



U.S. Fish & Wildlife Service Coastal Plains Landscape Conservation

Landscape Level Overview

Southeast Conservation Adaptation Strategy

Southeast Conservation Adaptation Strategy (SECAS) and the Southeast Conservation Blueprint

SECAS is a regional conservation initiative that spans the Southeastern United States and Caribbean. SECAS was started in 2011 by the states of the Southeastern Association of Fish and Wildlife Agencies and the federal agencies of the Southeast Natural Resource Leaders Group. SECAS brings together state and federal agencies, nonprofit organizations, private landowners and businesses, tribes, partnerships, and universities around a shared vision of the future. The Southeast Regional Director of the U.S. Fish and Wildlife Service serves on the Executive Steering Committee.

SECAS also tracks regional metrics of ecosystem health, function, and connectivity to report annually on progress toward achieving the SECAS Goal: A 10% or greater improvement in the health, function, and connectivity of Southeastern ecosystems by 2060.

The primary product of SECAS is the Southeast Conservation Blueprint (Figure 1), a living spatial plan to achieve the SECAS vision of a connected network of lands and waters that supports thriving fish and wildlife populations and improved quality of life for people. More than 2,000 people from over 500 organizations have participated in the development of the Blueprint so far, including more than 450 U.S. FWS staff. Using the Blueprint ensures this design integrates directly with strategic landscape-scale conservation priorities across the Southeast and Caribbean.

(SECAS 2025)

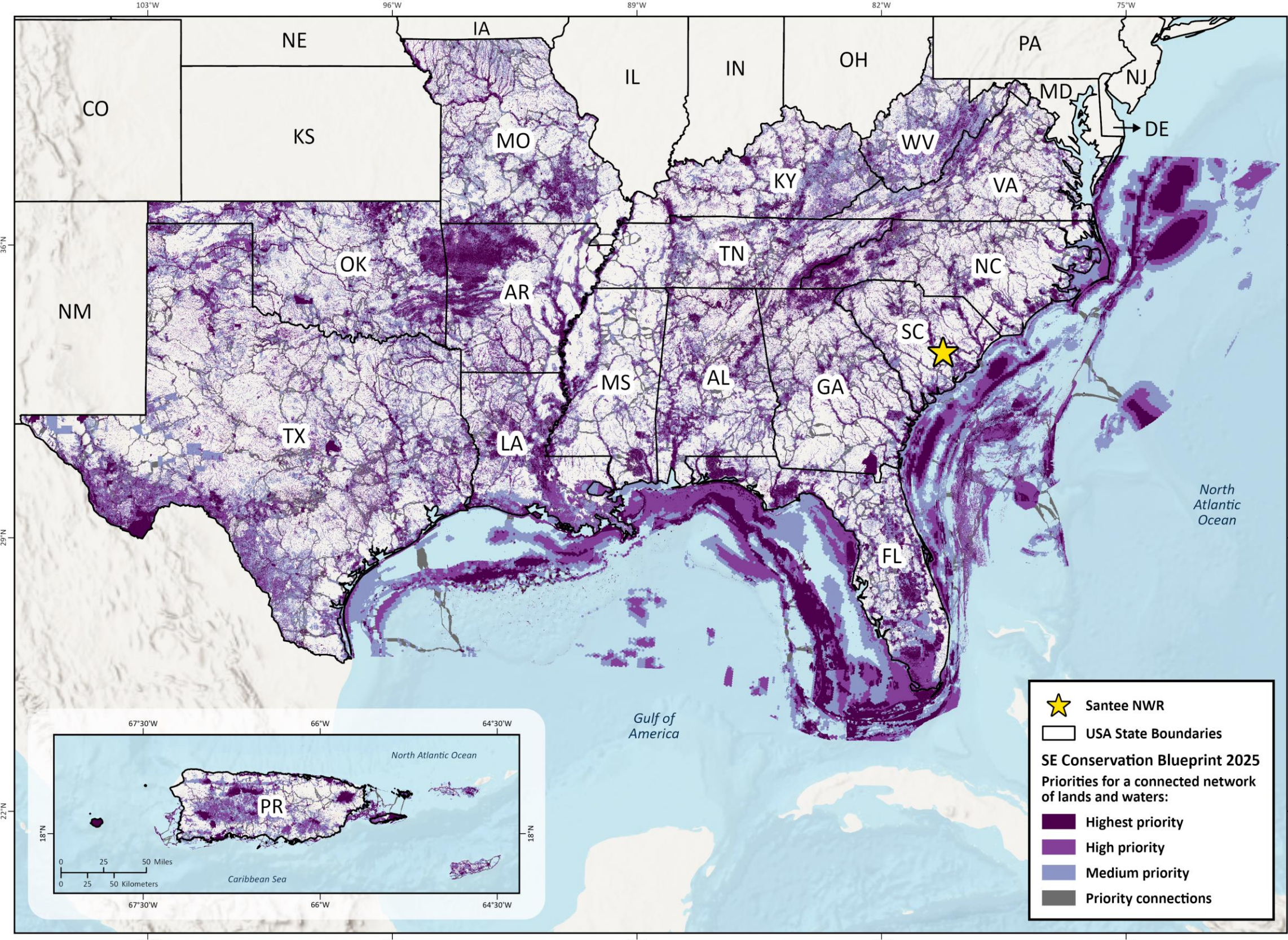


Figure 1. This figure shows the SECAS geography, the SECAS Blueprint 2025, and its relationship to Santee National Wildlife Refuge. The SECAS geography includes 15 Southeast states, Puerto Rico, the U.S. Virgin Islands, and the surrounding offshore marine environment.

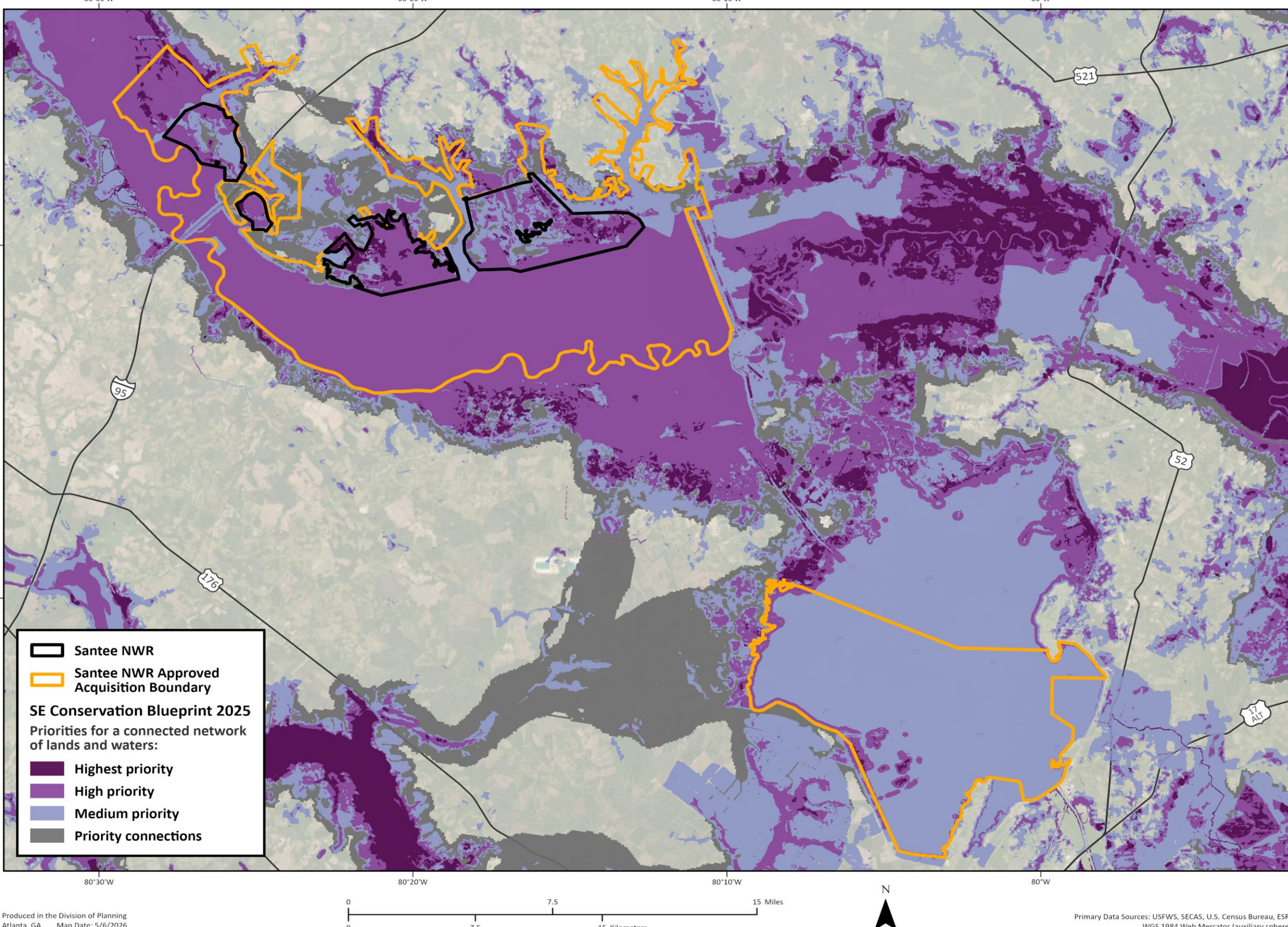


Figure 2. Southeast Conservation Blueprint priorities on Santee National Wildlife Refuge.



Southeast Conservation Blueprint and Santee NWR

Priorities: The Southeast Conservation Blueprint (2025) prioritizes 100% of the current Santee NWR boundary, highlighting its regional importance for shared conservation action (Figure 2).

Connectivity: 100% of the Refuge boundary falls within a corridor for connectivity in the Blueprint. It also contributes to large intact habitat cores. While Santee is already part of a highly connected landscape, additional land protection and restoration focused on growing and connecting intact patches could further reduce habitat fragmentation (Figure 2).

(SECAS 2025)

Savannah-Santee-Pee Dee Ecosystem – Regional Landscape Perspective

The Service's Savannah-Santee-Pee Dee Ecosystem (SSPD Ecosystem) includes approximately 92% of the State of South Carolina, as well as the northeastern portion of Georgia and the southwestern portion of North Carolina. The SSPD Ecosystem encompasses approximately 45,100 square miles and includes areas within the Blue Ridge Mountains, Piedmont, Carolina Sandhills, and Coastal Plain physiographic provinces. The SSPD Ecosystem supports large populations of wading birds, shorebirds, waterfowl, game and non-game mammals, reptiles, amphibians, and anadromous fish. The habitats within the SSPD Ecosystem fall within the Atlantic Flyway. Forage, refuge, cover, and staging areas for a variety of migrating waterfowl, neotropical migratory birds, raptors, and shorebirds are provided.

Two major types of river systems traverse these provinces. Alluvial rivers originate in the mountains and piedmont and include the Great Pee Dee, Savannah, Congaree, Wateree, Catawba, and Santee. Blackwater rivers originate in the coastal plain and include the Cooper, Ashley, Edisto, Salkehatchie, Combahee, Ashepoo, New, Four Holes, Little Pee Dee, Waccamaw, Black, and Lumber (Figure 3). The SSPD Ecosystem includes several important areas with protective designations, including 14 national wildlife refuges, six national forests, four national fish hatcheries, two national estuarine research reserves, and more than 50 state parks.

The greatest problem facing the SSPD Ecosystem is the loss of habitat through direct destruction and fragmentation, as well as through impacts from human activities. The predominant stresses for the SSPD Ecosystem are population growth, tourism, agriculture, silviculture, shipping ports, water channelization, urbanization, aquifer depletion, fire suppression, exotic species, non-point source pollution, and point source pollution.

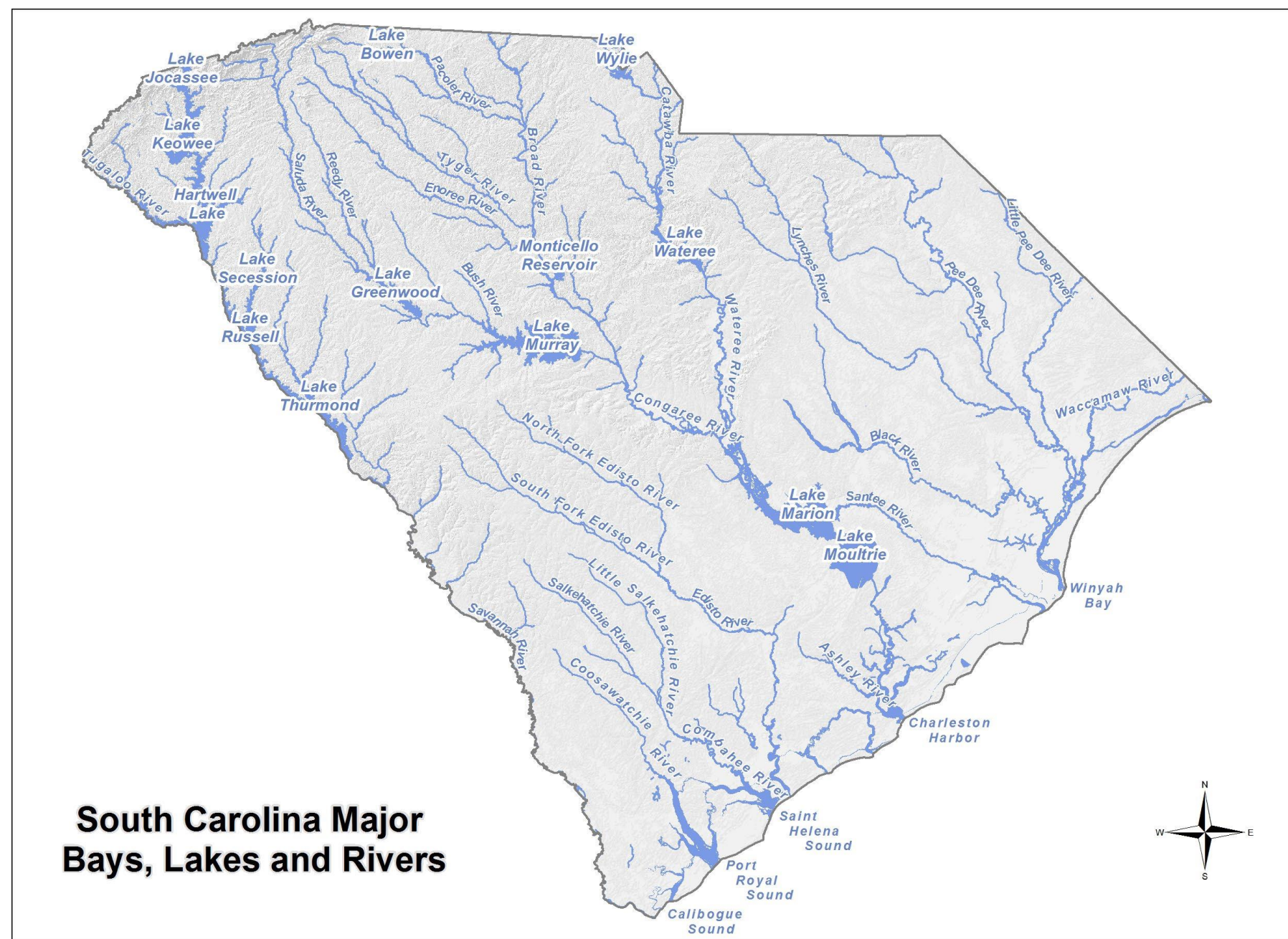


Figure 3. South Carolina's major bays, lakes, and rivers. (SC SWAP 2025)

Santee River

The Santee River originates where the Congaree and Wateree Rivers meet, about 11 miles above the lake. Most of the water flowing into the lake comes from upstream "blackwater" drainage (Tufford and McKellar 1999) and seasonal rainfall. Lake Marion, covering 110,600 acres, was formed between 1939 and 1942 as a hydroelectric project by the South Carolina Public Service Authority and is often referred to as "Santee Cooper." Positioned in the lower part of the Santee River basin, it represents one of the largest drainage areas on the East Coast. Together with its neighboring reservoir, Lake Moultrie, these bodies of water make up the Santee-Cooper Lake System.

Santee Southeastern and Coastal Plain Ecobasins

The region denoted the Southeastern Plains encompasses the Sandhills and Upper Coastal Plain and is sandwiched between the Piedmont to the north and the Lower Coastal Plain to the south (Figure 4). The upper extent of the Santee-Southeastern Plains Ecobasin is the Fall Line, which runs through central Lexington, Richland, and Kershaw Counties. The Ecobasin extends southeasterly to the upper portion of Berkeley County and includes three major rivers. The Congaree and Wateree merge to form the Santee River southeast of Columbia. The Ecobasin contains all of 17 watersheds and portions of 30 others and covers 5,346 km² (2,064 mi.²). The Ecobasin contains approximately 3,589 km² (2,230 mi.) of lotic habitat and 379 km² (146 mi.²) of lentic habitat, most of which is contained in Lake Marion (352 km² or 136mi.²).

