



U.S. Fish and Wildlife Service
Southeast Region Inventory and Monitoring Branch
I&M Branch RFP Final Report

Title: At-Risk Plant Occurrences on National Wildlife Refuges within the South Carolina Lowcountry and Savannah Complexes



Photo by Keith A. Bradley (Carolina birds-in-a-nest)

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ABSTRACT: The status of rare plant species, including Federal At-risk species, is generally unknown in national wildlife refuges in the Southeastern Coastal Plain. Seven refuges in South Carolina and Georgia in the Savannah and South Carolina Lowcountry refuge complexes were surveyed. All rare plant species encountered were mapped, and for each population its size, habitat characters, and threats determined. Five At-risk plant species were recorded; these were found on three refuges, Ernest F. Hollings ACE Basin, Savannah, and Waccamaw. Populations of state-tracked rare plant species were found at all seven refuges. Major threats to rare plant species on national wildlife refuges included sea level rise and associated saltwater intrusion, invasive pest plants, and feral hogs.

INTRODUCTION

Generally, there is a lack of knowledge concerning the distribution and population status of rare plants across the southern U.S. Considering the documentation in the Southeastern Coastal Plain of globally high levels of vascular plant endemism (e.g., Sorrie and Weakley 2001), near-catastrophic levels of native habitat loss (e.g., Bennett and Nelson 1991; Frost 2006), and increasing threats to what little remains of that habitat (e.g., Costanza et al. 2015), it is critical to assess the occurrences and abundances of these potentially imperiled species. There are currently 46 vascular plants petitioned or are candidates for listing under the Endangered Species Act, and four plant species that are listed as Threatened or Endangered, that have been known to occur or possibly occur due to optimum habitat and species range considerations on Southeast Region National Wildlife Refuges (refuge) (National Wildlife Refuge Association 2015). The U.S. Fish and Wildlife Service can play a pivotal role in the conservation and recovery of these species by evaluating their current distribution and status on refuges.

The Sea Islands/Coastal Marsh Level IV Ecoregion stretches along the southern Atlantic coast from Horry County, South Carolina to the St. Johns River in northeastern Florida (Omernik and Griffith 2008). This region represents the lowest elevations in Georgia and South Carolina, and contains environments influenced by oceanic wave, salt wind, and river actions. Habitats that are found in this geography include maritime uplands dominated by live oak and cabbage palmetto; shrublands dominated by wax-myrtle and yaupon; and tidal salt, brackish, and freshwater marshes dominated by a variety of wetland graminoids, shell middens, beach dunes, and more inland habitats such as bottomland forests and longleaf pine savannas. This geography has experienced extreme levels of land conversion over many centuries, including the alteration of

native riverine and estuarine wetlands for agriculture; widespread elimination through land clearing, logging, turpentine, and fire suppression of longleaf pine woodlands; and increased housing development pressure along maritime fringe zones. Current threats to ecosystems within the Sea Islands/Coastal Marsh Ecoregion include increased residential and commercial development pressure, disruption of riparian and estuarine processes due to dredging activities, impacts from sea-level rise, and invasion of exotic plants and animals.

There are two refuge Complexes—the Savannah Refuge Complex and the South Carolina Lowcountry Complex—that manage the seven refuges in this project, that are within and directly adjacent to the Sea Islands/Coastal Marsh Ecoregion. Of the 46 petitioned and candidate plants that occur or ‘could’ occur on refuges in the Southeast Region, 19 are within the range of these two Complexes of refuges. There are also four Federally listed species that occur within the range of the two refuge Complexes. Table 1 lists these species, and known refuge occurrences.

Table 1: Federal At-Risk and Listed Species in the Range of the Savannah and Lowcountry Refuge Complexes

Scientific Name	Common Name	Status	Refuge
<i>Amaranthus pumilus</i>	Seabeach amaranth	Threatened	Cape Romain
<i>Amorpha georgiana</i>	Georgia leadplant	At-Risk	
<i>Coreopsis integrifolia</i>	Ciliate-leaf tickseed	At-Risk	
<i>Dionaea muscipula</i>	Venus flytrap	At-Risk	
<i>Eupatorium paludicola</i>	Swamp justiceweed	At-Risk	
<i>Fimbristylis perpusilla</i>	Harper's fimbristylis	At-Risk	
<i>Forestiera godfreyi</i>	Godfry's privet	At-Risk	
<i>Isoetes hyemalis</i>	Evergreen Quillwort	At-Risk	
<i>Lindera melissifolia</i>	Pondberry	Endangered	
<i>Lobelia boykinii</i>	Boykin's lobelia	At-Risk	
<i>Ludwigia brevipes</i>	Long Beach seedbox	At-Risk	
<i>Ludwigia ravenii</i>	Raven's seedbox	At-Risk	
<i>Macbridea caroliniana</i>	Carolina birds-in-a-nest	At-Risk	
<i>Minuartia godfreyi</i>	Godfry's stitchwort	At-Risk	
<i>Nuphar sagittifolia</i>	Yellow pond-lily	At-Risk	Waccamaw
<i>Ptilimnium ahlesii</i>	Carolina bishopweed	At-Risk	Savannah
<i>Rhynchospora thornei</i>	Thorne's beaked-rush	At-Risk	
<i>Rudbeckia heliopsidis</i>	Sun-facing coneflower	At-Risk	
<i>Schwalbea americana</i>	American chaffseed	Endangered	
<i>Scutellaria ocmulgee</i>	Ocmulgee skullcap	At-Risk	
<i>Sideroxylon thornei</i>	Georgia bully	At-Risk	
<i>Sporobolus teretifolius</i>	Wireleaf dropseed	At-Risk	
<i>Tiedmannia canbyi</i>	Canby's dropwort	Endangered	

The objectives of this project are to:

- 1) Determine population estimates of At-risk vascular plant species across a series of seven National Wildlife Refuges
- 2) Map species occurrences
- 3) Describe specific environmental and vegetation attributes associated with each targeted At-risk plant species, with focus on other rare or Federally-listed plants and vulnerable or imperiled habitats

- 4) Identify immediate threats (e.g., invasive species encroachment, sea-level rise impacts) at each population
- 5) Recommend management and conservation measures

STUDY AREA

There are two refuge Complexes that manage the seven distinct refuges in the study, the Savannah Refuge Complex and the South Carolina Lowcountry Complex, all within the Coastal Plain. These range some 300 km from McIntosh County, Georgia, to Horry County, South Carolina. Six are within the Sea Islands/Coastal Marsh Ecoregion in the Southern Coastal Plain (Table 2, Figure 1). One refuge, Santee NWR, is more interior, within the Southeastern Plains Ecoregion. These refuges support a wide variety of ecosystems, both natural and artificial, including wet savannas, bottomland forests, freshwater marshes, blackwater streams, tidal freshwater marshes, tidal marshes, upland forests, pine savannas, dunes, and coastal shell middens. Several refuges (i.e. Savannah, ACE Basin, and Waccamaw) have areas that were historically converted to rice plantations resulting in the extensive construction of levees and water control structures to form impoundments. These remnant rice impoundments have created unique wetland ecosystems within the freshwater tidal marsh zone.

