Properties and Military Installations within SACS Boundary
SC, GA and FL, USA
SACS BOUNDARY
Waccamaw NWR
Santee
National Wildlife Refuge
USN Weapons
Station
Charleston
Cape Romain National
Wildlife Refuge
Charleston AFB
Ernest F. Hollings
Ace Basin
National Wildlife Refuge
Bears Bluff NFH
USMC Air Station
Beaufort
Savannah NWR
Marine Corps
Recruit Depot
Parris Island
Hunter
Army Airfield
Pinckney Island NWR
Fort Stewart
Tybee NWR
Wassaw NWR
Harris Neck NWR
Townsend
Air-To-Ground Range
Blackbeard Island NWR
Wolf Island
National Wildlife Refuge
Naval Submarine
Base Kings Bay
Naval Station
Mayport
Whitehouse Naval
Outlying Field
Blount Island
Command
Naval
Air Station
Jacksonville
Camp Blanding
Miles
0
100

U.S. Fish & Wildlife Service

Science Applications

Southeast Region USFWS Refuge Properties and Military Installations within SACS Boundary

VA, NC and SC, USA