The Santee-Coastal Plain Ecobasin originates in southeastern Clarendon County and encompasses portions of Williamsburg, Berkeley, Georgetown and Charleston Counties before terminating at the coast. The only major river within the Ecobasin is the Santee River. The Santee River flows for approximately 130 km (81 mi.) through the Coastal Plain, receiving inputs from Echaw Creek and Wambaw Creek, until terminating at the Atlantic Ocean. The Ecobasin intersects 19 watersheds and encompasses 1,606 km² (620 mi.²). (SC SWAP 2025)

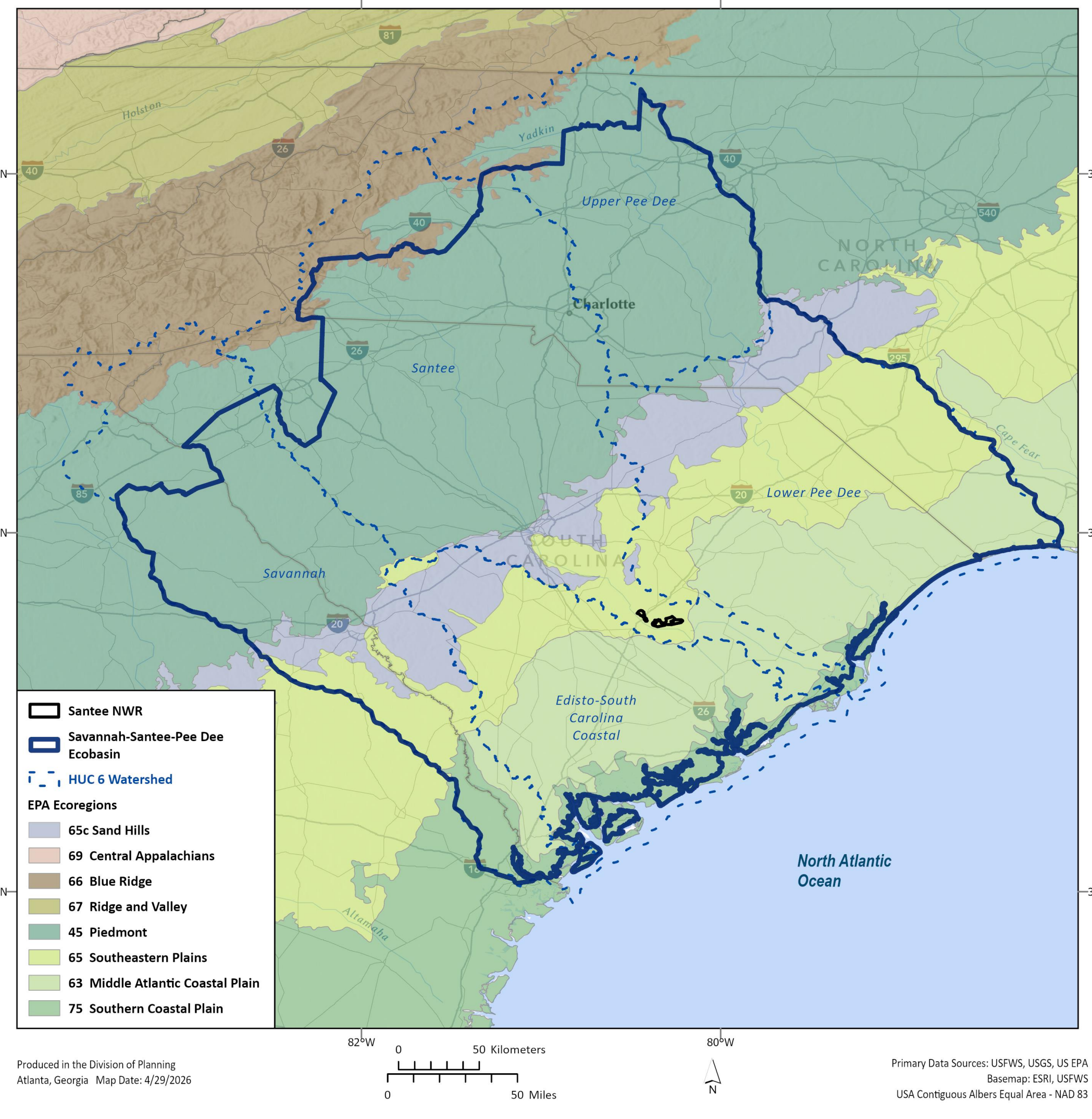


Figure 4. The EPA Ecobasins relative to the Santee NWR and other spatial ecosystem identifiers.

Threats and Opportunities

Habitat Loss

The Santee-ACE Coastal Plain Ecobasin is approximately 4,456,000 acres (6,962 mi²) in size. Between 2004 and 2024, the ecobasin experienced a net loss of almost 97,000 acres of forested habitat and 22,000 acres of wetlands.

Urban Growth Modeling

The FUTURES urban growth model predicts the likelihood that an area will urbanize at every decade from 2020 to 2100. Developed areas from the 2021 National Landcover Database serve as the baseline for current urban areas. The model simulates landscape change based on trends in population growth, local development suitability factors, and an urban patch-growing algorithm. It considers environmental drivers like distance to floodplain, slope, and available infrastructure, and even socio-economic status.

The probability of urbanization for each area reflects how many times it urbanized out of 50 model runs.

Urban growth does not represent a significant threat to Santee NWR. 3.7% of the current Refuge boundary is already urban in 2021, but none of the current refuge boundary, and only 0.1% of the refuge acquisition boundary, has even a moderate chance of urbanizing by 2060 (Figure 5).

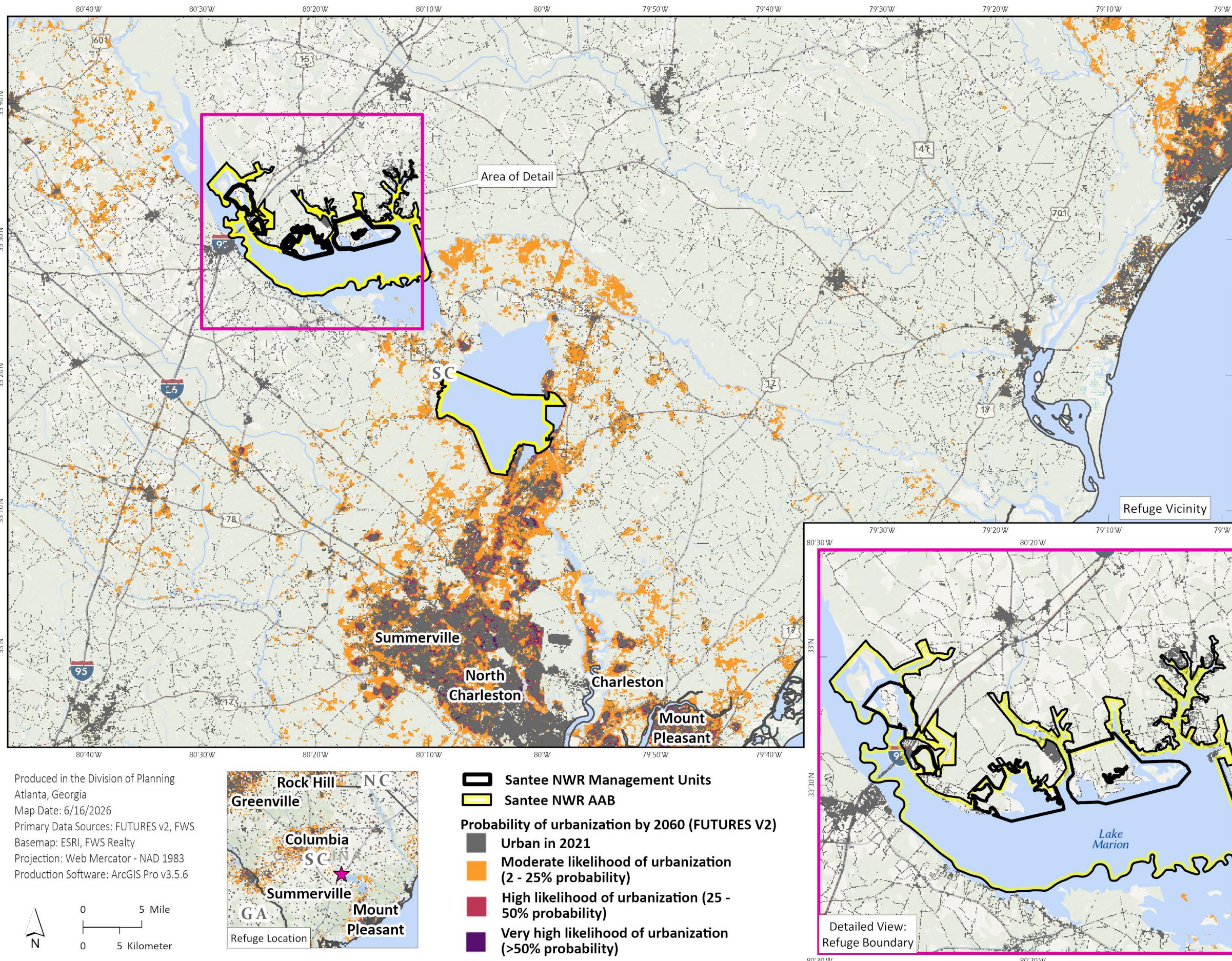


Figure 5. FUTURES v2 Urban growth probability by 2060 on and around Santee National Wildlife Refuge, South Carolina.

SECAS SE Conservation Blueprint: Imperiled Mammals Indicator

This indicator identifies potential habitat to support mammal Regional Species of Greatest Conservation Need (RSGCN). Using a rarity-weighted richness approach, it prioritizes places important for species that are restricted to smaller ranges, such as narrow endemics, which are therefore more vulnerable to habitat loss or change. RSGCN are regional priority species derived from the list of SGCN identified in Southeast State Wildlife Action Plans as most in need of conservation action. Approximately 55% of the refuge is of above average importance for these species (Figure 6 and Table 1).

(SECAS 2025)

Indicator Values: Importance for range-restricted species	Percent of Area
Highest importance (top 5% of larger analysis area)	0%
Very high importance (upper 5-10% of larger analysis area)	0%
High importance (upper 10-20% of larger analysis area)	27.6%
Medium importance (above average in larger analysis area)	27.3%
Low importance (below average in larger analysis area)	29.3%
Developed landcover or no potential habitat	15.8%
Total area	100%

Table 1. Indicator values for imperiled mammals within Santee NWR Boundary. (SECAS 2025)

SECAS SE Conservation Blueprint: Imperiled Amphibians & Reptiles Indicator

This indicator identifies potential habitat to support amphibian and reptile Regional Species of Greatest Conservation Need. Using a rarity-weighted richness approach, it prioritizes places important for species that are restricted to smaller ranges, which are therefore more vulnerable to habitat loss or change. Over 70% of the Refuge boundary resulted in a level of importance for these range restricted species (Figure 8 and Table 3).

(SECAS 2025)

Indicator Values: Importance for range-restricted species	Percent of Area
Highest importance (top 5% of larger analysis area)	37.6%
Very high importance (upper 5-10% of larger analysis area)	10.3%
High importance (upper 10-20% of larger analysis area)	24.7%
Medium importance (above average in larger analysis area)	5.1%
Low importance (below average in larger analysis area)	0.9%
Developed landcover or no potential habitat	21.4%
Total area	100%

Table 3. Indicator values for imperiled amphibians and reptiles within Santee NWR boundary. (SECAS 2025)

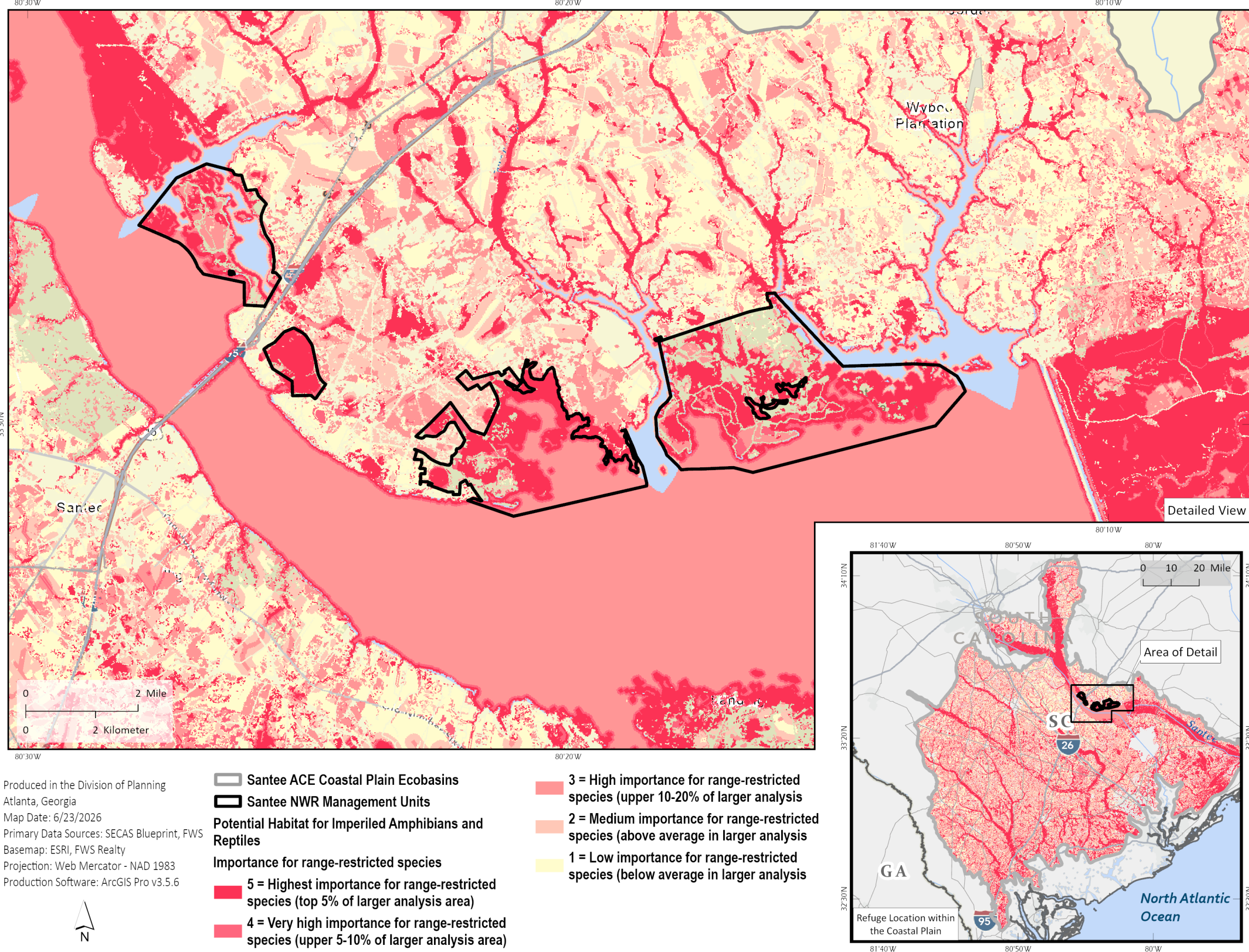


Figure 8. Santee NWR in relation to the SECAS SE Conservation Blueprint's imperiled reptiles & amphibians terrestrial indicator. This indicator was originally sourced from the U.S. Geological Survey Gap Analysis Project.

SECAS SE Conservation Blueprint: South Atlantic Forest Birds Indicator

This indicator is an index of habitat suitability for twelve upland hardwood and forested wetland bird species (wood thrush, whip-poor-will, American woodcock, red-headed woodpecker, Chuck-will's widow, hooded warbler, Kentucky warbler, Acadian flycatcher, Northern parula, black-throated green warbler, prothonotary warbler, Swainson's warbler) based on patch size and other ecosystem characteristics such as proximity to water and proximity to forest and ecotone edge. Over 60% of the Santee NWR boundary contains patches of land with potential for eleven of these avian species to be found (Figure 7 and Table 2).

(SECAS 2025)

Indicator Values: Potential for presence of forest bird index species	Percent of Area
Very large patches near water (potential for Swainson's warbler)	0%
Large patches often near water (potential for Northern parula, blackthroated green warbler, or Prothonotary warbler)	27.2%
Medium patches (potential for Acadian flycatcher)	2.2%
Small patches often near water (potential for hooded warbler or Kentucky warbler)	3.6%
Very small patches or near open areas (potential for wood thrush, whip-poorwill, red-headed woodpecker, Chuck-will's widow, or American woodcock)	31.2%
Less potential	35.8%
Total area	100%

Table 2 Indicator values for South Atlantic forest birds within Santee NWR Boundary. (SECAS 2025)

Santee National Wildlife Refuge

Clarendon County, South Carolina

Overview

Santee NWR Comprehensive Conservation Plan (CCP; USFWS 2008)

Establishing Authorities and Purposes

The Service administratively designated the Santee NWR (Figure 1) in 1941, under the Migratory Bird Conservation Act and the Refuge Recreation Act, thus outlining the primary purposes of these lands and waters: " ... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. 715d (Migratory Bird Conservation Act) " ...to conserve and protect migratory birds...and other species of wildlife that are listed...as endangered species or threatened species and to restore or develop adequate wildlife habitat." 16 U.S.C. 715i (Migratory Bird Conservation Act) " ... suitable for (1) incidental fish and wildlife-oriented recreational development, (2) the protection of natural resources, (3) the conservation of endangered species or threatened species ..." 16 U.S.C. 460k-1 " ... the Secretary ... may accept and use ... real ... property. Such acceptance may be accomplished under the terms and conditions of restrictive covenants imposed by donors ..." 16 U.S.C. 460k-2 (Refuge Recreation Act (16 U.S.C. 460k-460k-4), as amended).

CCP Supporting Goals (USFWS 2008)

Goal 1. Threatened and Endangered Species

Conserve, protect, and enhance populations of rare, threatened, and endangered species of plants and animals at existing or increased levels on the refuge and conserve, protect, manage, and restore native South Carolina coastal plain habitats occurring on the refuge to contribute to recovery goals.

Goal 2. Migratory Birds

Maintain and actively manage refuge wetlands and uplands primarily to contribute to migratory bird priorities of the refuge and South Carolina coastal plain physiographic area, while providing consistency with state, regional, and national goals.

Goal 4. Wildlife and Habitat Diversity

Protect, manage, and enhance the natural diversity of fish, wildlife, and habitats and the important landscapes of the refuge's coastal plain habitats to ensure that fish and wildlife populations remain naturally self-sustaining.