Table 2: National Wildlife Refuges in Study

Refuge	State	Complex
Harris Neck	Georgia	Savannah
Savannah	Georgia, South Carolina	Savannah
Cape Romain	South Carolina	Lowcountry
Ernest F. Hollings ACE Basin	South Carolina	Lowcountry
Pinckney Island	South Carolina	Savannah
Santee	South Carolina	Lowcountry
Waccamaw	South Carolina	Lowcountry

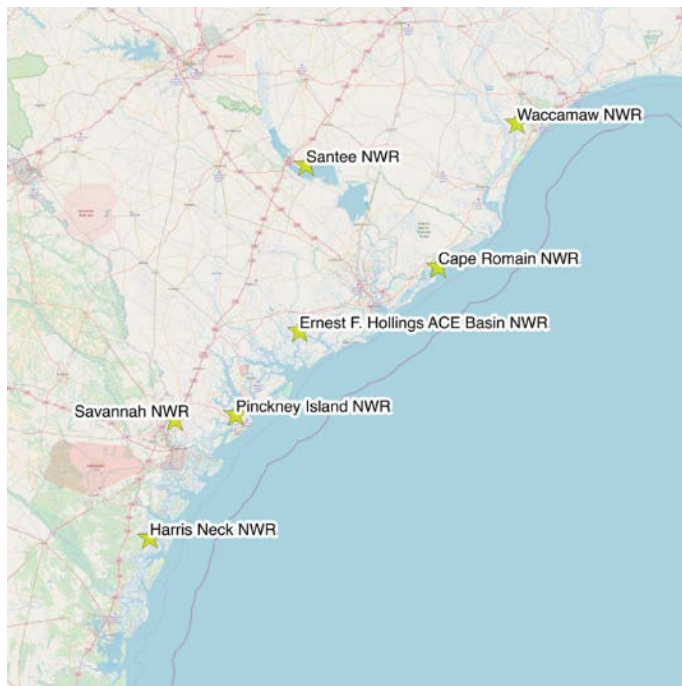


Figure 1: Locations of Refuges in Study

METHODS

Prior to field surveys data on rare plant species potentially occurring on study sites was compiled from online sources, literature, and knowledgeable individuals. Of particular importance was the SERNEC database (sernecportal.org), containing digitized herbarium specimen records from all major southeastern herbaria. Data available from state heritage program was also compiled, including that by the South Carolina Department of Natural Resources (SCDNR) and Georgia Department of Natural Resources (GADNR). Additional data were searched for in published literature, gray literature, and field trip reports by the South Carolina Association of Naturalists. Several herbaria, including the University of South Carolina (USCH), Clemson University (CLEMS), Furman University (FUGR), and the Charleston Museum (CHARL), were visited to examine specimens of target species to determine field characters and habitat preferences. Any floristic data that was found for refuges was compiled into a relational database and nomenclature standardized.

For each refuge potential search habitats were identified by analyzing available data sources to determine landscape features. Important resources included aerial photography (true color and infrared), LIDAR, and vegetation maps, when available.

Between September 2016 and November 2017 field surveys were conducted at regular intervals throughout the growing season. All surveys were conducted by the author. As much of each refuge as possible was visited. Emphasis was placed on habitats that could potentially support At-risk plant species, but as many habitats as possible in each refuge were surveyed. In many refuges the use of boats enabled access to more remote and little studied areas.

Appropriate habitats were searched opportunistically for rare plant and animal species, including At-risk species, Federally-listed species, in South Carolina refuges those tracked by SCDNR, and in Georgia refuges those tracked by GADNR. Other unusual plant species were also recorded and mapped, including untracked rare species, unusual exotic species, and new distributional records such as state records. Some locations with diverse, higher quality habitats were visited multiple times to find species with different flowering periods. Nearly all populations of previously known plant populations were revisited.

All rare species found were mapped with a Garmin GPSMAP 64 GPS unit. Individual plants were counted or population size estimated. For each rare species surrounding habitat characteristics were recorded to allow classification following either United States National Vegetation Classification (USNVC 2017) or the Carolina Vegetation Survey classification (Schafale 2012), and associated species noted. Plants or stems were counted, or, for larger colonies, estimated following a log₁₀ scale. Threats to each population were identified.

Surveys of *Ptilimnium ahlesii* were conducted from both boat and land. Because it is a short-lived annual these were done between May 9, when starting to flower, and June 15, when in fruit. Most colonies were visited twice to capture them in flower and fruit to ensure correct identification. Boat surveys were conducted at and around high tides to reach populations on mud banks at edges of freshwater tidal marshes. Land-based surveys were mainly done at lower tides to be able to reach plants growing below levees and road embankments.

The population of *Nuphar sagittifolia* at Waccamaw NWR was mapped principally by boat with field mapping supplemented by aerial photography. Occurrence of the species was recorded in waterways on and around the refuge (e.g. when travelling to the refuge). For waterways not reached by the end of the field season, true color aerial imagery from May 2017 was reviewed. Colonies of the species show a distinct pattern and color signature and were readily identified on larger waterways. This technique was not useful for narrow channels with overhanging vegetation.

Herbarium specimens were made for rare plant species when collection did not threaten populations. Specimens are deposited at the A.C. Moore Herbarium, University of South Carolina, in Columbia (USCH). Nomenclature of plant species in this report follows Weakley (2015). Herbarium specimen citations in this report include collector surname, collection number, and herbarium citation following Index Herbariorum (Thiers 2018). Heritage Program rankings follow the most recent data available on the web sites of the South Carolina Department of Natural Resources (SCDNR), Georgia Department of Natural Resources (GADNR), and for global conservation rankings NaturServe.

RESULTS

Field surveys were initiated in September 2016 and continued through November 2017. Five At-risk species were found. These were found on 3 refuges (Table 3). Also, 55 species of state-tracked rare plant species were found. All refuges contained tracked rare plant species. Summaries of findings by refuge are given below.

Table 3: At-Risk Species Found in National Wildlife Refuges

Scientific Name	Common Name	Refuges
<i>Coreopsis integrifolia</i>	Chipola dye-flower	ACE Basin
<i>Isoetes hyemalis</i>	Wintergreen quillwort	ACE Basin
<i>Macbridea caroliniana</i>	Carolina birds-in-a-nest	ACE Basin
<i>Ptilimnium ahlesii</i>	Carolina bishopweed	ACE Basin, Savannah, Waccamaw
<i>Nuphar sagittifolia</i>	Narrowleaf pondlily	Waccamaw

Summary of Findings by Refuge

Cape Romain National Wildlife Refuge

Surveys were conducted across Bulls Island and on Lighthouse Island around the lighthouse. No At-risk species were found. This refuge is known to have had colonies of the Federally Threatened *Amaranthus pumilus* on Bulls Island, Cape Island, Lighthouse Island, Raccoon Key, and Sandy Point. New colonies of this species were not detected. There are currently no wild individuals of this species in the refuge, but a reintroduction program is underway (A. Punsalan, personal communication, 2017).

Twelve State-tracked species were found (Table 4, Figure 3, Figure 4). An additional rare plant, an undescribed species of *Trichostema* (informally called “species 1” or “*nesophilum*”), is also known from the refuge. It was not observed during this study but is known to be extant on Cape Island.