Goal 5. Forests

Maintain and manage for high-quality oak-pine mixed woodland and edge habitats on Santee NWR to support Neotropical songbirds, such as the painted bunting, and other resident wildlife within the South Carolina Coastal Plain Physiographic Area.

Goal 6. Exotic, Invasive, and Nuisance Species

Control and eliminate, where feasible, exotic, invasive, and nuisance species on the refuge to maintain and enhance the biological integrity of the refuge's native South Carolina coastal plain habitats.

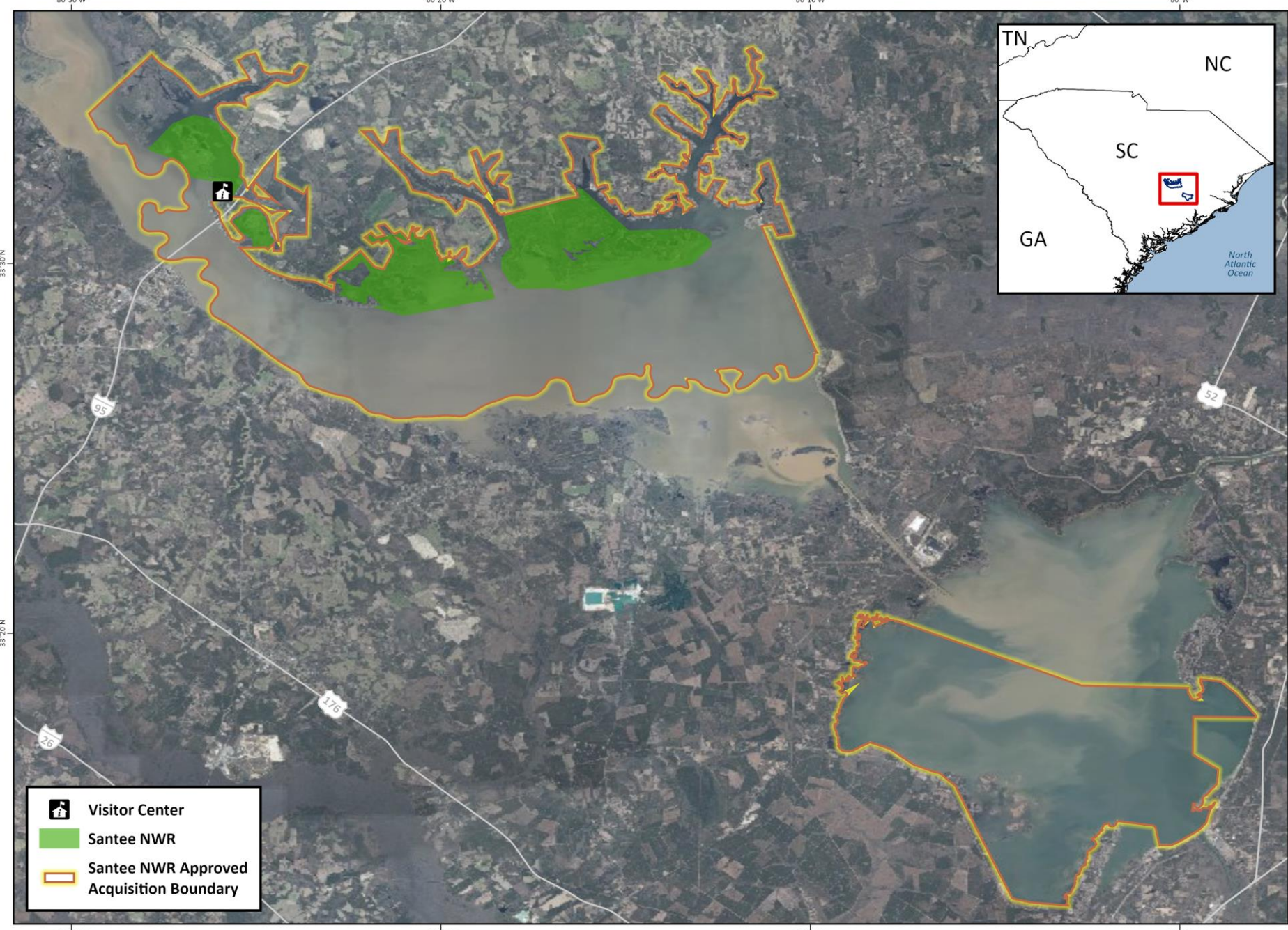


Figure 1. The Santee National Wildlife Refuge boundary and approved acquisition boundary.

Vision (USFWS 2008)

Through a motivated, experienced, and well-trained staff and volunteers, and with active participation of partners, Santee NWR will strive to maintain its unique ecological landscape features. Through team development, the refuge will strive to be a model of excellence in natural resource management and celebrate achievements with the public and our partners. The management of wildlife and habitat on the refuge will be an adaptive, science-based, comprehensive endeavor that links biological needs with resource management. The refuge will actively seek partnerships to support the informational needs of the refuge, being able to adapt and being responsive to change. We will seek and develop appropriate and compatible public use opportunities and enhance awareness and appreciation of the refuge and the Refuge System. The refuge will work in partnership with the state, local agencies, non-governmental organizations, and others to coordinate and enhance resource management, visitor services, and protection. Neighboring communities will support and understand the refuge and appreciate how it enhances the quality of their lives. Through outreach and public participation, the community will share in the values of the Refuge System to ensure a fish and wildlife heritage for all Americans.

Overview and Biological Resources on Santee National Wildlife Refuge

Overview

The Santee NWR is located within Clarendon County South Carolina, on the north side of Lake Marion about 85 miles northwest of Charleston. It is one of many protected areas in this part of South Carolina (Figure 2). The Refuge's management boundary covers approximately 12,870 acres. Major landcover classes are mixed hardwoods, mixed pine hardwoods, pine plantations, marsh, croplands, old fields, ponds, impoundments, and open water. Santee NWR is one of four refuges in the South Carolina Lowcountry National Wildlife Refuge Complex, along with Cape Romain, Ernest F. Hollings ACE Basin, and Waccamaw NWRs (USFWS 2008).

Special Designations

- Audubon Designated Important Bird Area
- Refuge Designated Waterfowl Sanctuary
- Santee Indian Mound/Fort Watson is listed on the National Register of Historic Places

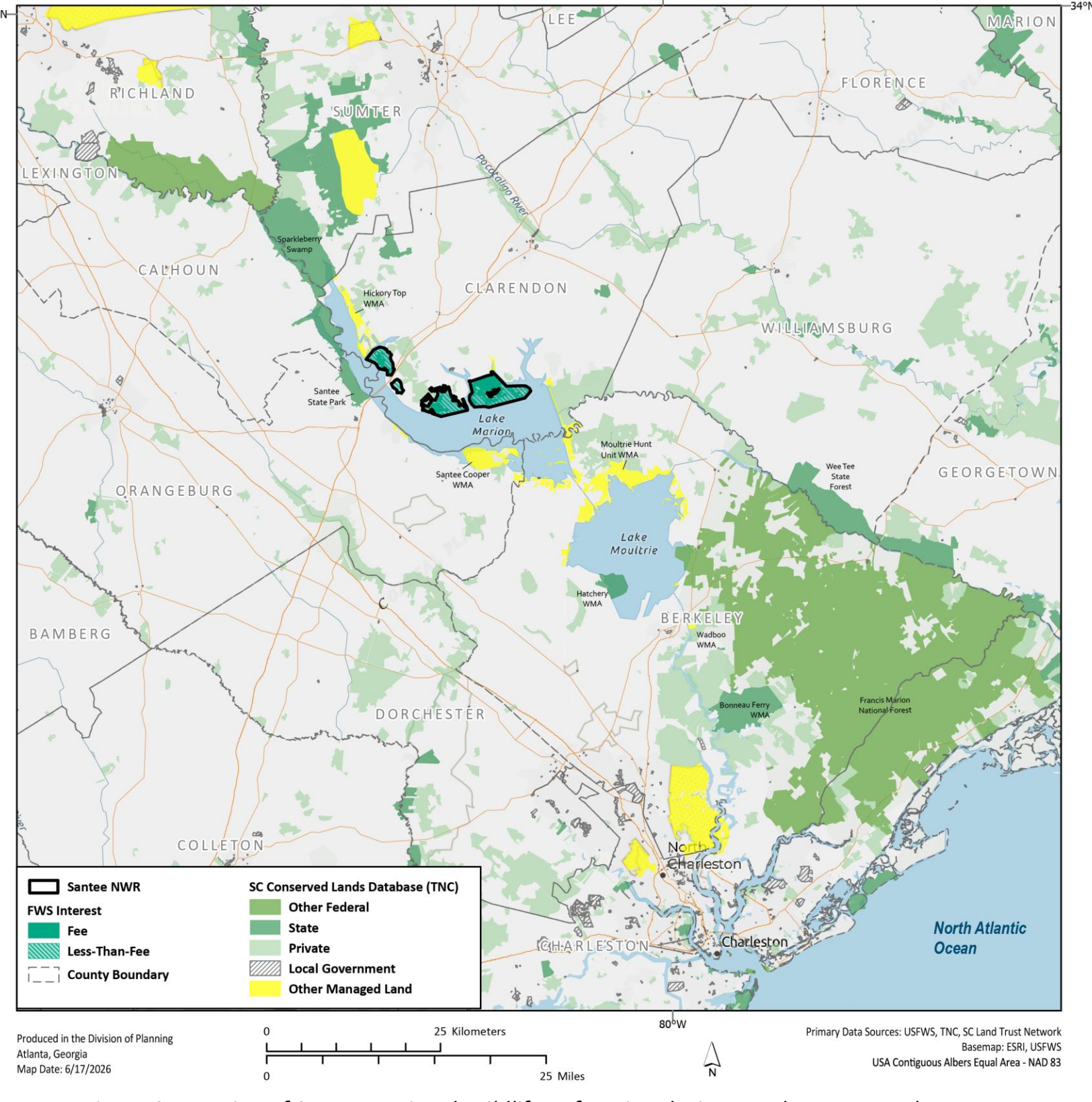


Figure 2. Location of Santee National Wildlife Refuge in relation to other protected areas.

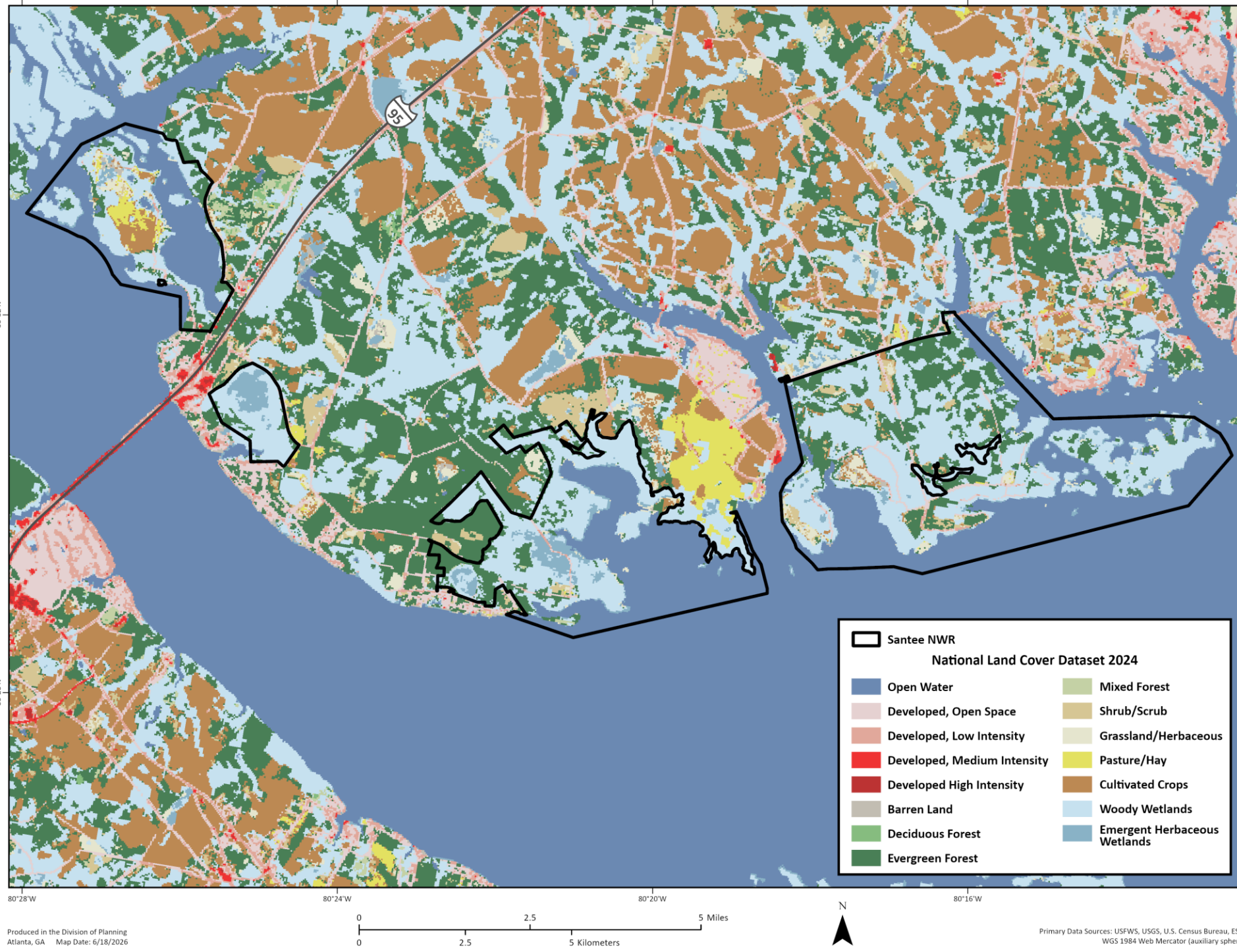


Figure 3. USGS's 2024 land cover classifications in and around the Santee National Wildlife Refuge.

Land Cover

The U.S. Geological Survey's Earth Resources Observation and Science Center creates and provides a suite of products to track and understand Earth's surface. Their land cover data is extremely useful to scientists, resource managers, and decision makers by classifying land use and recording land change over time. The top three land cover classes for the Santee NWR (Figure 3) is:

- Open Water - areas of open water, generally with less than 25% cover of vegetation or soil
- Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water
- Evergreen Forest - areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. more than 75% of the tree species maintain their leaves all year, canopy is never without green foliage

(U.S. Geological Survey 2024)

Santee NWR Physical Resources

Geology and Hydrology

The Santee Limestone underlies a large portion of the South Carolina Coastal Plain Region but is exposed at the surface only along the Santee River valley and its surrounding counties. The most spectacular example of Karst topography (the term given to landscapes which are sculpted primarily by groundwater activity) is in Santee State Park along the western shore of Lake Marion. The park contains sinkholes, caves, disappearing streams, solution valleys, and sinkhole lakes. Park naturalists conduct tours of the caves during times when visits will not bother the native bat population. Rock samples, many of which contain fossils, may be found outside of the park boundaries on both sides of Lake Marion. The limestone itself is composed of a mixture of limey sands, lime muds, and shell-hash layers. Accumulations of oyster beds, from the shallow continental shelf located here 40 million years ago, are found in several places within the major sinkhole area of Santee State Park.

The 110,600-acre Lake Marion (Figure 4) was created from 1939-1942 as a hydroelectric project by the SCPSA and is commonly known as "Santee Cooper". Being in the lower portion of the Santee River basin, it is one of the largest drainages on the east coast. Lake Marion and its companion reservoir, Lake Moultrie, are collectively called the Santee-Cooper Lake System. The Santee River begins at the confluence of the Congaree and Wateree Rivers, approximately 11 miles upriver from the lake. Most of the water coming into the lake is from upstream "blackwater" drainage (Tufford and Mckellar 1999) and from seasonal precipitation patterns.

There is an average annual rainfall of 43 inches, which mostly occurs in June, July, August, and September. With the creation of Lake Marion, the extensive flood-plain and bottomland forest that existed along the Santee River were drowned. The lake is shallower (average 7 feet) in the upper stream (i.e., Santee Swamp) areas and deepens (average 16 feet) at the lower dam area of the lake. The lake becomes wider and deeper below the I-95 Highway, having more lacustrine characteristics.

Santee Cooper manages the water levels in Lake Marion. Lake levels are typically high in summer to provide for hydro-power and recreation, and low in winter to provide flood storage. These seasonal levels are often different than what is needed for water level management and waterbird use at the Santee NWR.