Table 4: Rare Plant Species of Cape Romain NWR

Scientific Name	Common Name	Recorded	USFWS	SCDNR	Global Status
<i>Amaranthus pumilus</i>	Seabeach amaranth	No	Threatened	S1	G2
<i>Canna flaccida</i>	Golden canna	Yes		S2	G4?
<i>Carex hyalinolepis</i>	Shoreline sedge	Yes		S2	G4G5
<i>Cyperus distinctus</i>	Swamp flatsedge	Yes		S1	G4
<i>Cyperus tetragonus</i>	Four-angled flatsedge	Yes		S2	G4?
<i>Dichantheium aciculare</i>	Needle-leaf witchgrass	Yes		SNR	G5
<i>Ipomoea imperati</i>	Beach morning-glory	Yes		SNR	G5
<i>Muhlenbergia sericea</i>	Dune hairgrass	Yes		S3S4	G5T5?
<i>Rhynchospora inundata</i>	Narrow-fruit horned beaksedge	Yes		S2?	G4?
<i>Sagittaria weatherbiana</i>	Weatherby's arrowhead	Yes		S1	G3T3T4
<i>Spiranthes laciniata</i>	Lace-lip Ladies'-tresses	Yes		S1S2	G4G5
<i>Symphotrichum elliottii</i>	Southern swamp aster	Yes		S3	G4
<i>Trichostema</i> "species 1"	Dune blue curls	No		SNR	-
<i>Tridens chapmanii</i>	Chapmans triodia	Yes		S1	G5T3

Other Notable Species

- *Phyla lanceolata* (Marsh frogfruit): This native groundcover was found in a ditch on the edge of Big Pond Road. It is rarely collected in South Carolina where it occurs in freshwater tidal habitats.
- *Parapholis incurva* (Sickle grass): This exotic grass was found in one location. This European species was discovered in South Carolina in 2008 at Pinckney Island NWR (Payne 2010). It was then found in 2011 in Horry County on dredge spoil along the Intracoastal Waterway. The occurrence at CRNWR is thus the third location in the state. The colony was found on Bulls Island, on the causeway close to the boat landing.



Figure 2: *Sagittaria weatherbiana*

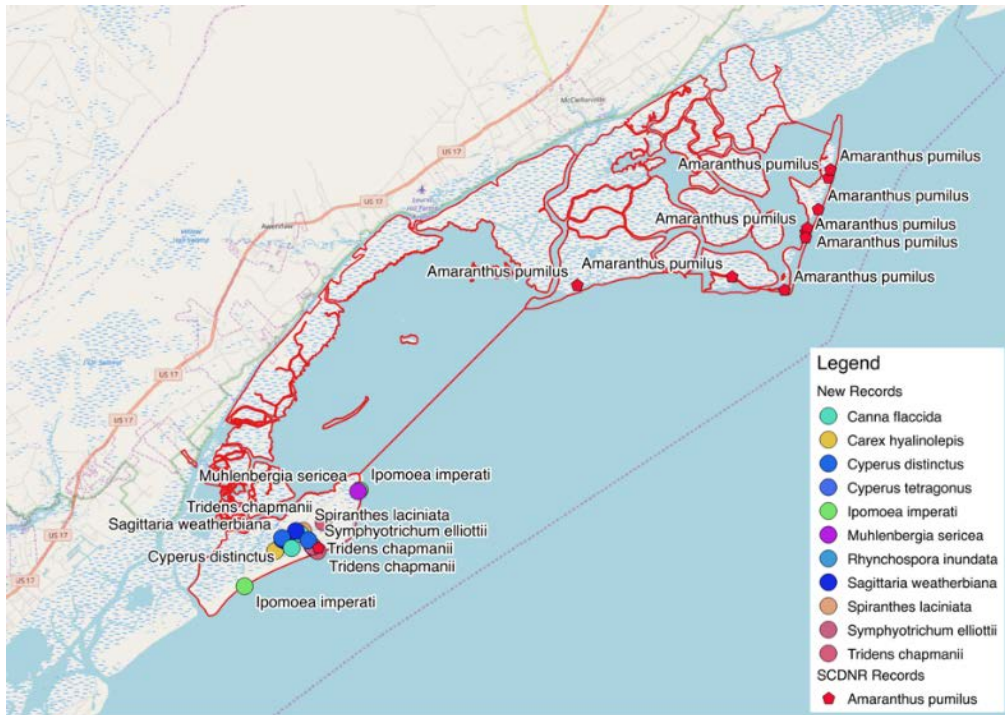


Figure 3: Rare Plants of Cape Romain NWR



Figure 4: Rare Plants of Bulls Island, Cape Romain NWR

Ernest F. Hollings ACE Basin National Wildlife Refuge

Four At-risk species were found at ACE Basin NWR, all new records. Nine rare species tracked by SCDNR were found (Table 5, Figure 5, Figure 6). SCDNR had no rare plant occurrence data for the refuge. Surveys were conducted in the Bonny Hall, Combahee Fields, Grove Plantation, Jehossee Island, Upper Combahee, and Yemassee South units.

Table 5: Rare Plant Species of Ernest F. Hollings ACE Basin NWR

Scientific Name	Common Name	Recorded	USFWS	SCDNR	Global Status
<i>Burmannia biflora</i>	Violet burmannia	Yes		S2	G4G5
<i>Carex amphibola</i>	Eastern narrow-leaved sedge	Yes		SNR	G5
<i>Carex hyalinolepis</i>	Shoreline sedge	Yes		S2	G4G5
<i>Coreopsis integrifolia</i>	Chipola dye-flower	Yes	At-Risk	S1	G1G2
<i>Dichanthelium aciculare</i>	Needle-leaf witchgrass	Yes		SNR	G5
<i>Ilex amelanchar</i>	Sarvis holly	Yes		S3	G4
<i>Isoetes hyemalis</i>	Wintergreen quillwort	Yes	At-Risk	S1	G2G3
<i>Macbridea caroliniana</i>	Carolina birds-in-a-nest	Yes	At-Risk	S3	G2G3
<i>Peltandra sagittifolia</i>	Spoonflower	Yes		S2	G3G4
<i>Physostegia leptophylla</i>	Tidal marsh obedient-plant	Yes		SNR	G4?
<i>Ptilimnium ahlesii</i>	Carolina bishopweed	Yes	At-Risk	S1	G1
<i>Symphyotrichum elliottii</i>	Southern swamp aster	Yes		S3	G4
<i>Tridens strictus</i>	Longspike fluffgrass	Yes		S1	G5

- *Coreopsis integrifolia* (Chipola dye-flower): Two colonies were found in the Upper Combahee Unit (Figure 5). One colony contains 3,000-5,000 stems. This extensive linear colony occurs along the edges of two connecting management roads. Here it grows mainly in the moist, shallow swales on each side of the roads, creeping into the beds of the roads. This is adjacent to a mixed hardwood forest in the Combahee River floodplain, as close as 75 m to the river. Species associates include a diverse assemblage of native and exotic wetland species, including *Symphyotrichum* spp., *Triadica sebifera*, *Nekemias arborea*, *Lobelia puberula*, *Erianthus contortus*, *Physostegia leptophylla*, and *Carex* spp. A second small colony of 10 plants was found adjacent to the Combahee River in undisturbed bottomland forest (Atlantic Coastal Plain Small Blackwater River Floodplain Forest). Species associates include *Taxodium distichum*, *Nyssa biflora*, *Quercus laurifolia*, *Carpinus caroliniana*, *Sabal minor*, *Hypericum galioides*, and *Hypoxis curtissii*.
- *Isoetes hyemalis* (Wintergreen quillwort): Three colonies were found in the Upper Combahee Unit (Figure 5). These colonies were both in natural and artificial habitats. One colony is on the bank of the Combahee River in bottomland forest. Another is about 80 meters from the river in shallow, muddy drainages in bottomland forest. The third is in shallow roadside swales next to management roads, growing in association with *Coreopsis integrifolia*. Species associates in bottomland populations include *Nyssa biflora*, *Taxodium distichum*, *Cornus stricta*, *Saururus cernuus*, *Onoclea sensibilis*, *Styrax americanus*, *Hypericum galioides*, and *Viburnum nudum*. The population in the roadside swale is as described above for *C. integrifolia*.
- *Macbridea caroliniana* (Carolina birds-in-a-nest): One colony was found in the Upper Combahee Unit (Figure 5). This population is along the easternmost management road 1.0 km from the Combahee River, growing in a shallow roadside swale on the east edge of the road. This is adjacent to a dense *Pinus taeda* plantation. The colony contains about