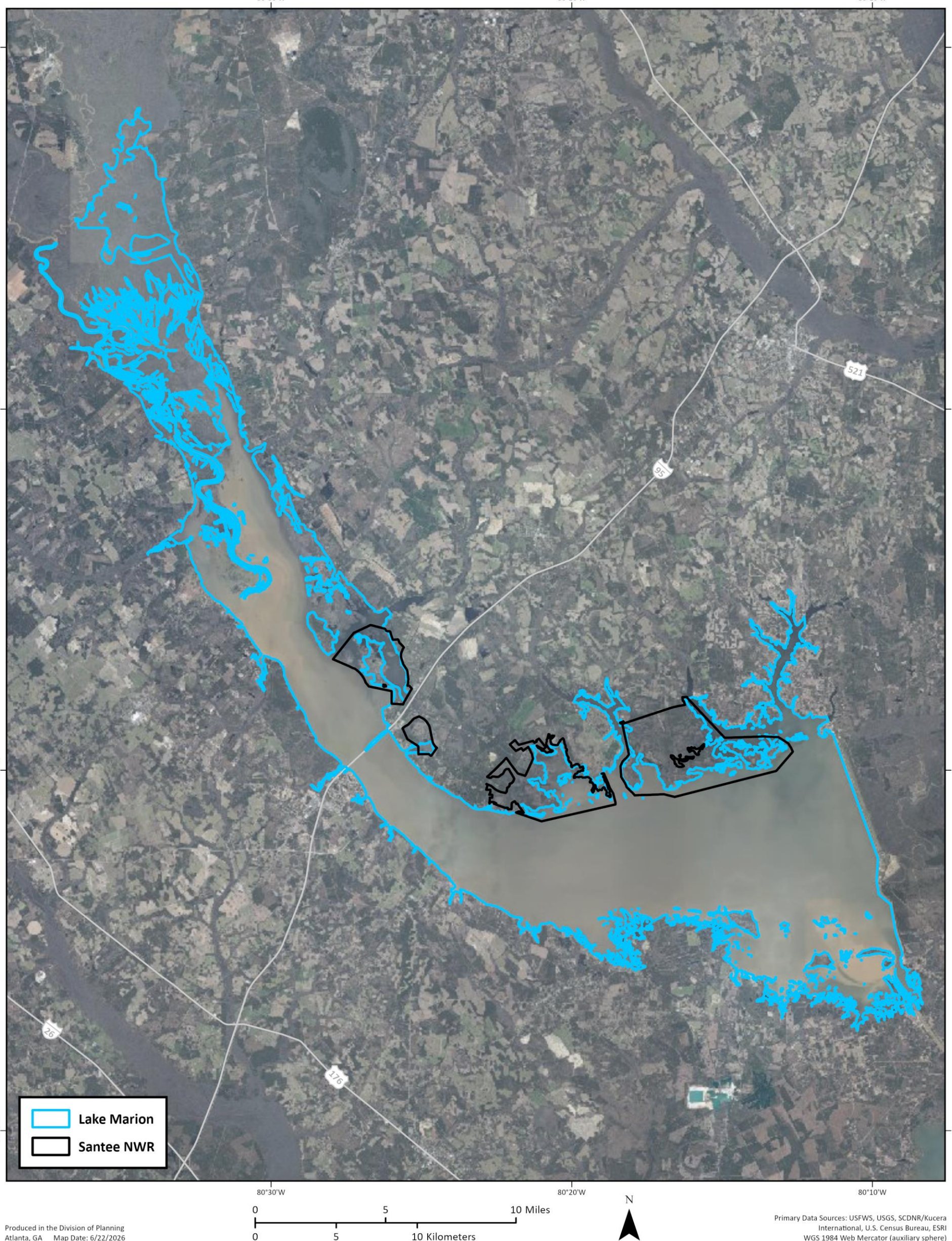


Figure 4. The USGS National Hydrography Dataset's boundary for Lake Marion in relation to the Santee National Wildlife Refuge.

Water Quality and Quantity

Limestone, found in the coastal plain of South Carolina, is exposed in the Santee area near Lake Marion, allowing the formation of features characteristic of Karst topography. This porous limestone is the aquifer for much of the lower part of the state. Because of the rapid flow of groundwater through the Karst system around Santee, the aquifer is highly susceptible to contamination. Quality groundwater supplies for home use and farm irrigation could easily be lost if proper conservation measures are not taken.

Loss of water quality would also have a significant impact on the entire Santee community, including Santee NWR and Santee State Park. As recreation and tourism become an even greater economic resource to this region, a readily available source of groundwater is a critical requirement. The public must become aware of the special properties of limestone rock aquifers and protect such areas from pollution. Measures must be taken so that hazardous waste is not placed in a location that could affect major underground water supplies.

Santee NWR Physical Resources

Cultural Resources

Santee NWR is an important location for Native American history and culture. Built on the Santee Indian Mound overlooking the Santee River, British Fort Watson controlled movement through this important transportation route. Its siege and eventual capture by Francis Marion and his men highlights an interesting chapter of the American Revolution. The Santee Indian Mound is a well-preserved example of flat-topped Native American ceremonial mounds that were once located throughout the southeastern United States. This mound was a gathering place, serving much of the central coastal plain of South Carolina. It served as a platform on which a temple could be built. The mound probably also served as a central distribution point for food and other supplies. These mounds have sometimes been mistakenly identified as burial mounds, but their shape and function were very different from those of burial mounds.

Archaeologists theorize that the Santee Indian Mound was built sometime between 1200 and 1400 A.D., because it occurs along the easternmost extension of the region inhabited by the mound building culture. The spread of the mound culture coincided with the spread of large-scale agriculture and trade among the Native American population.



Figure 3.Santee Indian Mound, O'Brian, Bill/USFWS, Public Domain, <https://www.fws.gov/media/santee-indian-mound-0>

Soils

While the majority of the Refuge's approved acquisition boundary is water, existing soils fit into three taxonomic orders and 21 components based on the United States Department of Agriculture Natural Resources Conservation Service's Soil Survey Geographic Database. Table 1 breaks down these soil classifications in more detail. The NRCS Soil Component Names are soil taxonomic series names, except for Udorthents which represents taxon above the family level. Soil types within the Refuge's approved acquisition boundary include sand, loamy sand, loam, and sandy loam. The dominant drainage class for the majority of these soils is well drained (Figure 5), meaning water is readily removed from the soil, internal free water is deep or very deep, and soils are mainly free of features related to wetness. (Soil Survey Geographic Database, Soil Science Division Staff 2017)

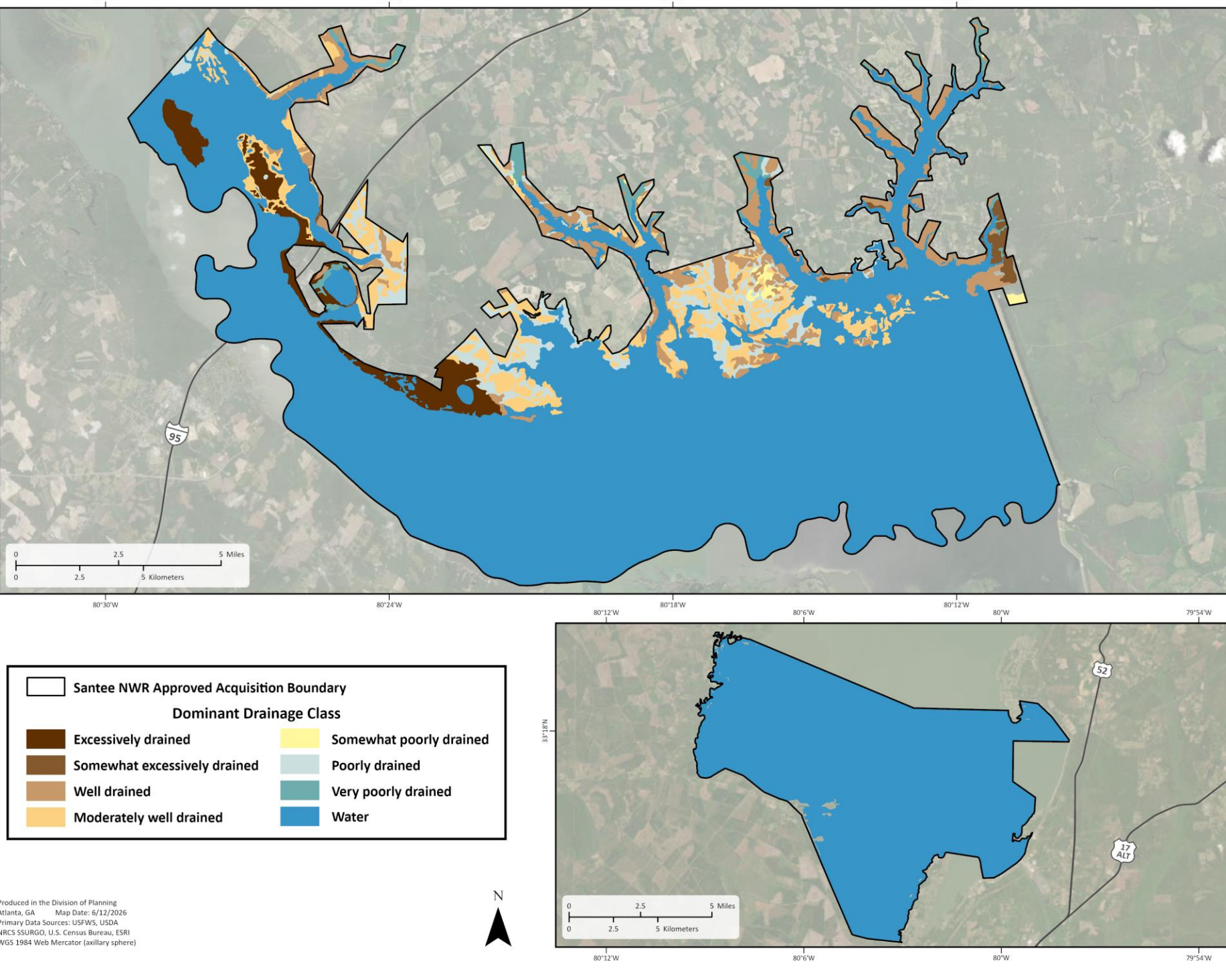


Figure 5. Dominant drainage condition of soils in the Santee National Wildlife Refuge approved acquisition boundary.

Soil Order	NRCS Soil Component Name	Drainage class	US Survey Acres
Entisols	Lakeland	Excessively drained	2,936
	Osier	Poorly drained	41
	Udorthents	Well drained	52
		Moderately well drained	0.1
Inceptisols	Rutlege	Very poorly drained	182
	Tawcaw	Somewhat poorly drained	84
	Cantey	Poorly drained	3,403
	Clarendon	Moderately well drained	379
	Dothan	Well drained	623
	Faceville	Well drained	75
	Foreston	Moderately well drained	468
	Fuquay	Well drained	3,270
Ultisols	Lynchburg	Somewhat poorly drained	199
	Marlboro	Well drained	57
	Ocilla	Somewhat poorly drained	3
	Orangeburg	Well drained	742
	Paxville	Very poorly drained	856
	Persanti	Moderately well drained	5,032
	Rains	Poorly drained	175
	Red Bay	Well drained	266
	Summertown	Well drained	991
	Troup	Somewhat excessively drained	512

Table 1. Classification of soils in the Santee National Wildlife Refuge approved acquisition boundary. (Soil Survey Geographic Database)



Sunrise at Bluff Unit Santee NWR, USFWS, Lake Ecosystem. Public Domain, <https://www.fws.gov/media/sunrise-bluff-unit-santee-nwr>

**Santee NWR: Forested Habitat Objective for
Priority Resources of Concern: Painted bunting (*Passerina ciris ciris*) and Wood thrush (*Hylocichla mustelina*)**

Habitat and Species Objective (Stepped down from CCP Goals 1, 2, 5, 6 and Associated Objectives (USFWS 2008))	Primary Habitat and Wildlife Response Variables	Probable Assessment Methods
Forest Objective 1: On a rotational basis (every 2-4 years), maintain and manage up to 1,200 acres of longleaf, mixed hardwood/pine, and pine stands to support desired stand structure (Table 1), utilizing fire, mechanical, chemical, and biological strategies across the Bluff, Cuddo, Pine Island, and Dingle Pond Units (Figures 1-2 and Table 2). This is part of a larger upland landscape characterized by a mosaic of open forest, scrub-shrub, and grassy patches with the following desired conditions for the painted bunting: - Pine-oak canopy cover less than 75 percent, and/or canopy tree stocking at a basal area less than 50 feet per acre. - Mid-story comprised of 20 to 50 percent woody shrubs, less than 20 feet tall and including fleshy fruit-bearing shrubs, such as wax myrtle and yaupon. - Over time convert loblolly to longleaf pine. Forest Objective 2: As appropriate and possible, manage bottomland hardwood, green tree reservoirs, and cypress/tupelo stands in the Bluff, Cuddo, Pine Island, Dingle Pond Units (Figures 1-2 and Table 2) to support desired forest conditions (Table 3).	- Forest Stand composition, structure, and regeneration - Forest Stand habitat components (snags, coarse woody debris, cavities) - Songbird, woodpecker, raptor, wading bird, wood duck and other cavity nester, use, composition, and abundance - Forest breeding bird use (species composition, abundance, and type of use) - Bat species composition, abundance, and use of forests and cavities	- Forest Inventory sampling (traditional cruise parameter and habitat components) - GIS Stand mapping and harvest records - Regeneration plots - Breeding landbird surveys (point counts) - Cavity checks, mobile acoustical bat surveys - Other wildlife surveys

Table 1. Desired Stand Structure for wildlife habitat in Dry and Mesic Longleaf Pine stands (White and Nordman 2016). SDI = Stand Density Index, BA = Basal Area, DBH = Diameter at Breast Height

Dry & Mesic Longleaf Pine Woodlands Metrics Data Sheet				
If the optional Stand Density Index metric is used, then Canopy Southern Pine Basal Area and Southern Yellow Pine Canopy Cover do not need to be used as metrics				
Canopy Metrics	Excellent = 4.0	Good = 3.0	Fair = 2.0	Poor = 1.0
Canopy Southern Pine Basal Area	30-80 RF/acre basal area of longleaf pine	10 to <30 or >80 to 105 RF/acre basal area of longleaf pine	10 to <20 or >80 to 105 RF/acre basal area of longleaf pine	<10 or >105 RF/acre basal area of longleaf pine
Canopy Southern Yellow Pine Basal Area	30-85% canopy cover of longleaf pine	>20 to <30% or >65 to 75% canopy cover	>20 to 85% canopy cover or >75 to 85% canopy cover	<20 or >85% canopy cover of longleaf pine
Canopy Southern Yellow Pine Canopy Cover	BA ≥ 20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class	BA ≥ 20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class	BA ≥ 20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class	<20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class
Canopy Southern Yellow Pine Stand Age	BA ≥ 20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class	BA ≥ 20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class	BA ≥ 20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class	<20 RF/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥ 14" DBH class
Canopy Hardwood Basal Area	<20 RF/acre BA of hardwood trees	20 to 25 RF/acre BA of hardwood trees	>25 to 35 RF/acre BA of hardwood trees	>35 RF/acre BA of hardwood trees
Stand Density Index (SDI) (applies to longleaf pine)	SDI = 60 – 125 (15–31% of Maximum SDI of 400)	SDI = 60 – 125 (15–31% of Maximum SDI of 400)	SDI = 60 – 125 (15–31% of Maximum SDI of 400)	SDI = 60 – 125 (15–31% of Maximum SDI of 400)
Midstory/Shrub Metrics	Excellent = 4.0	Good = 3.0	Fair = 2.0	Poor = 1.0
Midstory Fire Tolerant Hardwood Cover	<15% cover of midstory fire tolerant hardwoods	15 to <20% cover of midstory fire tolerant hardwoods	20 to <25% cover of midstory fire tolerant hardwoods	>25% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20 to <30% cover of woody midstory	30 to <40% cover of woody midstory	>40% cover of woody midstory
Short Shrub (3-10 ft) Cover	Short shrubs average <30% cover	Short shrubs average 30 to 35% cover	Short shrubs average >35 to 45% cover	Short shrubs average >45% cover
Tall Shrub (10-16 ft) Cover	Tall shrubs average <20% cover	Tall shrubs average 20 to 30% cover	Tall shrubs average >30 to 40% cover	Tall shrubs average >40% cover
Ground Layer Metrics	Excellent = 4.0	Good = 3.0	Fair = 2.0	Poor = 1.0
Overall Native Herbaceous Ground Cover	40-98% herbaceous cover	30 to <40% or >88% herbaceous cover	20 to <30% herbaceous cover	<20% herbaceous cover
Longleaf Pine Regeneration	Longleaf pine regeneration cover is ≥ 15% of stand (Good and Excellent)	Longleaf pine regeneration cover is ≥ 15% of stand (Good and Excellent)	Longleaf pine regeneration cover is present but is <15% of stand or no regeneration seen, but one longleaf pine seedling is present	Longleaf pine regeneration cover is sparsely present but is <15% of stand or no regeneration is present, but one longleaf pine seedling is present
Native Warm Season Grass Cover	>25 to 97% foliar cover of all native warm season grasses	>15 to 25% or >97% foliar cover of all native warm season grasses	10-15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Identification	Invasive nonnative plant species cover is very low (<5% cover)	Invasive nonnative plant species in any stratum present, but <10% of cover	Invasive nonnative plant species in stratum uncommon or <10% cover	Invasive nonnative plant species in any stratum >10% cover
Final Score by:				Canopy Score
Canopy Score	4.0 to 3.5 = Excellent, 3.5 to 2.5 = Good, 2.5 to 1.5 = Fair, 1.5 to 1.0 = Poor			4.0 to 3.5

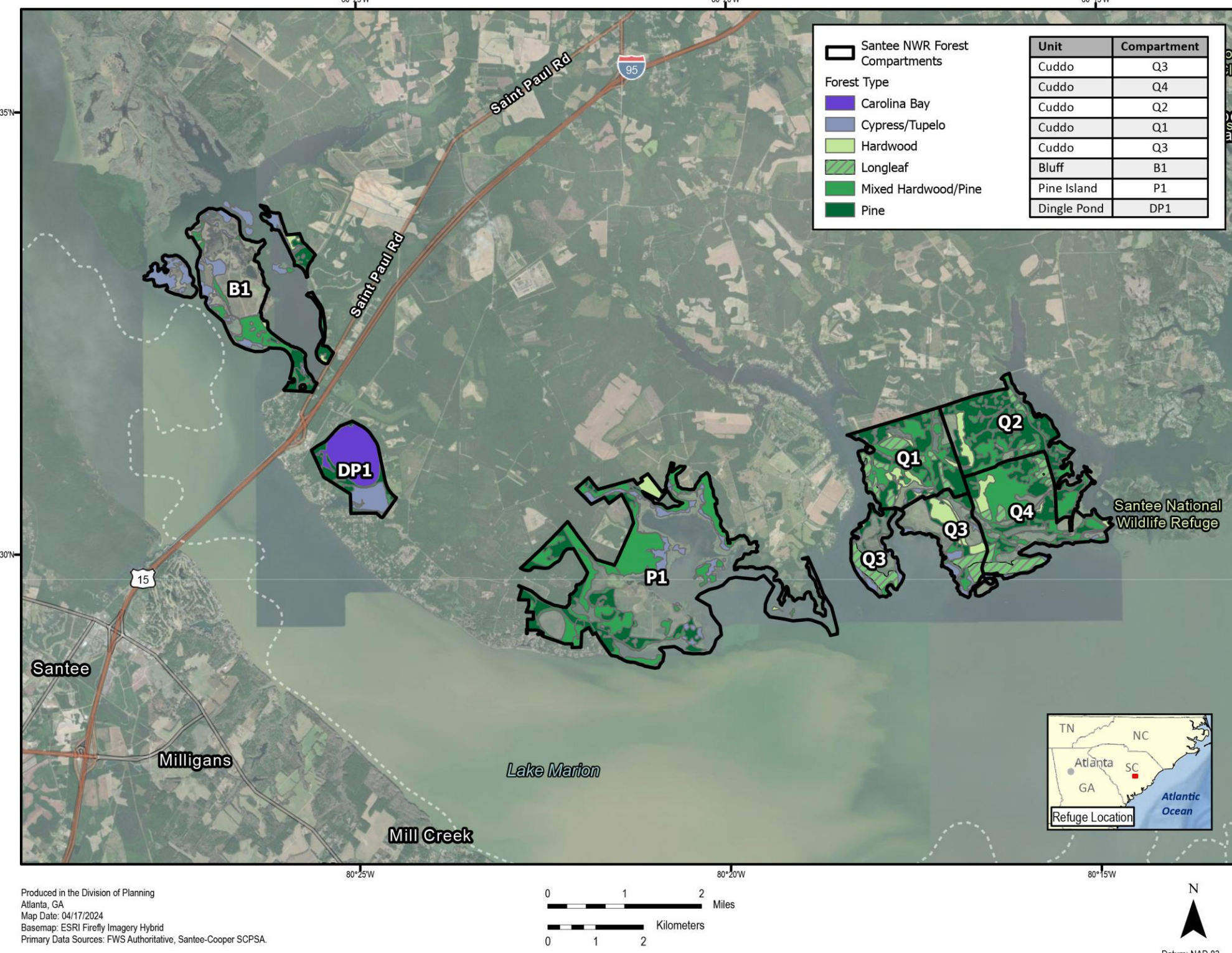


Figure 1. Forest types on Santee National Wildlife Refuge, Clarendon County, South Carolina.