300 plants and extends about 425 m. Associated plant species include *Juncus effusus*, *Scirpus cyperinus*, *Ludwigia pilosa*, and *Erianthus contortus*. Despite diligent searches, this species was not found in natural habitats along the river. This species may have at one time been more common near the Bonny Hall Unit. Elliott (1824) writes “is very abundant between Saltcatcher bridge and Murphy’s bridge on the Edisto River.” The Saltcatcher Bridge is just beyond the western boundary of the unit on the Combahee River, on US21/US17A, and Murphy’s Bridge was due north on US21, south of Branchville on the Edisto River (B. Pittman, email, 11/8/17). It is not clear from Elliott’s description if he observed plants to be abundant at Saltcatcher (i.e. on the Combahee River), or at other places between the two bridges.

- *Ptilimnium ahlesii* (Carolina bishopweed): This species was found on the Bonny Hall and Combahee Fields units. A total of 21 colonies were found on or near the refuge (Figure 7). This includes the re-location of collection sites made in 1956 (Bell 3767, NCU) on SC-33 near Sugar Hill Landing, and in 2008 (Nelson 27198, USCH) at the Cuckolds Creek Boat Ramp in Colleton County. Of the 21 colonies nine were within the refuge; one of these in the Combahee Fields Unit and the rest in the Bonny Hall Unit. The 21 colonies contained about 409 plants, with 198 of those within the refuge. Colonies found off-refuge, in addition to those above, were on the tidal creek between the Sugar Hill Boat Landing and the Combahee River (5), the Combahee River west of the Bonny Hall Unit (3), and the Combahee River east of the Bonny Hall Unit (1). All colonies were found in freshwater tidal ecosystems (Southern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh), at the edges of or very close to tidal waterways, including the Combahee River and Cuckolds Creek. Plants along the largest waterway, the Combahee River, were found mainly in floating mats of vegetation. Here, these mats typically form in small coves, such as in front of rice trunks, where protection from the main current allows vegetative debris and floating aquatic plants to collect. Common associates included *Alternanthera philoxeroides*, *Hydrocotyle ranunculoides*, *Myriophyllum aquaticum*, and *Cicuta maculata*. These mats are usually next to dense growths of *Zizaniopsis miliacea*, *Zizania aquatica*, *Schoenoplectus tabernaemontani*, *S. californicus*, and *Typha angustifolia*. In smaller waterways, such as the tidal creek to Sugar Hill Landing, plants were found on decomposing tree trunks at edges of creeks, usually surrounded by water, associated with *Physostegia leptophylla*, *Symphyotrichum elliottii*, *S. tabernaemontani*, and *Juncus acuminatus*. Other colonies were found at the high tide line on the edges of levees, roads, and boat ramps. These colonies are always adjacent to freshwater tidal swamps, with *Typha angustifolia*, *Zizania miliacea*, and *Schoenoplectus tabernaemontani*.

Other Notable Species

- *Phyla lanceolata* (Marsh frogfruit): This native groundcover was found in the Bonny Hall Unit in a floating mat on the Combahee River Road with *P. ahlesii*. It is rarely collected in South Carolina where it occurs in freshwater tidal habitats. The colony at ACE Basin represents a new county (Beaufort) for the species.
- *Schoenoplectus californicus* (Giant bulrush): This native sedge was found on the Combahee River along the edge of the Bonny Hall Unit. This species, while not tracked by SCDNR, is known from only a few collections in the state. The colony at ACE Basin represents a new county (Beaufort) for the species.

- *Mecardonia procumbens* (Baby jump-up): This herb was found in two locations in the Grove Plantation Unit. This small herb is native to the Southern US from Florida to Arizona. This is the first documentation of the species from South Carolina. It was found in a maintenance yard and in front of the Grove Plantation House, and was most likely introduced here accidentally.
- *Carex australis* (Southern sedge): This exotic sedge was found in the Grove Plantation Unit. It is native to states west of the Mississippi River and was discovered in South Carolina in 1999. It has been found a total of only 4 times in the state, always in the piedmont. This record represents the first expansion of this weedy species to the coastal plain of South Carolina.

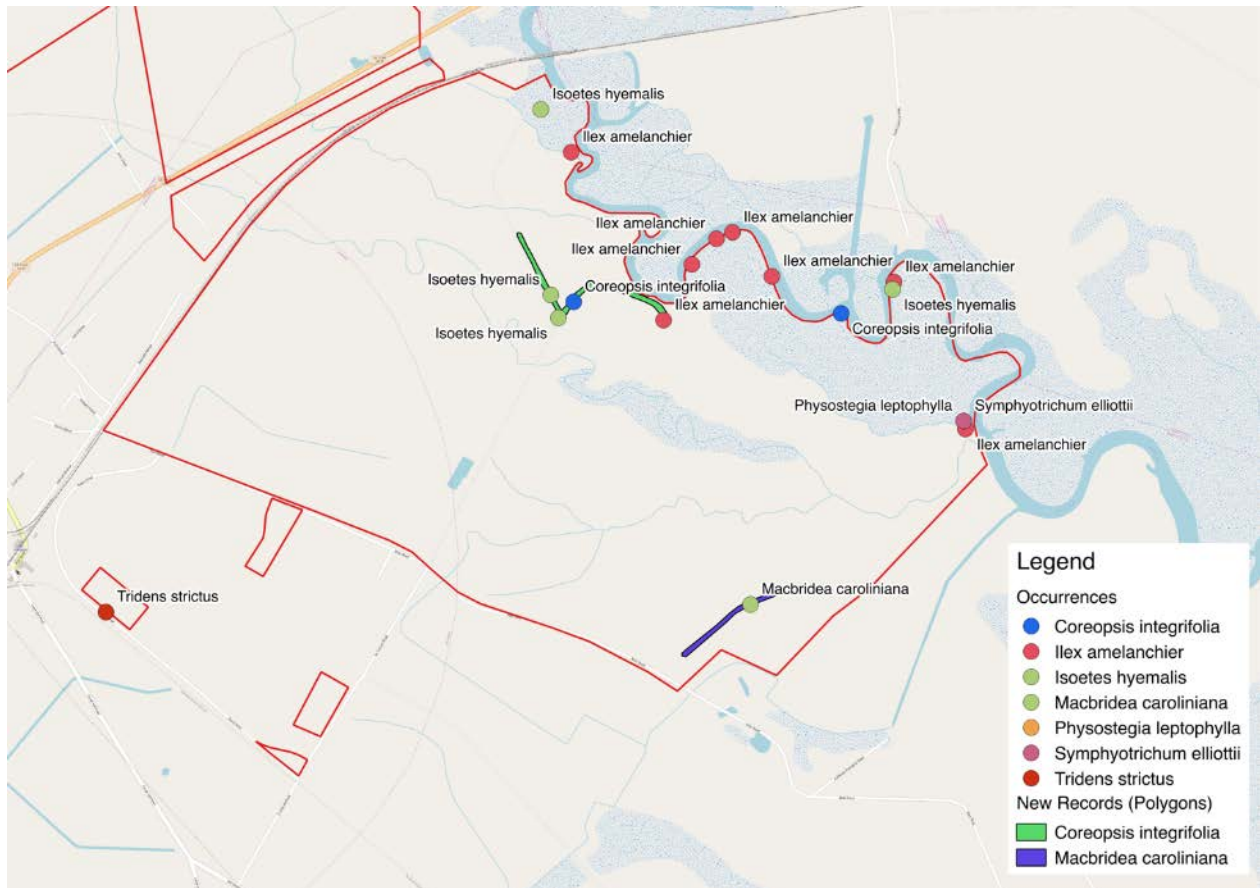


Figure 5: Rare Plants of Ernest F. Hollings ACE Basin NWR (Upper Combahee Unit)

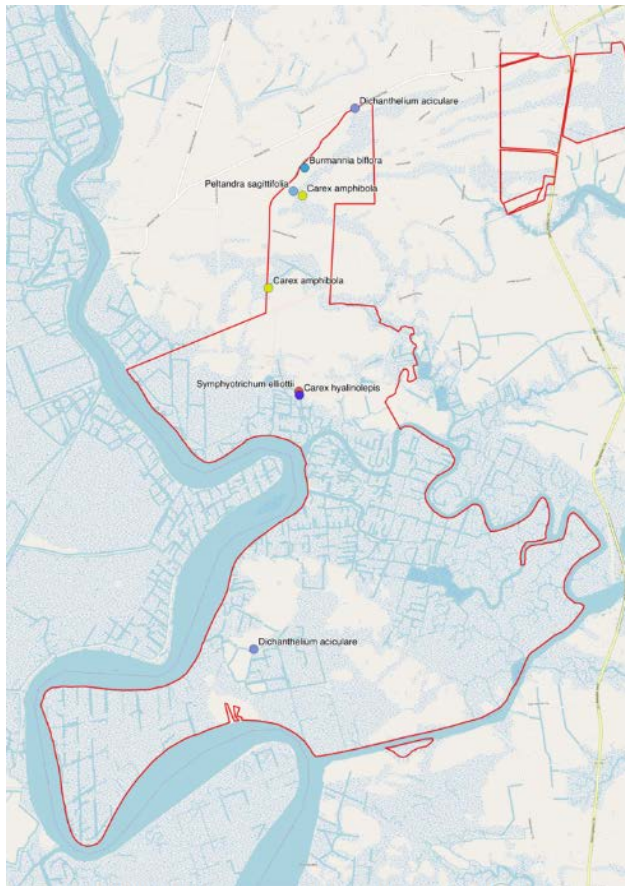


Figure 6: Rare Plants of Ernest F. Hollings ACE Basin NWR (Grove Plantation and Jehossee Island units)

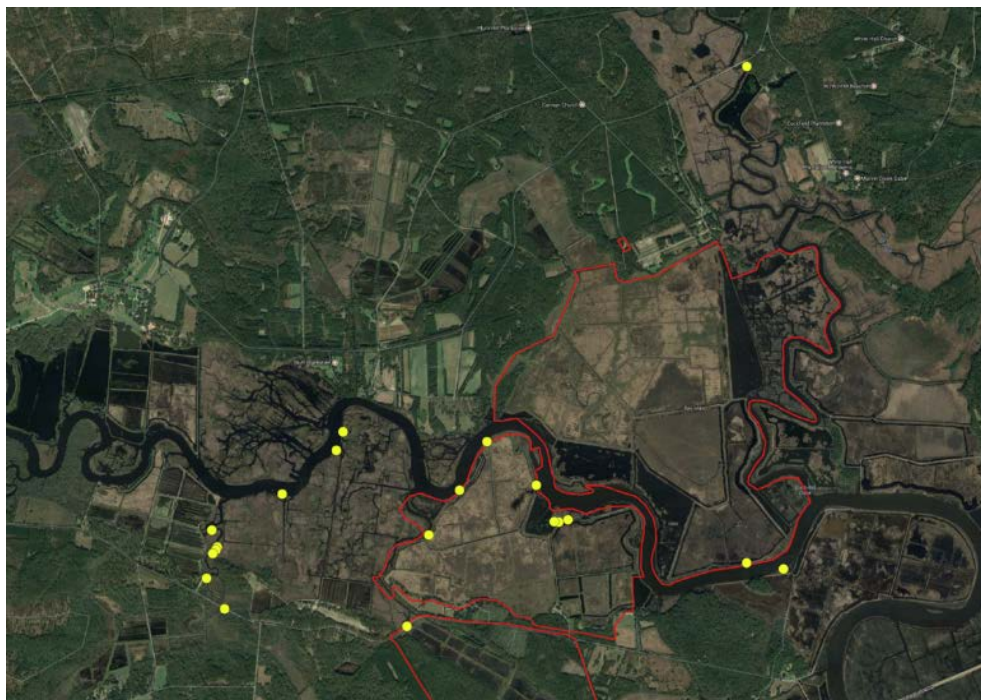


Figure 7: *Ptilimnium ahlesii* (Carolina bishopweed) in Ernest F. Hollings ACE Basin NWR (Bonny Hall and Combahee Fields units)



Figure 8: Coreopsis integrifolia on Combahee River



Figure 9: Coreopsis integrifolia in roadside swale



Figure 10: Macbridea caroliniana, in fruit



Figure 11: Ptilimnium ahlesii, habitat inside rice impoundment



Figure 12: *Ptilimnium ahlesii*, floating mat on Combahee River



Figure 13: *Ptilimnium ahlesii*, stump in tidal creek near Sugar Hill Landing

Harris Neck National Wildlife Refuge

No At-risk plant species were found at Harris Neck NWR. Three State-tracked species were found (Table 6, Figure 15). The GADNR heritage program database had one tracked species mapped for the refuge, *Aeschynomene viscidula*. This mapped occurrence was not relocated and may be extirpated, but the species was found in two other locations in the refuge.

Table 6: Rare Plant Species of Harris Neck NWR

Scientific Name	Common Name	Recorded	USFWS	GADNR	Global Status
<i>Aeschynomene viscidula</i>	Sticky joint-vetch	Yes		S1?	G5?
<i>Andropogon longiberbis</i>	Longbeard bluestem	Yes		S1?	G5
<i>Eleocharis montevidensis</i>	Sand spikerush	Yes		S3?	G5

Other Notable Species

- *Desmodium triflorum* (Threeflower ticktrefoil): A large colony of the exotic herb was found in lawns at the refuge entrance on Harris Neck Road, just east of the Harris Neck Creek bridge. This species is native to the Old-World tropics. This is the first time it has been found in Georgia, otherwise known only in the continental US from Florida and Louisiana.
- *Carex australis* (Southern sedge): This exotic sedge was found at the edge of Goose Pond. This species is native to states west of the Mississippi River. It was discovered in Georgia in Macon County in 2013. This record represents an expansion of this weedy species to the Georgia coast.