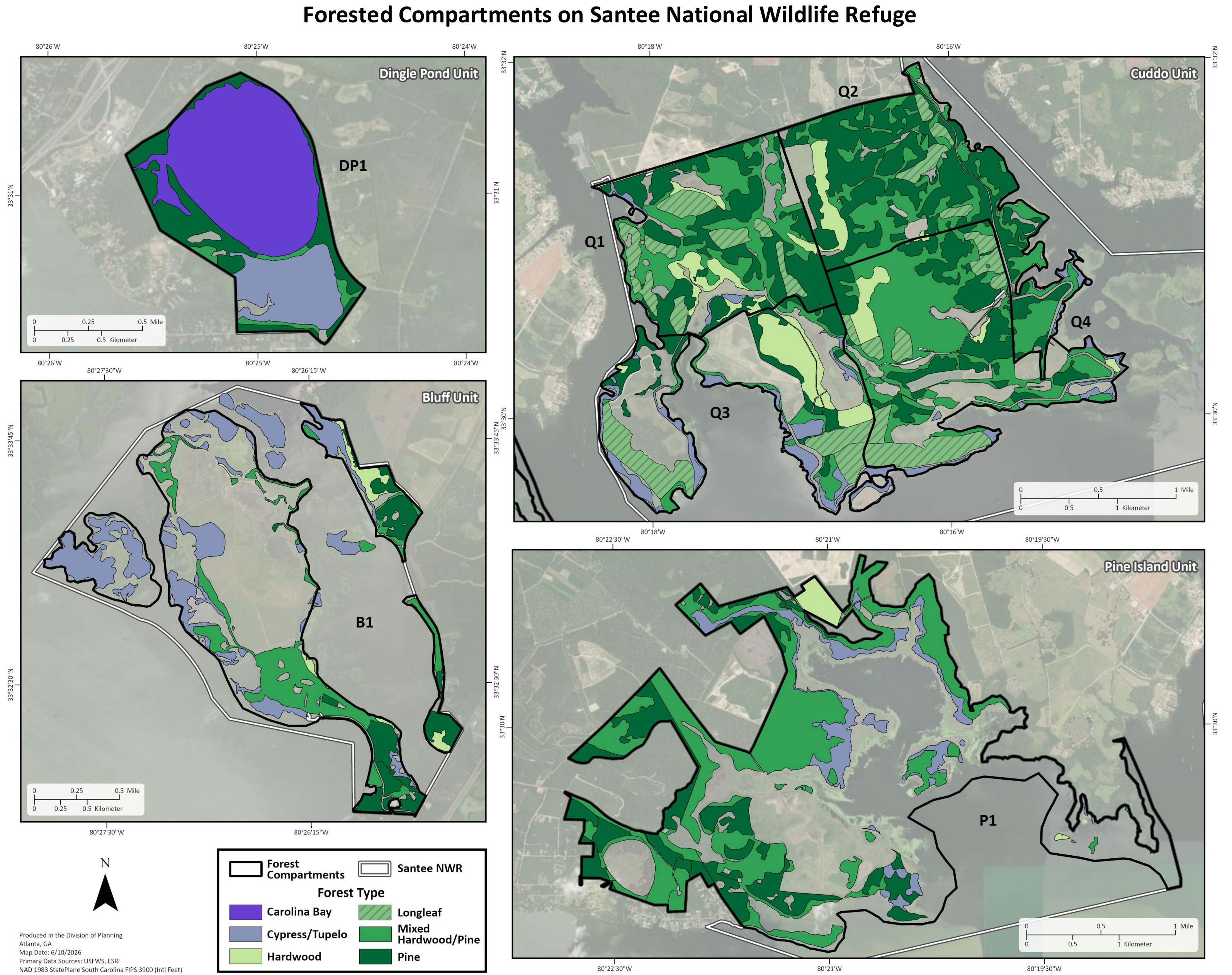


Figure 2. Forest types within each forest compartment of Santee National Wildlife Refuge.

Forest Type	Acres			
	Cuddo	Pine Island	Dingle Pond	Bluff
Carolina Bay	0	0	273	0
Cypress/Tupelo	163	172	90	258
Hardwood	247	37	0	28
Longleaf	445	0	0	0
Mixed Hardwood/Pine	927	751	16	168
Pine	1,055	356	100	116

Table 2. Acres of each forest type present in each land unit of Santee National Wildlife Refuge.



Bald cypress forest at Santee National Wildlife Refuge, Marc Epstein/USFWS, Public Domain, <https://www.fws.gov/media/bald-cypress-forest-santee-national-wildlife-refuge>

Priority Resources of Concern: Painted bunting (*Passerina ciris ciris*) and Wood thrush (*Hylocichla mustelina*)
Other species that may benefit: Bachman's Sparrow, prothonotary warbler (*Protonotaria citrea*), yellow-billed cuckoo (*Coccyzus americanus*), wood duck, rusty blackbird, eastern red bat (*Lasiurus borealis*), tricolored bat (*Perimyotis subflavus*), evening bat (*Nycticeius humeralis*), eastern wood-pewee (*Contopus virens*), black-throated blue warbler (*Setophaga caerulescens*), worm-eating warbler (*Helmitheros vermivorum*), and scarlet tanager (*Piranga olivacea*).

Painted Buntings

Santee NWR hosts what is thought to be the furthest inland nesting area for birds inhabiting the inner coastal plain (USFWS 2005). Across the Refuge, the birds are sighted along woodland edges and in grassland/scrub-shrub habitats during the April to August breeding season and occasionally during the fall (USFWS 2020a). However, based on breeding bird survey data, the state's population hasn't recovered from historic declines. Valuable wetland and scrub-shrub habitats that support the Atlantic coast populations continue to be converted into managed pine stands and residential development, highlighting the need to protect existing habitat (USFWS 2019). To sustain a population of 100 to 200 breeding pairs of painted buntings requires landscapes 1,200 to 2,500 acres characterized by a mosaic of open forest or woodland, scrub-shrub, and grassy patches adjacent to a water source, such as emergent marsh, stream, or canal (USFWS 2019).

For painted buntings, ideal pine-hardwood stands should have a canopy cover less than 75 percent, and/or canopy tree stocking at a basal area of 50 feet or less per acre. The forest mid-story should have a 20 to 50 percent woody shrub component (less than 20 feet tall) that contains fleshy fruit-bearing shrubs such as wax myrtle and yapon (USFWS 2019). Management activities that would benefit painted buntings on the Refuge include conducting prescribed burns on a 4-to-6-year basis in areas of pine and mixed pine-hardwood forests to control mid-story development and favor a mosaic of understory vegetation and grass ground cover (USFWS 2019).



A pair of Painted Bunting. Photo Credit: Marc Epstein, USFWS

Wood Thrush

The wood thrush is listed as a bird of conservation concern and a migratory bird of management priority by the U. S. Fish and Wildlife Service. Partner organizations, including Partners in Flight and the South Atlantic Joint Venture have also included the wood thrush as a high priority species in need of management action (U.S. Fish and Wildlife Service 2013). The wood thrush requires contiguous tracts of mixed hardwood-pine forests for breeding and protection. As the wood thrush loses more wintering habitat in the tropics, mixed forests such as those provided at Santee NWR become more important for nesting. The wood thrush breeds mainly in the interior woodlands of mostly deciduous but sometimes mixed forests within areas that support tall, mature trees. Numbers have declined in recent decades due to nest parasitism by brown-headed cowbirds (*Molothrus ater*). As forests are cut into smaller fragments, it apparently becomes easier for cowbirds to penetrate these small woodlots and locate thrush nests. High forest density is therefore essential for wood thrush nesting success to prevent nest parasitism. The Refuge also benefits many other interior neotropical bird migrants through its protection of dense mixed forests for wood thrush.

Table 3. Desired Stand Structure for wildlife habitat in many bottomland stands in the Southeast (LMJV Working Group 2023).^{1,2} BA = Basal Area, dbh = diameter at breast height

Stand Factors	Desired Stand Structure Targets	Conditions that may warrant management
Primary Factors		
Overstory Canopy Cover	60% – 70%	>80% or <50%
Midstory Canopy Cover	30% – 40%	<20% or >50%
Relative Basal Area	60% – 70% of maximum BA	>80% of maximum BA
Secondary Factors		
Dominant Trees	>1/acre	
Understory Canopy Cover	25% – 40%	
Shade-Intolerant Regeneration ³	30% – 40% of area	
Coefficient of Variation of BA ⁴	≥30%	
Older/Den/Cavity Trees⁵	15% – 20% of BA ≥20" dbh	
Stressed Trees and Snags⁶	≥6 trees/acre ≥10" dbh, ≥2 trees/acre ≥20" dbh, or ≥4 ft ² BA ≥ 10" dbh	

¹ Treatments may reduce the values of a factor below the desired range to obtain sufficient sunlight and allow for growth into the desired range.

² Present not on every acre, but for at least 5 – 10 acres up to the entire stand. Regenerating Forest >7 acres and canopy gaps <7 acres (Chapter 3), contribute to the stand averages.

³ Advance reproduction of shade-intolerant trees in sufficient numbers for their size to ensure their eventual development into the overstory canopy. Areas of advance reproduction of shade-intolerant trees can be released through canopy gaps <7 acres, but should be restricted to ≤50% of stand acres.

⁴ Calculated from BA by plot samples with ≥20 sample points.

⁵ Calculated from BA by plot samples. Trees ≥20" dbh, where possible, are older and have the potential for dens/cavities.

⁶ Calculated from BA by plot samples of actual stressed trees or snags. Older Age/Den/Cavity Trees and Stressed Trees and Snags can be the same stems, the values in these two Secondary Factors are not cumulative.

Potential and Selected Management Strategies and Tools

Forest Habitat Management Strategies:
Potential and Selected Strategies in Forest Management Units (Figures 1-2)

Inventory and determine Stand baseline data

Prescribed Fire

Intermediate Treatments

- Crown Thinning (thinning of dominants and co-dominants)
- Low Thinning (thinning of suppressed and intermediates)
- Free Thinning (planned combination of various thinning)
- Variable Density Thinning (varied target residual stocking)
- Thinning by Rules (BA, diameter, species, spatial, etc.)
- Salvage/Sanitation Cutting

Regeneration Harvest Methods

- Uneven-aged
 - Individual Tree Selection
 - Group Selection
 - Patch Selection
 - Femelschlag (expanding gaps)
- Even-aged with or without reserves
 - Shelterwood
 - Seed Tree
 - Clear-cuts

Non-commercial Forest Stand Improvement Strategies

- Prescribed Fire
- Mulching
- Pre-commercial Thinning
- Wildlife Stand Improvement
- Sanitation Cutting
- Hydrological Restoration

Mechanical Management (Site Preparation for Plantations)

- Disking
- Mowing
- Ripping/Subsoiling
- Hydrological Restoration

Chemical Management (Site Preparation, Treatment of Invasives, and within Stand Manipulation)

- Pre-emergent
- Hack and squirt
- Stem injection
- Cut stump
- Basal spray
- Streamline
- Foliar spray
- Fogging

Stand Regeneration/Plantation Establishment Strategies

- Site Preparation for Natural Regeneration
- Coppice
- Planting seedlings or cuttings
- Direct seeding
- Under-planting

Utilize State Best Management Practices when Conducting Forestry Operations

Monitor Future Vegetation Community Trends

(Note: for general definitions of treatment and strategy terms used in this section see e.g., Smith (1962))

Nuisance Animal Control: Potential Strategies for Forest Management Units

- Employ integrated pest management techniques when a species is having a significant impact on an area resulting in major habitat replacement or damaging rare species.
- Determine the need for site-specific control, based on the potential of the nuisance animals to negatively affect wildlife and habitat management objectives on the refuge.
- Monitor results and adjust strategies if warranted
- Potential control methods:
 - Trapping/shooting
 - Habitat Manipulation/Mechanical Control
 - Chemical Control
 - Biological Control

Invasive Plant Control: Potential Strategies for Forest Management Units

- The following strategies will be utilized in Forest Habitat Management and Afforestation to control invasive plant species:
- Prior to the initiation of invasive species control efforts, refuge staff must understand the biology of the species to be controlled
 - Prevent introduction of invasive species
 - Eradicate new or small infestations
 - Employ early detection and rapid response actions
 - Prioritize invasive plant control efforts
 - Control or contain large established infestations; eradicate if possible
 - Monitor results and adjust strategies if warranted
 - Potential control methods:
 - Habitat Manipulation/Mechanical Control
 - Chemical Control
 - Biological Control
 - Prescribed Fire

Prescribed Fire Management

- Utilize prescribed fire as a wildfire mitigation tool to manage and maintain appropriate habitat conditions and/or reduce fuel loads to minimize wildfire risks.
- Explore opportunities to use partners, such as the Forest Service, to provide fire crews and equipment that is not available on the refuge.
- The prescribed fire program is to be designed to mimic natural fire regimes as much as possible. Fire frequency, intensity, burn season, and spatial pattern should be suited to the specific habitat objectives for each habitat classification.
- Conduct a vigorous prescribed fire program consistent with the highest professional and technological standards.
- Continually evaluate the prescribed fire program to better meet program objectives by updating prescriptions and monitoring plans, and by integrating newly proven technical and scientific treatments.
- Ignition shall be in accordance with Service policy as detailed in the *Interagency Standards for Fire and Fire Aviation Operations* (NFES 2724).
- No ignition shall occur without an approved prescribed fire plan and concurrence of the Project Leader.
- Ignition methods shall be selected with due regard for safety and smoke management concerns.

Santee NWR: Grassland and Upland Cropland Objective for Priority Resources of Concern: Eastern Painted Bunting (*Passerina ciris ciris*), Sandhill Crane (*Grus canadensis*), Wintering Grassland Birds

Habitat and Species Objective (Stepped down from CCP Goals 1, 2, 6 and Associated Objectives (USFWS 2008))	Primary Habitat and Wildlife Response Variables and Survey Methods
Grassland Objective: On an annual basis, maintain and manage up to 1,200 acres (See Figures 1 + 3 and Table 1) of grassland-dominated, early successional habitat across the Bluff, Cuddo, and Pine Island Units, as part of a larger upland landscape characterized by a mosaic of open forest, scrub-shrub, and grassland patches with the following desired conditions for breeding and migrant painted buntings, and wintering grassland birds: - One hundred acre or more grassland patches of greater than 50 percent native warm-season grasses, such as broomsedge (<i>Andropogon virginicus</i>), little bluestem (<i>Schizachyrium scoparium</i>), Indiangrass (<i>Sorghastrum nutans</i>), and switch grass (<i>Panicum virgatum</i>). - Interspersed, 2-to-10-acre patches or edge habitat of 3-to-18-foot-tall native woody shrubs including wax myrtle (<i>Myrica cerifera</i>), yaupon (<i>Ilex vomitoria</i>), American beautyberry (<i>Callicarpa americana</i>), Eastern red cedar (<i>Juniperus virginiana</i>), Ironwood (<i>Ostrya virginiana</i>), American holly (<i>I. opaca</i>), Elderberry (<i>Sambucus nigra</i>), and Sumac (<i>Rhus spp.</i>), with a grassy understory. - Less than 30 percent encroachment by woody species, such as sweet gum (<i>Liquidambar styraciflua</i>) and groundsel tree (<i>Baccharis halimifolia</i>).	- Breeding bird surveys - Water depth - Grassland plant composition - Winter Grassland bird surveys and projects - Crane surveys - Habitat use surveys
Upland Agriculture Objective: Annually, manage up to 50 acres of croplands among Fields A, B, and C in the Bluff Unit (Figures 2-3 and Table 2) for grain crops such as milo, corn, or millet to create a minimum of 237,500 Waterfowl Energy Days to benefit sandhill cranes and other native wildlife.	- Waterfowl counts (monthly Nov -Feb) - Crane surveys - Other wildlife and habitat surveys - Grassland Bird surveys

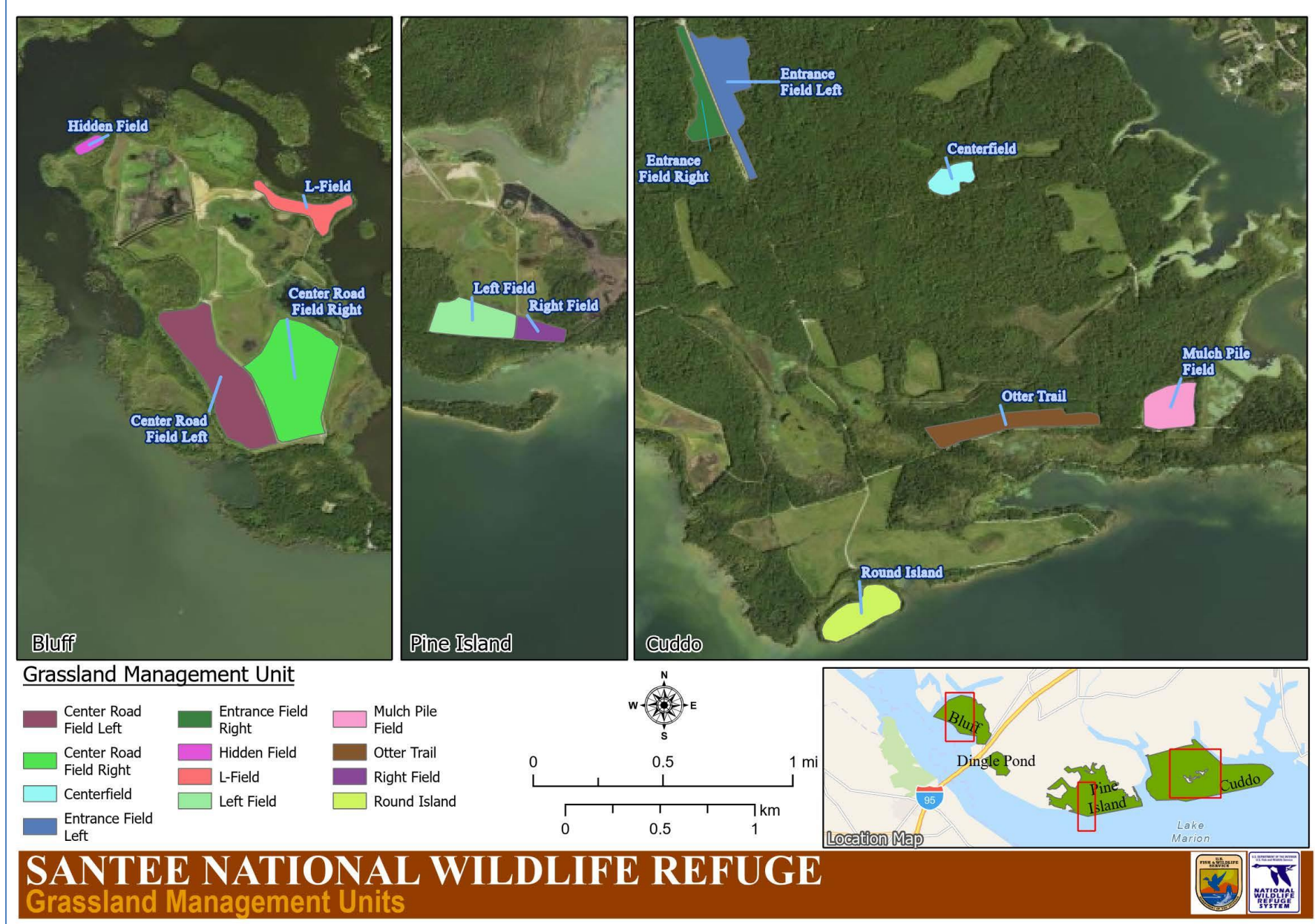


Figure 1. Grassland Management Units with Unit Names on Santee National Wildlife Refuge, Bluff, Pine Island, and Cuddo Units.



Figure 2. Upland Agricultural Unit with Unit Names on Santee National Wildlife Refuge, Bluff Unit.

Grassland and Upland Agriculture Units on Santee National Wildlife Refuge

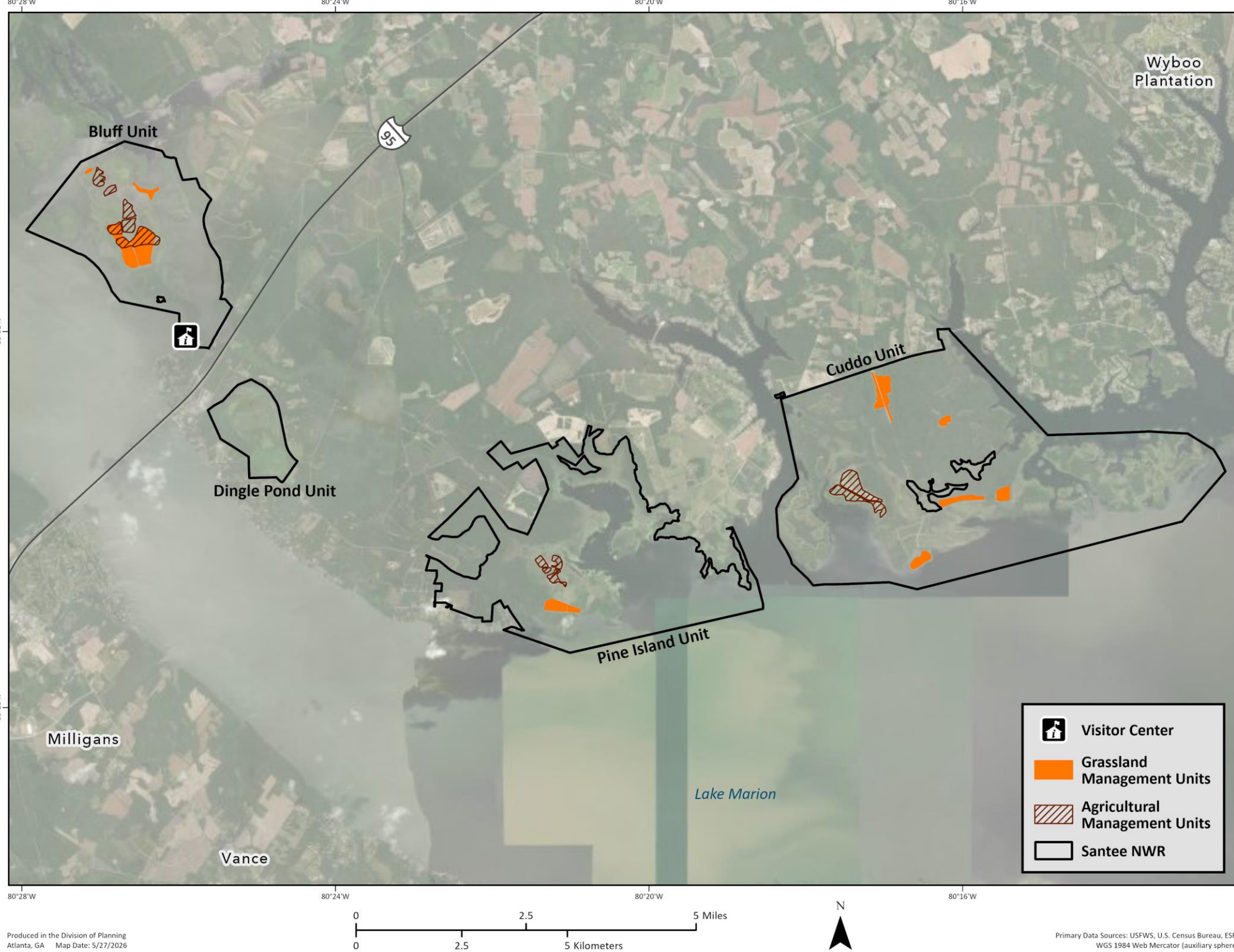


Figure 3. Grassland and agricultural management units on Santee National Wildlife Refuge.



LeConte's Sparrow Singing on the Prairie, Kimberly Emerson/USFWS, Public Domain, <https://www.fws.gov/media/lecontes-sparrow-singing-prairie>

SECAS SE Conservation Blueprint : Grassland & Savanna Restoration Indicator

The SECAS 2025 Southeast Conservation Blueprint uses a set of natural and cultural resource indicators to produce its main conservation priority categories. Their grassland & savanna restoration indicator represents potential restoration opportunities for grasslands and savannas within their historic ranges. Specifically, the classes represent:

- Highest - in a grassland/savanna hub, in a protected area with management potential, in a historic patch >10 acres
- Very high - in a grassland/savanna hub, unprotected landcover with good restoration potential, in a historic patch >10 acres
- High - outside a grassland/savanna hub, in a protected area with management potential, in a historic patch >10 acres
- Medium - outside a grassland/savanna hub, unprotected landcover with good restoration potential, in a historic patch >10 acres
- Low - other historic grassland/savanna
- Very low - already known or likely grassland/savanna

Santee NWR contains over 500 acres of land that has highest restoration potential. Figure 4 shows the spatial distribution of each class within the Santee NWR.

(SECAS 2025)

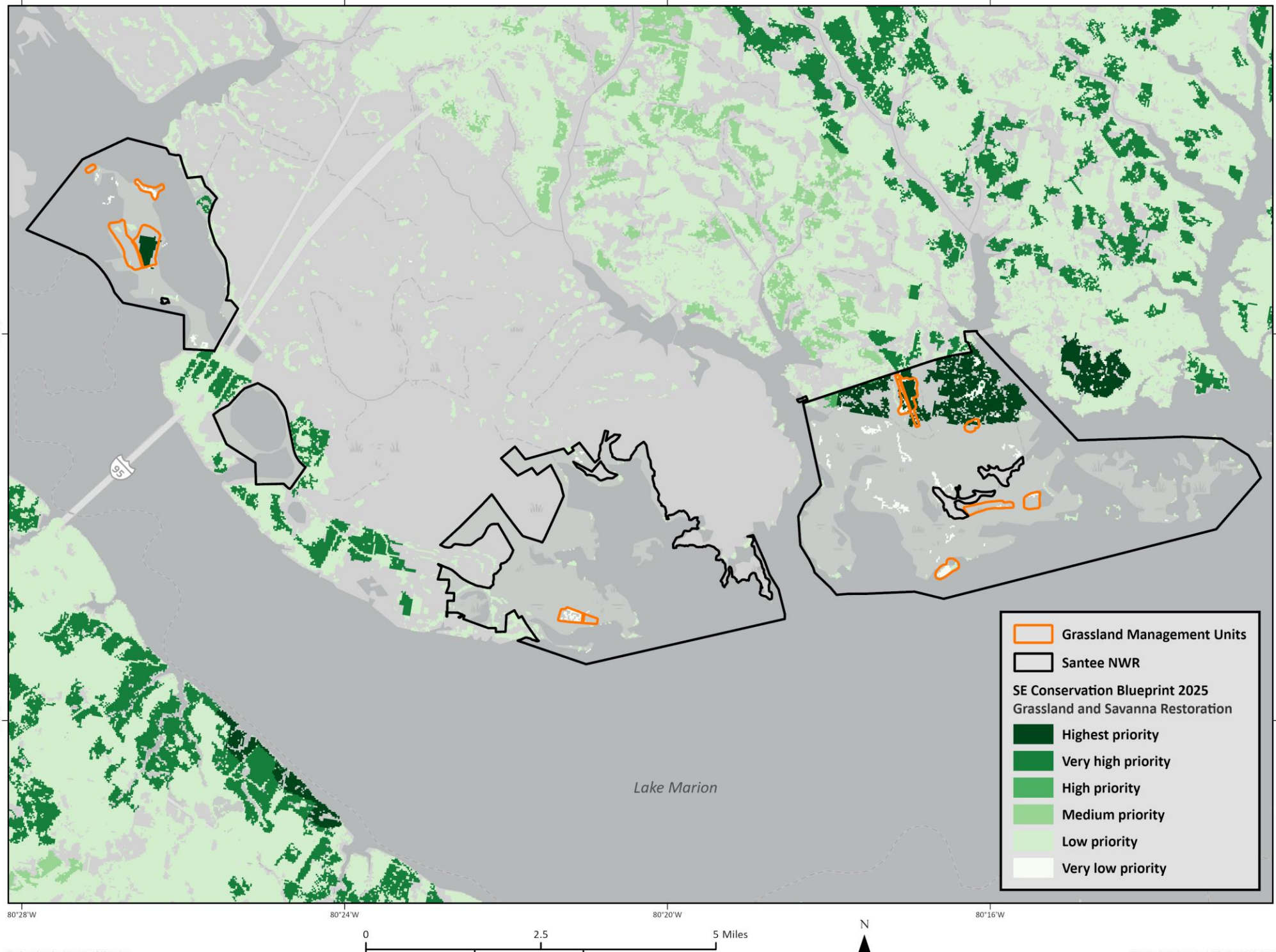


Figure 4. Grassland management units in relation to the SECAS SE Conservation Blueprint's grasslands and savanna restoration indicator on Santee National Wildlife Refuge. This indicator was originally sourced from multiple projects including the Longleaf Suitability Analysis and the National Land Cover Database.

Priority Resources of Concern: Eastern Painted Bunting (*Passerina ciris ciris*), Sandhill Crane (*Grus canadensis*), Wintering Grassland Birds – Henslow's sparrow (*Centronyx henslowii*), LeConte's Sparrow (*Ammodramus leconteii*)

Other benefitting species: Loggerhead shrike (*Lanius ludovicianus*), American woodcock (*Scolopax minor*), Bachman's sparrow (*Peucaea aestivalis*), prairie warbler (*Setophaga discolor*), Northern bobwhite (*Colinus virginianus*), Eastern towhee (*Pipilo erythrophthalmus*), field sparrow (*Spizella pusilla*), Eastern kingbird (*Tyrannus tyrannus*), brown thrasher (*Toxostoma rufum*), grasshopper sparrow (*Ammodramus savannarum*), Northern harrier (*Circus hudsonius*), American kestrel (*Falco sparverius*), and Eastern meadowlark (*Sturnella magna*)

Priority Resource of Concern

Painted Bunting: Santee NWR hosts what is thought to be the furthest inland nesting area for birds inhabiting the inner coastal plain (USFWS 2005). Across the Refuge, painted buntings are sighted along woodland edges and in grassland and scrub-shrub habitats during the April to August breeding season and occasionally during the fall (USFWS 2020).

To sustain a population of 100 to 200 breeding pairs of painted buntings requires landscapes of 1,200 to 2,500 acres characterized by a mosaic of open forest or woodland, scrub-shrub, and grassy patches adjacent to a water source, such as emergent marsh, stream, or canals (USFWS 2019). Preferred ground cover is comprised of greater than 50 percent native grasses and 2-to-10-acre patches of shrubs or edge habitat, 3-to-18-foot-tall with a grassy understory (USFWS 2019). Management activities that would benefit painted buntings within Santee NWR's early successional habitats include maintaining or increasing the current acreage of grassland habitats and establishing buffers of warm season grass-forbs-legumes around crop fields (USFWS 2019).

Priority Resource of Concern

Grassland Songbirds: Henslow's and LeConte's sparrows both are identified as a species of Continental Concern by Partners in Flight (Rosenberg et al. 2016) and a Bird of Conservation Concern by the Service (USFWS 2021b). In South Carolina, McNair and Post (2000) noted that winter populations of the two birds were "much more abundant" in late 1800s and early 1900s and attributed their early declines to the conversion of grasslands to row crops and pine plantations, and more recently, relative scarcity of old fields and urbanization. The Henslow's sparrow is listed as Species of Highest Conservation Concern by the South Carolina Department of Natural Resources (SCDNR 2015). South Carolina supports autumn migrant and wintering populations of Henslow's sparrows and LeConte's sparrows (SCDNR 2015). Here, the species are known to winter in upland, open habitats with dense ground cover (McNair and Post 2000); Henslow's sparrows also are found in longleaf pine (*Pinus palustris*) savanna habitats (Carrie et al. 2002, Tucker and Robinson 2003, Bechtoldt and Stouffer 2005). Although rare, both birds have been sighted on Santee NWR, on the Pine Island Unit. However, in recent years, encroaching woody vegetation into the Unit's open habitats has been reducing habitat quality for these and other wintering grassland birds. McNair and Post (2000) noted that within the lower coastal plain habitats, maintaining and/or restoring 100 acre or more patches of one-to-five-year-old fields containing native species, such as moist and dry broomsedge, crabgrass, and *Panicum spp.* would benefit grassland sparrows, and managing longleaf pine stands for dense ground cover such as wire-grass and beakrush also would provide high-quality wintering grounds for the Henslow's sparrow (McNair and Post 2000).