Figure 9: *Aeschynomene viscidula*

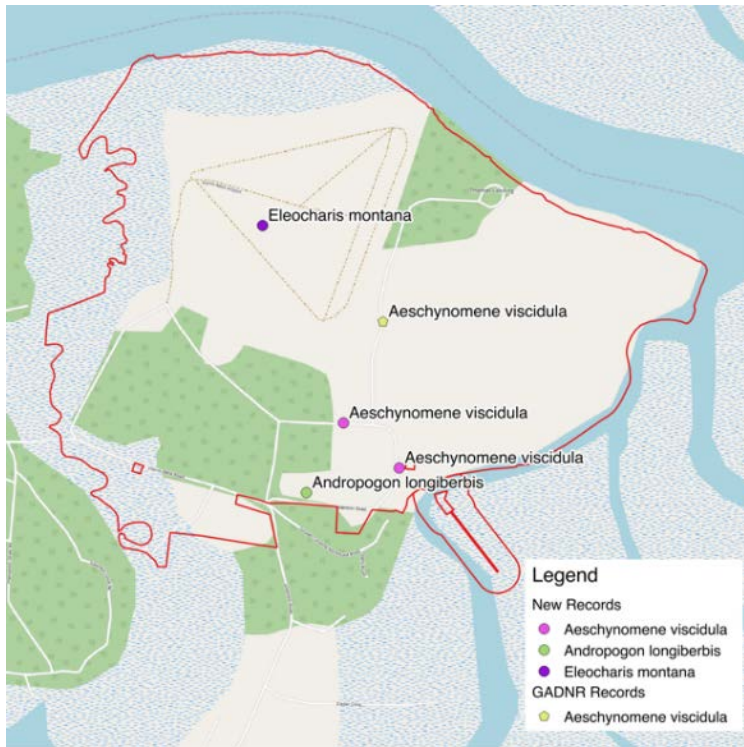


Figure 10: Rare Plants of Harris Neck NWR

Pinckney Island National Wildlife Refuge

Surveys were conducted throughout the refuge, including Pinckney Island from Last End Point to White Point, as well as on Big Harry Island, Little Harry Island, and Corn Island. Some survey work was also previously done by other botanists, most notably D. Payne from 1998-2006 (Payne 2010).

No federal species of interest were encountered, nor have any been previously documented on the refuge. Eight state-tracked species were found, seven of these newly reported for the refuge (Table 7, Figure 17). The state-tracked *Clematis catesbyana* was found previously by R. Porcher in 1996 (2696, CLEMS), but not seen in the present survey.

Table 7: Rare Plant Species of Pinckney Island NWR

Scientific Name	Common Name	Recorded	USFWS	SCDNR	Global Status
<i>Clematis catesbyana</i>	Coastal virgin's-bower	No		SNR	G4G5
<i>Cyperus distinctus</i>	Swamp flatsedge	Yes		S1	G4
<i>Dichanthelium aciculare</i>	Needle-leaf witchgrass	Yes		SNR	G5
<i>Eupatorium anomalum</i>	Anomalous eupatorium	Yes		S1?	G2G3
<i>Muhlenbergia sericea</i>	Dune hairgrass	Yes		S3S4	G5T5?
<i>Psilotum nudum</i>	Whiskfern	Yes		S1	G5
<i>Quercus austrina</i>	Bluff oak	Yes		S1	G4?
<i>Sageretia minutiflora</i>	Small-flowered buckthorn	Yes		S3	G4
<i>Scutellaria mellichampii</i>	Mellichamp's skullcap	Yes		-	NA
<i>Tridens chapmanii</i>	Chapman's triodia	Yes		S1	G5T3

Other Notable Species

- *Scutellaria mellichampii* (Mellichamp's skullcap): Although not tracked by SCDNR or NaturServe it is included here because of its rarity both in South Carolina and globally. The range of the species includes South Carolina, Georgia, and Alabama. In South Carolina it is known from several populations in the Beaufort area, in the vicinity of the refuge (Payne 2010). It is also known from Jasper County, mainly in the Savannah National Wildlife Refuge and one population in Calhoun County. In Georgia it is known with certainty from a single location (T. Patrick, personal communication, 2017), and is rare in Alabama (Brian Keener, personal communication, 2017). At the refuge two colonies were found, one on Dick Pond Point, and one on White Point. The largest occurred on the extension shell deposits on Dick Pond Point, previously found here by D. Payne. About 500 plants occur here, mainly in partly sunny conditions, associated with sparse *Pinus taeda* and *P. elliotii*, short *Ilex vomitoria*, and tall scattered *Sabal palmetto* with *Erythrina herbacea*, *Trichostema dichotomum*, *Piptochaetium avenaceum*, *Erigeron strigosus*, *Festuca octoflora*, and *Solidago odora* (South Atlantic Coastal Shell Midden Woodland). A second colony found by Payne was not relocated (Payne 4813, CLEMS); the locality data on the label may be in error. A new colony of only a few plants was found on the trail to White Point, in upland hammock with *Ilex vomitoria*, *Quercus virginiana*, and *Pinus taeda*.



Figure 11: *Scutellaria mellichampii*

- *Parapholis incurva* (Sickle grass): This exotic grass was discovered in South Carolina at Pinckney Island NWR by D. Payne in 2008 (Payne, 2010). This is a European species that is spreading regionally; it has now been found at two additional locations in South Carolina, including Cape Romain NWR. It has the potential to become problematic in coastal habitats. At Pinckney Island it still occurs along a fill road leading to Dick Point, adjacent to tidal marsh.
- *Rhynchosia minima* (Least snoutbean): This vine was discovered in South Carolina at Pinckney Island NWR by D. Payne in 2008 (Payne, 2010). It is a common species in Florida, rare in Georgia, and ranges west to Texas. During the present surveys it was observed at several locations on the refuge, both on fill adjacent to US278, but also on high quality habitats near Dick Point. This appears to be a natural occurrence.
- *Ipomoea macrorhiza* (Indian-midden morning glory): Tracked as S1 by SCDNR, this vine was mapped in their database for the refuge on Buzzard Island. This mapping is in error, having been observed at a different location in Beaufort County (B. Pittman, personal communication, 2016). It is not known to have occurred at this refuge.
- *Forestiera godfreyi* (Godfrey's forestiera): This At-risk shrub was found in the 1800s just 2.1 km southwest of the refuge, across Mackay Creek on a small island east of Jess Island.

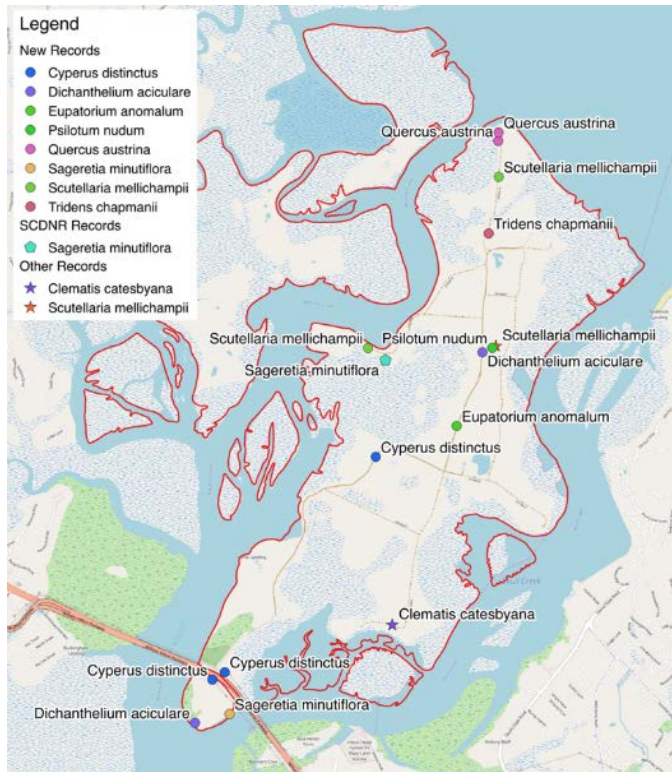


Figure 12: Rare Plants of Pinckney Island NWR

Santee National Wildlife Refuge

Surveys were conducted in each of the four management units on the refuge. Santee NWR has some history of botanical collecting activity, with data available on the SERNEC portal. The SCNDR Heritage Program database also has rare plant records for the refuge, representing six species. These records were from between 1960 and 1998.