Priority Resource of Concern

Sandhill Crane: Across their range, the major threat to sandhill cranes is habitat alteration and loss. Cranes exhibit strong site fidelity to stopover, breeding, and wintering sites making them vulnerable to population declines when these key areas are lost or degraded (Kaufman 2014). Since the 1980s, the acreage of agricultural lands that supported wintering cranes in the Eastern Flyway Population has declined (Gerber et al. 2020). In addition to the loss of agricultural lands, changes in agricultural practices, oil and mineral extraction, and development all represent potential long-term risks to crane populations (Krapu et al. 2011). Other threats include reduced habitat quality or availability from infestations of non-native vegetation, such as common reed and purple loosestrife (Kessler et al. 2011), and mortality from powerline collisions and wind turbines (Walkinshaw 1956, Faanes and Johnson 1992, Ward and Anderson 1992, Navarrete and Griffis-Kyle 2014).

Management actions that are known to benefit sandhill cranes include: 1) preserving and managing habitat complexes composed of riverine roost sites in close proximity to cornfields, lowland grasslands, and alfalfa (Davis 2003); 2) considering all habitats within about three miles of known roosts when planning for habitat management, mitigation, acquisition, and easements (Ivey et al. 2015); and 3) managing for food resources around roost sites, especially in areas where cranes show strong site fidelity (Ivey et al. 2015).



Sandhill Cranes, Karney, Lee/USFWS, Public Domain, <https://www.fws.gov/media/sandhill-cranes-16>

Potential and Selected Management Strategies and Tools

Administrative Land Management Unit	Grassland Management Unit	Acres
Bluff	Center Road Field Left	53
Bluff	Center Road Field Right	61
Bluff	Hidden Field	3
Bluff	L-Field	12
Cuddo	Centerfield	9
Cuddo	Entrance Field Left	30
Cuddo	Entrance Field Right	14
Cuddo	Mulch Pile Field	17
Cuddo	Otter Trail	23
Cuddo	Round Island	19
Pine Island	Left Field	22
Pine Island	Right Field	7

Cropland Habitat Management for Upland Species

Cooperative Farming (25% Refuge share and 75% Cooperative farmer share) and Refuge Farming

The refuge and cooperative farmer will jointly select the crops that best meet the needs of waterfowl and the farmer (rice, milo, soybeans, millet, and moist-soil plants), and the locations for the refuge's share of the crop to provide the most benefit for waterfowl foraging use.

Some grain crops retained for wildlife should be in a dry, non-flooded location.

All chemicals will be approved through the Pesticide Use Proposal process and will follow Integrated Pest Management Policy (§69 FW 1).

Herbicide treatments allow for very selective removal of plant species or groups of species, with little or no damage to crops that are considered desirable. Insecticides and fungicides reduce the impacts of insects and fungal diseases on crops, protecting the crops and increasing the yield potential. Pesticides will be applied according to the directions on the label, and used solely for the purpose for which the chemical was designed. A list of permissible herbicides is maintained within the Pesticide Use Permit Database.

Prescribed Fire Management

- Utilize prescribed fire as a wildfire mitigation tool to manage and maintain appropriate habitat conditions and/or reduce fuel loads to minimize wildfire risks.
- Explore opportunities to use partners, such as the Forest Service, to provide fire crews and equipment that is not available on the refuge.
- The prescribed fire program is to be designed to mimic natural fire regimes as much as possible. Fire frequency, intensity, burn season, and spatial pattern should be suited to the specific habitat objectives for each habitat classification.
- Conduct a vigorous prescribed fire program consistent with the highest professional and technological standards.
- Continually evaluate the prescribed fire program to better meet program objectives by updating prescriptions and monitoring plans, and by integrating newly proven technical and scientific treatments.
- Ignition shall be in accordance with Service policy as detailed in the *Interagency Standards for Fire and Fire Aviation Operations* (NFES 2724).
- No ignition shall occur without an approved prescribed fire plan and concurrence of the Project Leader.
- Ignition methods shall be selected with due regard for safety and smoke management concerns.

Administrative Land Management Unit	Agriculture Management Unit	Acres
Bluff	Field A	46
Bluff	Field B	15
Bluff	Field C	13

Invasive Plant Control: Potential Strategies

The following strategies will be utilized in Forest Habitat Management and Afforestation to control invasive plant species:

- Prior to the initiation of invasive species control efforts, refuge staff must understand the biology of the species to be controlled
- Prevent introduction of invasive species
- Eradicate new or small infestations
- Employ early detection and rapid response actions
- Prioritize invasive plant control efforts
- Control or contain large established infestations; eradicate if possible
- Monitor results and adjust strategies if warranted
- Potential control methods:
 - Habitat Manipulation/Mechanical Control
 - Chemical Control
 - Biological Control
 - Prescribed Fire

Nuisance Animal Control: Potential Strategies

- Employ integrated pest management techniques when a species is having a significant impact on an area resulting in major habitat replacement or damaging rare species.
- Determine the need for site-specific control, based on the potential of the nuisance animals to negatively affect wildlife and habitat management objectives on the refuge.
- Monitor results and adjust strategies if warranted
- Potential control methods:
 - Trapping/shooting
 - Habitat Manipulation/Mechanical Control
 - Chemical Control
 - Biological Control

U.S. Fish & Wildlife Service

Santee National Wildlife Refuge

Clarendon County, South Carolina

Managed Wetlands

Managed Wetlands Objectives for the Priority Resources of Concern: Wintering Dabbling Ducks - Green-winged Teal (*Anas carolinensis*), Wood Duck (*Aix sponsa*) and, Wood Stork (*Mycteria americana*)

Habitat and Species Objective (Stepped down from CCP Goals 1, 2, 4, 6 and Associated CCP Objectives (USFWS 2008))	Primary Habitat and Wildlife Response Variables and Probable Assessment Methods
Managed Wetland Objective: Maintain, improve, and/or restore up to 1,135 acres of managed wetlands including moist-soil, permanent, green-tree, and agricultural impoundments (Figures 1-3 and Table 1) for the following desired conditions to contribute toward the foraging habitat needs (4,385,097 Waterfowl Energy Days) for 60,895 migrating and wintering (October to March) dabbling ducks, including the green-winged teal, wood duck, Northern shoveler (<i>Spatula clypeata</i>), Northern pintail (<i>Anas acuta</i>), gadwall (<i>Mareca strepera</i>), and American widgeon (<i>Mareca americana</i>), and provide high-quality habitat resources for wading birds, such as the wood stork: - Manage up to 770 wetland acres across the Bluff, Cuddo, Pine Island, and Dingle Pond Units for 70 to 80 percent emergent vegetative cover, such as softstem bulrush (<i>Schoenoplectus tabernaemontani</i>), native sedges (<i>Carex spp.</i>), duck potato (<i>Sagittaria latifolia</i>), spike rush (<i>Eleocharis palustris</i>), and native millet (<i>Panicum decompositum</i>), 20 percent or less invasive species such as giant salvinia (<i>Salvinia molesta</i>), alligatorweed (<i>Alternanthera philoxeroides</i>), water hyacinth (<i>Pontederia crassipes</i>), and parrot feather (<i>Myriophyllum aquaticum</i>), and a range of water depths of 6 to 24 inches from November to March. - Annually manage up to 15 acres in Bluff (Millet Field) Unit and 65 acres in the Cuddo (Upper Tier and Lower Tier of Timber Island Field) Units for grain crops such as Japanese millet, flooded to water depths of 18 inches or less beginning late summer through the fall to provide 380,000 Waterfowl Energy Days towards the Refuge objective. - Annually, manage up to 60 acres in the Cuddo Unit (Upper Tier and Lower Tier of Timber Island Field) and 25 acres in the Pine Island Unit (Maidencane, Savannah A, B, and C, and Rail Fields) for grain crops, such as rice, flooded to water depths of 18 inches or less, during cultivation (April - August) and during winter sanctuary (November - February) to provide up to 387,600 Waterfowl Energy Days towards the Refuge objective. - Annually manage up to 120 acres of green-tree reservoirs in the Cuddo and Pine Island Units to maintain a range of water depths of 6 to 24 inches from November to March for wintering wood ducks and other dabbling ducks. - Foraging, nesting, and brood-rearing wood ducks - Late spring or early summer flooded wetlands and beaver ponds with emergent and scrub-shrub vegetation such as smartweed, fall panicum, wild millet, alder, and willow - Forested wetland landscapes with a composition of greater than 25 percent hard mast trees per acre, including oak and hickory species, and multiple large cavity trees or snags with diameter at breast height greater than or equal to 12 inches with four small cavities (entrance diameters 3.5 to 10 inches) per acre and one large cavity (entrance diameter greater than 10 inches) per 10 acres	- Number of WED days - Water depth - Wetland plant composition - Marshbird surveys and projects - Stork observations - Wintering Waterfowl counts - Secretive marshbird surveys - Other wildlife surveys - Water depth monitoring - Wetland plant monitoring

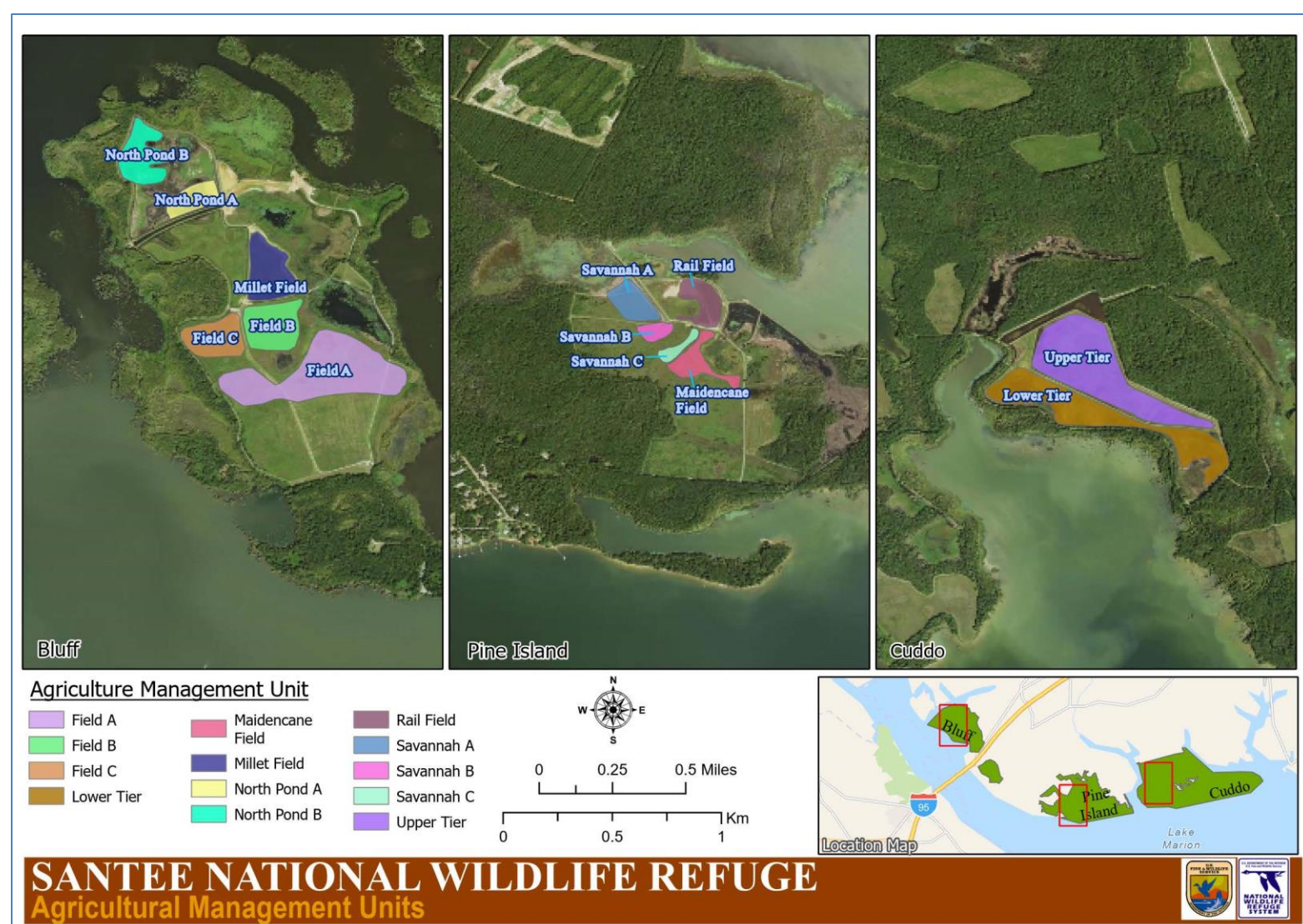


Figure 1. Agricultural Management Units on Santee National Wildlife Refuge.

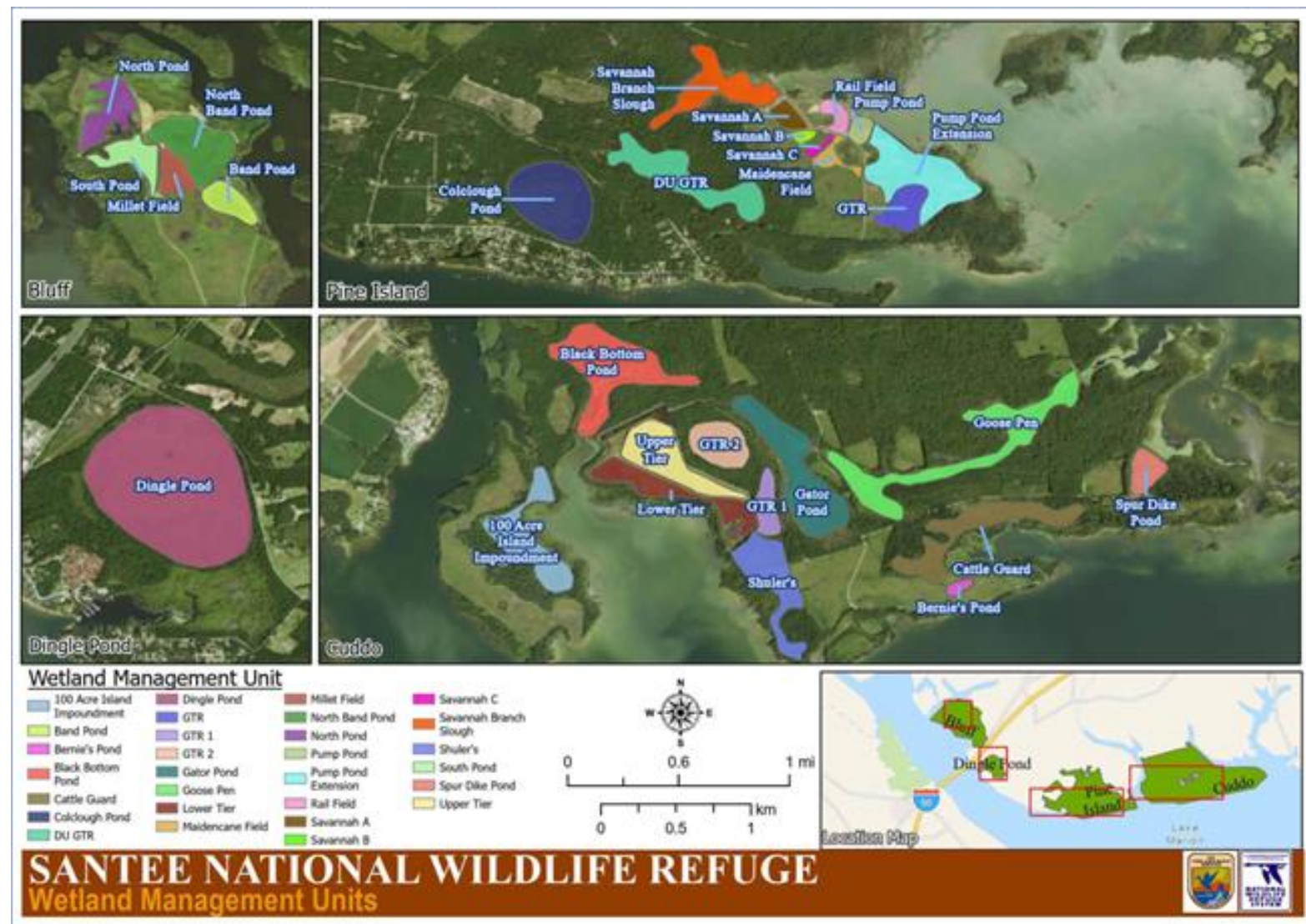


Figure 2. Wetland Management Units on Santee National Wildlife Refuge.

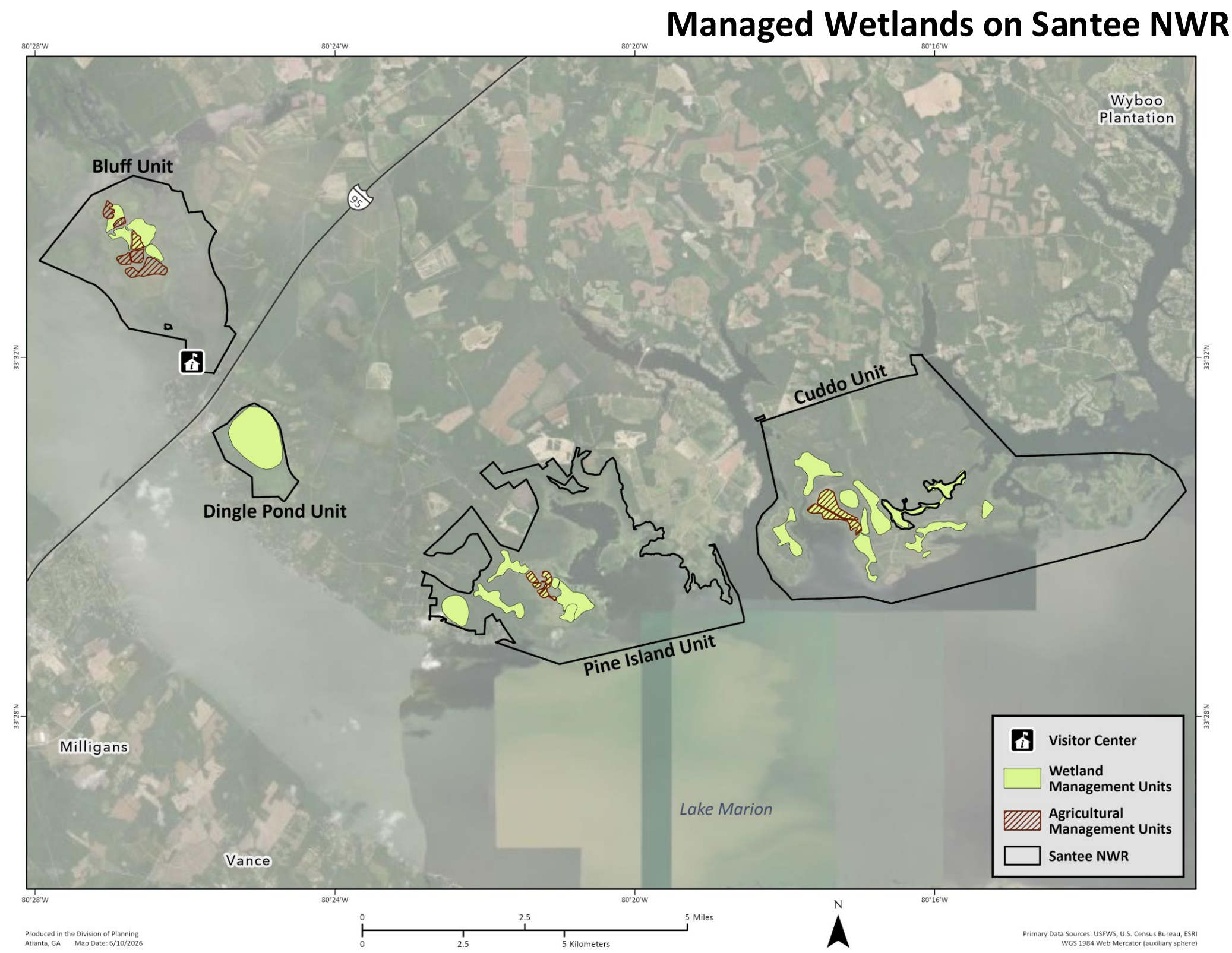


Figure 3. Managed wetland and agricultural units on Santee National Wildlife Refuge.

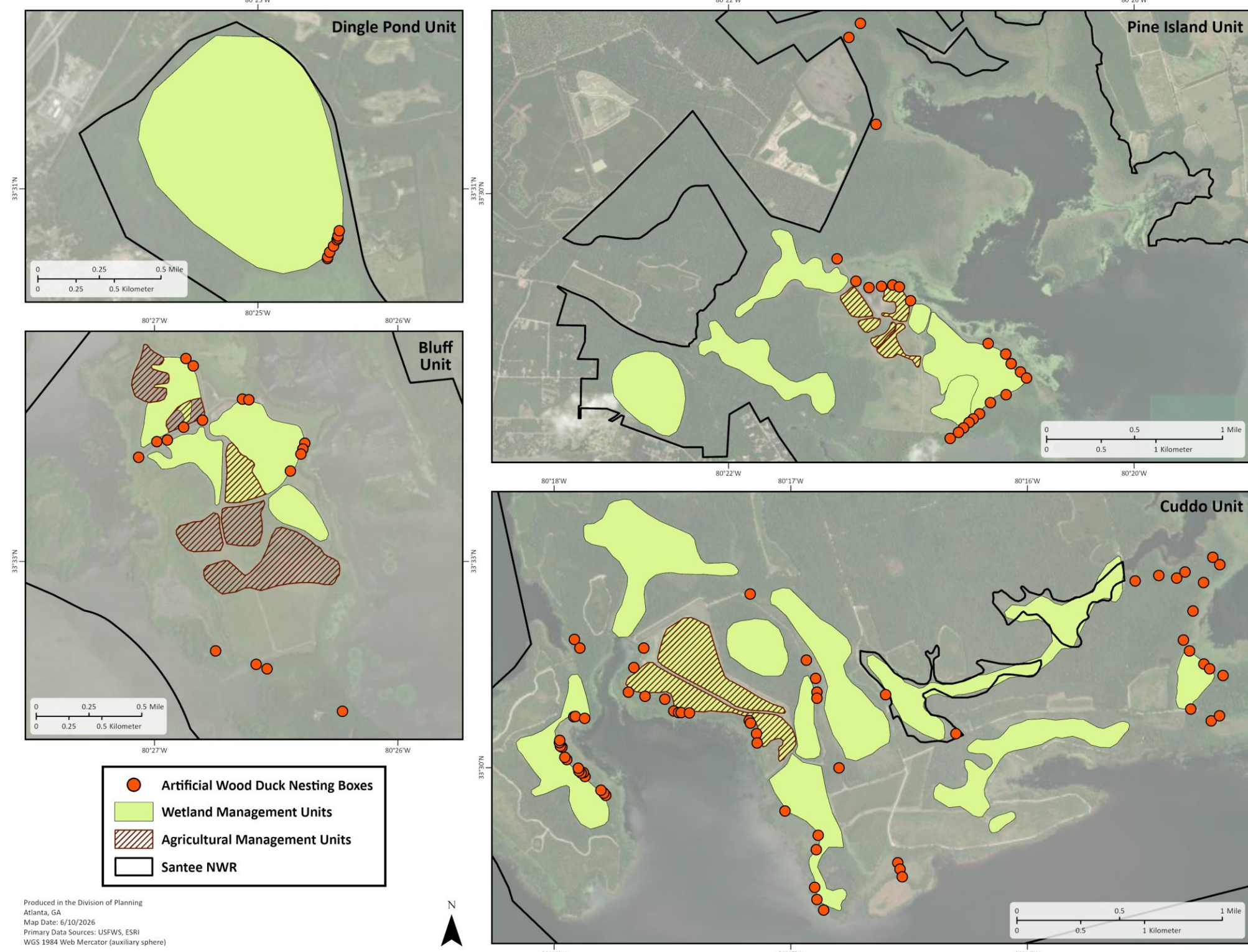


Figure 4. The 2018 inventory of all artificial Wood Duck nesting boxes in relation to the current wetland and agricultural management units on Santee National Wildlife Refuge.

Administrative Land Management Unit	Wetland Management Unit	Acres
Bluff	Band Pond	18
Bluff	Millet Field	15
Bluff	North Band Pond	46
Bluff	North Pond	26
Bluff	South Pond	22
Cuddo	100 Acre Island Impoundment	49
Cuddo	Bernie's Pond	3
Cuddo	Black Bottom Pond	78
Cuddo	Cattle Guard	53
Cuddo	Gator Pond	70
Cuddo	Goose Pen	79
Cuddo	GTR 1	16
Cuddo	GTR 2	29
Cuddo	Lower Tier	36
Cuddo	Shuler's	45
Cuddo	Spur Dike Pond	15
Cuddo	Upper Tier	45
Dingle Pond	Dingle Pond	257
Pine Island	Colclough Pond	65
Pine Island	Rail Field	9
Pine Island	Savannah B	3
Pine Island	DU GTR	55
Pine Island	GTR	20
Pine Island	Maidencane Field	8
Pine Island	Pump Pond	7
Pine Island	Pump Pond Extension	65
Pine Island	Savannah A	8
Pine Island	Savannah Branch Slough	41
Pine Island	Savannah C	3

Table 1. Wetland Management Units in the Administrative Units and acreages on Santee National Wildlife Refuge.



Wood Duck, Sweet, Mike, Public Domain, <https://www.fws.gov/media/wood-duck-6>

Priority Resources of Concern: Wintering Dabbling Ducks - Green-winged Teal (*Anas carolinensis*), Wood Duck (*Aix sponsa*) and Wood Stork (*Mycteria americana*)

Other benefitting species: American alligator (*Alligator mississippiensis*), American coot (*Fulica americana*), common gallinule (*Gallinula galeata*), pied-bill grebe (*Podilymbus podiceps*), ring-necked duck (*Aythya collaris*), gadwall (*M. strepera*), lesser scaup (*A. affinis*), great egret (*Ardea alba*), great blue heron (*A. herodias*), little blue heron (*Egretta caerulea*), white ibis (*Eudocimus albus*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violacea*), and lesser yellowlegs (*Tringa flavipes*)

Priority Resources of Concern

Wood Stork: In South Carolina, the first wood stork nesting colony was documented in 1981, with 11 nests (SCDNR 2006). Over the years, the population continued to increase, and currently, the state supports 24 known nesting colonies with a record high count of 3,928 nests in 2022 (SCDNR 2022). Colonies occur in nine counties in the southern and eastern regions of the state (Jasper (one colony) Beaufort (eight colonies), Hampton (one colony), Bamberg (one colony), Colleton (three colonies), Charleston (four colonies), Horry (three colonies), Georgetown (two colonies), and Berkeley (one colony) Counties (SCDNR 2016)). Although South Carolina supports significant portion of the current breeding population of wood storks, it is not a year-round resident in the state, and most individuals migrate midwinter to Georgia and Florida (Coulter et al. 2020). At present, Santee NWR serves as a post-nesting foraging and loafing area for the species. In 2023, stork sightings were recorded on at least eight occasions in the Bluff and Cuddo Units, with group sizes ranging from 1 to 12 birds.

Priority Resources of Concern

Dabbling and Wood Ducks: One of the most abundant wintering ducks on the Refuge is the green-winged teal. The smallest of the dabbling ducks, this popular, fast-flying gamebird is widespread and common throughout its range. The birds nest as far north as Alaska and migrate in all four flyways. Flocks of migrating and wintering birds can number in the thousands. In South Carolina, green-winged teal are common winter residents (Sprunt et al. 1970, Johnson et al. 2020).

Another abundant duck on Santee NWR is the wood duck. South Carolina supports resident and migrating/wintering wood duck populations, and the birds occur year-round on the Refuge (USFWS 2008). Wood duck populations have largely recovered from the severe range-wide population declines of the late 1800s as a result of conservation measures in the early and mid-1900s and regulated hunting beginning in the 1940s. Today, populations are stable or increasing throughout much of their range (USDA NRCS 2012, Hepp and Bellrose 2020), and in recent years, the wood duck has comprised more than 10 percent of the annual duck harvest in the United States (Raftovich et al. 2019, 2020). On Santee NWR, the birds are found within the Refuge's managed wetlands and green-tree reservoirs (Appendix B; Figure 4). Beginning in the 1960s, artificial wood duck nest boxes were placed in wetland habitats across the Refuge that lacked available tree cavities. As many as 300 boxes were maintained in the 1970s and 1980s. Currently, 129 artificial wood duck nest boxes [Bluff Unit (18 boxes); Cuddo Unit (77 boxes); Dingle Pond Unit (9 boxes), and Pine Island (25 boxes)] are maintained and monitored as resources allow. Figure 4 shows the 2018 geospatial inventory of nesting boxes. Each year, the Refuge also bands wood ducks from July through September (pre-nesting season), as part of the National duck banding effort.



Banded female Wood duck released at Santee NWR, USFWS, Public Domain, <https://www.fws.gov/media/banded-female-wood-duck-released-santee-nwr>

Managed Impoundment Strategies

The preferred hydrological management of managed impoundments during the summer would be to have lower, drawn-down conditions to encourage moist-soil vegetation and also tree growth and productivity in greentree reservoirs. Gravity drainage from the impoundments is slow or non-existent when the lake levels are high during the summer months. Under these conditions, pumping must be used to maintain lower water levels in the impoundments. Pumping costs and maintenance can be high where permeable dikes allow water to seep back into the impoundments from the lake.

During the fall and winter, low lake levels are typical and may inhibit pumping when the water is needed. Under these conditions, the existing pump for the Bluff Unit often cannot provide water for late summer/early fall flooding of the units. If the elevation of the pump's intake pipe is above the lake level (often at such times) no water is available for pumping. Permeability of soils and dikes also inhibit water retention, particularly at the Bluff Unit. However, lack of maintenance of the dike and water control systems on the Cuddo, Pine Island, and Dingle Pond units will require the refuge to conduct a comprehensive wetland management plan to upgrade and repair these systems.



Santee NWR Green-winged Teal. Photo Credit: USFWS

Potential and Selected Management Strategies: Waterfowl Sanctuary

- Santee NWR was established as a feeding and resting area (sanctuary) for migratory waterfowl.
- Sanctuary areas on the Refuge are closed to public access during periods of peak waterfowl use (November 1 to March 1).

Potential and Selected Management Strategies and Tools

Potential and Selected Management Strategies
Impounded Units Drawdowns to stimulate species-specific moist-soil plant germination - Timing: - Early drawdowns (April 15-June 1) are generally the most effective for producing desirable plants, such as annual smartweeds, millets, spike rush, and chufa. - Mid-season drawdowns (June 1-July 15) tend to produce millets, red-rooted sedge, sesbania, and cocklebur (generally, this date is the most risky for proliferation of nuisance plants such as cocklebur and sesbania). - Late drawdowns (after July 15) tend to produce mainly panic grass, sprangletop, and beggar ticks. - Rate of drawdown: - Slow drawdowns (over 2-6 weeks or a 3/10 of a foot per week) will produce the greatest diversity of plants. - Rapid drawdowns (occurring in less than a week) typically produce less diverse vegetation. - Limitations: - Drawdowns cannot occur during high-water events when water is higher outside the moist-soil unit than inside. - Beavers plugging water-control structures during drawdowns are a continuous problem that must be addressed using suitable control methods. Setting back plant succession to improve desirable plant production and seed yield - Setting back plant succession is generally attempted every 2-5 years, particularly when undesirable plants comprise $\geq 50\%$ of the unit. - Disking, fire, or stubble rolling are the primary means of setting back plant succession and woody vegetation. - Mowing is another option for setting back succession and is used primarily for promoting monocots such as wild millets, sedges, sprangletop, etc. Reducing nuisance plant competition and increasing moist-soil plant production - Chemical control is a common method in reducing competition of undesirable plants in moist-soil and the type and amount of approved herbicide used depends on the nuisance plant species and existing beneficial plants. A contracted aerial or ground applicator typically applies the herbicide; however, Refuge staff are acquiring the resources needed to do some of the applications force account. - Fertilizing moist-soil units can increase desirable plant production. In some moist-soil units the Refuge may aerially, or ground apply fertilizer based off soil test recommendations. - Irrigating moist-soil units reduces nuisance plant competition and increases seed production. Irrigating is accomplished through a periodic flush of water, mostly used within moist-soil units, or a continuous flood, such as is used in rice fields following sprouting. Irrigation water is obtained via pumping of surface water or from underground wells and delivered and distributed via a series of canals, ditches, levee gates, pipes or water control structures. Internal levees also help control flooding depth and distribution.

Forest Habitat Management: Potential and Selected Strategies in Potential Greentree Reservoir Management Units (Figure 2, 3, and 4A-D) Inventory and determine Stand baseline data Intermediate Treatments - Crown Thinning (thinning of dominants and co-dominants) - Low Thinning (thinning of suppressed and intermediates) - Free Thinning (planned combination of various thinning) - Variable Density Thinning (varied target residual stocking) - Thinning by Rules (BA, diameter, species, spatial, etc.) - Salvage/Sanitation Cutting Regeneration Harvest Methods a) Uneven-aged	- Individual Tree Selection - Group Selection - Patch Selection - Femelschlag (expanding gaps) - Even-aged with or without reserves - Shelterwood - Seed Tree - Clear-cuts Non-commercial Forest Stand Improvement Strategies - Prescribed Fire - Mulching - Pre-commercial Thinning - Wildlife Stand Improvement - Sanitation Cutting - Hydrological Restoration Mechanical Management (Site Preparation for Plantations) - Disking - Mowing - Ripping/Subsoiling	- Hydrological Restoration Chemical Management (Site Preparation, Treatment of Invasives, and within Stand Manipulation) - Pre-emergent - Hack and squirt - Stem injection - Cut stump - Basal spray - Streamline - Foliar spray - Fogging Stand Regeneration/Plantation Establishment Strategies - Site Preparation for Natural Regeneration - Coppice - Planting seedlings or cuttings - Direct seeding - Under-planting Utilize State Best Management Practices when Conducting Forestry Operations Monitor Future Vegetation Community Trends (Note: for general definitions of treatment and strategy terms used in this section see e.g., Smith (1962))	Cropland Habitat Management for Waterfowl Cooperative Farming (25% Refuge share and 75% Cooperative farmer share) The refuge and cooperative farmer will jointly select the crops that best meet the needs of waterfowl and the farmer (rice, milo, soybeans, millet, and moist-soil plants), and the locations for the refuge's share of the crop to provide the most benefit for waterfowl foraging use. Some grain crops retained for waterfowl should be in a location that can be flooded, or at least near water, and have sanctuary status. All chemicals will be approved through the Pesticide Use Proposal process and will follow Integrated Pest Management Policy (569 FW 1). Herbicide treatments allow for very selective removal of plant species or groups of species, with little or no damage to crops that are considered desirable. Insecticides and fungicides reduce the impacts of insects and fungal diseases on crops, protecting the crops and increasing the yield potential. Pesticides will be applied according to the directions on the label and used solely for the purpose for which the chemical was designed. A list of permissible herbicides is maintained within the Pesticide Use Permit Database.
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Nuisance Animal Control: Potential Strategies

- Employ integrated pest management techniques when a species is having a significant impact on an area resulting in major habitat replacement or damaging rare species.
- Determine the need for site-specific control, based on the potential of the nuisance animals to negatively affect wildlife and habitat management objectives on the refuge.
- Monitor results and adjust strategies if warranted
- Potential control methods:
 - Trapping/shooting
 - Habitat Manipulation/Mechanical Control
 - Chemical Control
 - Biological Control