No federal species of interest were encountered, nor have any been previously documented on the refuge. Four state-tracked species were found, three of these newly reported for the Refuge (Table 8, Figure 19). Five of the state tracked species previously found here could not be relocated, all probably because of changes in habitat conditions. One, *Bacopa innominata*, was found in 1960 in the “Five Pines area”, a site unknown to the author but mapped by SCDNR in the Bluff Unit. The other four were found at the edge of Dingle Pond.

Table 8: Rare Plant Species of Santee NWR

Scientific Name	Common Name	Recorded	USFWS	SCDNR	Global Status
<i>Bacopa innominata</i>	Tropical water-hyssop	No		S1	G3G5
<i>Carex decomposita</i>	Cypress-knee sedge	No		S2	G3G4
<i>Dichanthelium aciculare</i>	Needle-leaf witchgrass	Yes		SNR	G5
<i>Hydrolea corymbosa</i>	Skyflower	Yes		S1	G5
<i>Hypericum adpressum</i>	Bog St. John’s-wort	No		S2	G3
<i>Lilaeopsis carolinensis</i>	Carolina lilaeopsis	No		S2	G3G5
<i>Rhexia aristosa</i>	Awned meadow-beauty	No		S3	G3G4
<i>Rhynchospora inundata</i>	Narrow-fruit horned beaksedge	Yes		S2?	G4?
<i>Sagittaria weatherbiana</i>	Weatherby’s arrowhead	Yes		S1	G5T3T4

Other Notable Species:

- *Ptilimnium ahlesii* (Carolina bishopweed): This Federal At-risk species has been reported for the refuge based on an herbarium specimen (Nelson 32060, USCH). This specimen is actually *P. capillaceum*.
- *Lysimachia terrestris* (Bog loosestrife): One population of this native herb was found in the Bluff Unit. It was also found at Dingle Pond in 1982 (Logue 5337, USCH). It may have also been collected within the refuge in 1957 by A. Radford (24469, NCU), 4 miles SSW of St. Paul. While not tracked by SCDNR the population at the refuge is the only currently known in South Carolina. It should be assessed for tracking by SCDNR.
- *Schoenoplectus californicus* (Giant bulrush): This sedge was found in a marsh in the Bluff Unit. This species, while not tracked by SCDNR, is known from only a few collections in the state. The colony at Santee was first found by J. Nelson in 2013 (32068, USCH). It should be assessed for tracking by SCDNR.
- *Lobelia boykinii* (Boykin’s lobelia): This At-risk herb was documented 3.1 km from the refuge, to the north of the Dingle Pond and Pine Island units, at Monkey Bay. While habitats were probably present historically at the refuge, such as in Dingle Pond and Colclough Pond, altered hydrology has probably eliminated suitable habitat.
- *Tiedemannia canbyi* (Canby’s cowbane): Like *L. boykinii*, this Federally-listed Endangered herb was documented 3.1 km from the refuge, to the north of the Dingle Pond and Pine Island units, at Monkey Bay. While habitats were probably present historically at the refuge, such as in Dingle Pond and Colclough Pond, altered hydrology has probably eliminated suitable habitat.



Figure 13: *Lysimachia terrestris*

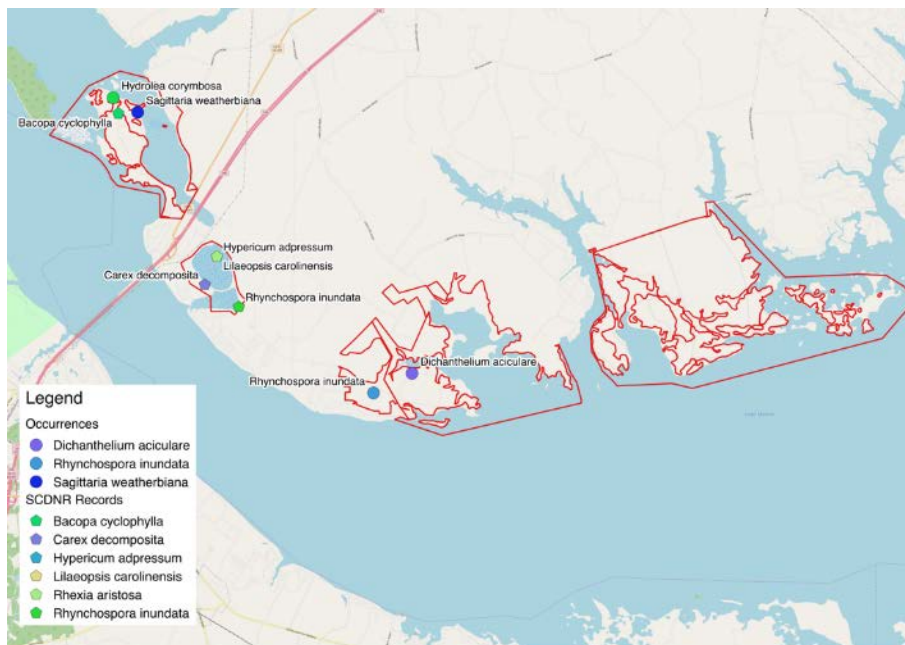


Figure 14: Rare Plants of Santee NWR

Savannah National Wildlife Refuge

The Savannah NWR has more historical floristic data than other refuges in this study. This is mainly due to a floristic inventory of the refuge done by Mellinger & Mellinger (1960), who collected extensively in the refuge. Other botanists have collected sporadically at the refuge since then, with data available on the SERNEC portal. SCDNR and GADNR also have element occurrence data for the refuge.

Surveys were conducted nearly throughout the refuge. A focus was placed on upland habitats within and at the edge of the floodplain of the Savannah River, accessed mainly by boat, and in freshwater tidal marshes. One At-risk species was found in the refuge, *Ptilimnium ahlesii*. Additionally, 15 species tracked by either SCDNR or GADNR were found in the state where tracked (Table 9, Figure 22).

Table 9: Rare Plant Species of Savannah NWR

Scientific Name	Common Name	USFWS	Rank Where Found	Global Status
<i>Carex corrugata</i>	Prune-fruited sedge		GA(S2?)	G5?
<i>Carex dasycarpa</i>	Velvet sedge		GA(S3)	G4?
<i>Collinsonia punctata</i>	Florida horsebalm		SC(S1)	G3G4
<i>Dichantheium aciculare</i>	Needle-leaf witchgrass		SC(SNR)	G5
<i>Halesia diptera</i>	Common two-wing silverbell		SC(S1)	G5
<i>Ilex amelanchier</i>	Sarvis holly		GA(S2)	G4
<i>Physostegia leptophylla</i>	Tidal marsh obedient-plant		SC(SNR); GA(S2S3)	G4?
<i>Ptilimnium ahlesii</i>	Carolina bishopweed	At-risk	SC(S1); GA(S1)	G1
<i>Quercus austrina</i>	Bluff oak		SC(S1); GA(S3?)	G4?
<i>Rhapidophyllum hystrix</i>	Needle palm		SC(S1)	G4
<i>Scutellaria mellichampii</i>	Mellichamp's skullcap		GA(S2?)	-
<i>Sideroxylon alachuense</i>	Alachua bully		G1(S1)	-
<i>Symphyotrichum elliotii</i>	Southern swamp aster		SC(S3)	G4
<i>Thalia dealbata</i>	Powdery thalia		SC(S2)	G4
<i>Verbesina walteri</i>	Walter's wingstem		GA(S1?)	G4

- *Ptilimnium ahlesii* (Carolina bishopweed): This species was known from a single site in the refuge prior to this study. This station is on Argyle Island along Alligator Alley (GA-25) on the Georgia side of the refuge, just west of the Little Back River. The site, the only known from Georgia, was found in 1966 by J. Bozeman (6100, NCU). This location was revisited in 2016 by Jacob Thompson (GADNR) in 2016 and relocated.

A total of 10 new colonies were found in 2017, including one off-refuge (Figure 23). Colonies were found in Georgia (six colonies) and in South Carolina (five colonies). The off-refuge colony was at the Houlihan Boat Ramp in Georgia, on the south side of Alligator Alley at the



Figure 20: *Ptilimnium ahlesii* in fruit

Savannah River. All populations were found in freshwater tidal marshes. Plants were found mainly in two microhabitats. Those reached by boat, on the Middle River and Little Back River, grow from very small berms that are just above high tide level. These berms are situated against shallower marshes dominated by species such as *Zizaniopsis miliacea*, *Schoenoplectus tabernaemontani*, and *Typha angustifolia*. Other colonies were found along roads and levees, also just above high tide, adjacent to similar graminoid dominated marshes. Some colonies occur at the upper edges of freshwater tidal marshes, also just above high tide, where they intersect levees and roads, such as along the west edge of Wildlife Drive on the east side of the Little Back River. These populations are associated with *Zizania aquatica*, *Zizaniopsis miliacea*, *Schoenoplectus tabernaemontani*, *Typha angustifolia*, *Sium suave*, *Eryngium aromaticum*, and *Symphyotrichum elliottii*. The similar *P. capillaceum* also occurs in abundance in this portion of the refuge. While the two species can be found within meters of each other, the latter species was always observed within impoundments and not on tidal sides of levees.

Populations were found along a north-south gradient of 4.0 km. Downstream of populations salinity is expected to increase, and marshes become less diverse, dominated by *Spartina alterniflora*. Upstream, marshes are replaced with freshwater swamp shrublands and forests, with little open sun available to this species.

Other Notable Species

- *Scutellaria mellichampii* (Mellichamp’s skullcap): This rare herb was collected in the refuge in 1959 by E.O. Mellinger (s.n., NCU). The specimen was originally determined as *S. incana* but was later annotated to *S. mellichampii*. This species does not appear under either name in Mellinger & Mellinger (1960), but is probably referable to their inclusion of *S. ovata*, with a locality of “upland woods along U.S. 17-A”. The specimen label is not specific, saying only “South Carolina, Jasper County, Savannah, N.W. Refuge”, a part of the refuge without suitable upland habitat. It was probably collected along US17-A at what is now the refuge visitors center or just to the south at the intersection with the Seaboard Coast railroad line. During this study it was found on seven upland tree islands in both Georgia (2) and South Carolina (5), and four colonies along two areas of bluffs facing the river floodplain on the eastern side of the refuge. All colonies were found north of I-95.
- *Sideroxylon alachuense* (Alachua bully): This small tree was found on three high islands within the floodplain of the Savannah River north of I-95, in both South Carolina (1) and Georgia (2). This species was once thought to be endemic to Florida, but populations have presumably been found in Georgia and South Carolina. The distinctiveness of this species from *S. tenax* is uncertain and is under study at the University of Florida. The plants found in the refuge match characters of *S. alachuense*. It had only been collected a single time in South Carolina, by P. McMillan in Aiken County along the Savannah River.
- *Collinsonia punctata* (Florida horsebalm): This herb, tracked as S1 by SCDNR, is native from South Carolina to Louisiana. Despite the type specimen being originally from South Carolina it has only been



Figure 21: *Sideroxylon alachuense*

found a few times in the state. A small colony was found off Purrysburg Rd. on the bluff at the edge of the Savannah River floodplain. This is now one of only two known populations in the state, the other also in Jasper County. It is also tracked by GADNR, but was not encountered on the Georgia parts of the refuge.

- *Isotrema tomentosa* (Woolly Dutchman's-pipe): This woody vine was found on the Effingham County, Georgia side of the Savannah River opposite the Becks Ferry Boat Ramp. It is a rare species in Georgia, but is not tracked by GADNR. It has been documents in 8 widely scattered Georgia counties, with the closest location in McIntosh County. The species is tracked by SCDNR as S1. It is known from only a few localities in the State, including two on the Savannah River in Allendale and Hampton Counties. While it was not found on the South Carolina side of the refuge in this study, it could occur there.
- *Cyperus entrerianus* (Deeprooted sedge): A rapidly expanding exotic sedge from South America, it was first found in South Carolina in August 2016, just before this study was initiated. This colony was found by J. Nelson south of the refuge at Turn Bridge Landing. During the present study a colony was found by the author along Wildlife Drive. Colonies were also observed right next to the refuge on the southbound shoulder of I-95 east of the Savannah River, along Purrysburg Rd., and at Millstone Landing.
- *Melinis repens* (Natal grass): This exotic African grass was observed right next to the refuge on the southbound shoulder of I-95 east of the Savannah River, growing with *Cyperus entrerianus* and *Mitracarpus hirtus*. Prior to this it had been found in South Carolina a single time, at an abandoned nursery in Beaufort County (Payne 2010). Because of its invasiveness in Florida it is listed as a Category I species by the Florida Exotic Pest Plant Council (FLEPPC 2017).
- *Mitracarpus hirtus* (Girdle-pod): This exotic herb from tropical America was observed right next to the refuge on the southbound shoulder of I-95 east of the Savannah River, growing with *Cyperus entrerianus* and *Melinis repens*. This is the first documentation of the species from South Carolina.
- *Butia odorata* (Brazilian butia): This exotic palm was found naturalizing in upland forest on the Solomon Tract, in Chatham County, Georgia. It is a commonly used landscape species, but this is the first time it has been documented as an escapee in Georgia.
- *Lindera melissifolia* (Southern spicebush): This Federally-listed Endangered species has been recorded in Effingham County, Georgia. Three colonies in the GADNR database, all seen in 2009, are between 13.5 and 14.0 km northwest of the refuge. While these occurrences were within *Nyssa*-dominated ponds, it is possible that the species could be found in bottomland forests along the Savannah River.
- *Coreopsis integrifolia* (Chipola dye-flower): This At-risk species, occurs near the refuge, 4.25 km northeast of the north boundary, on Purrysburg Rd. in Jasper County South Carolina. It is possible that the species could be found along the Savannah River, but no ideal habitats were seen.

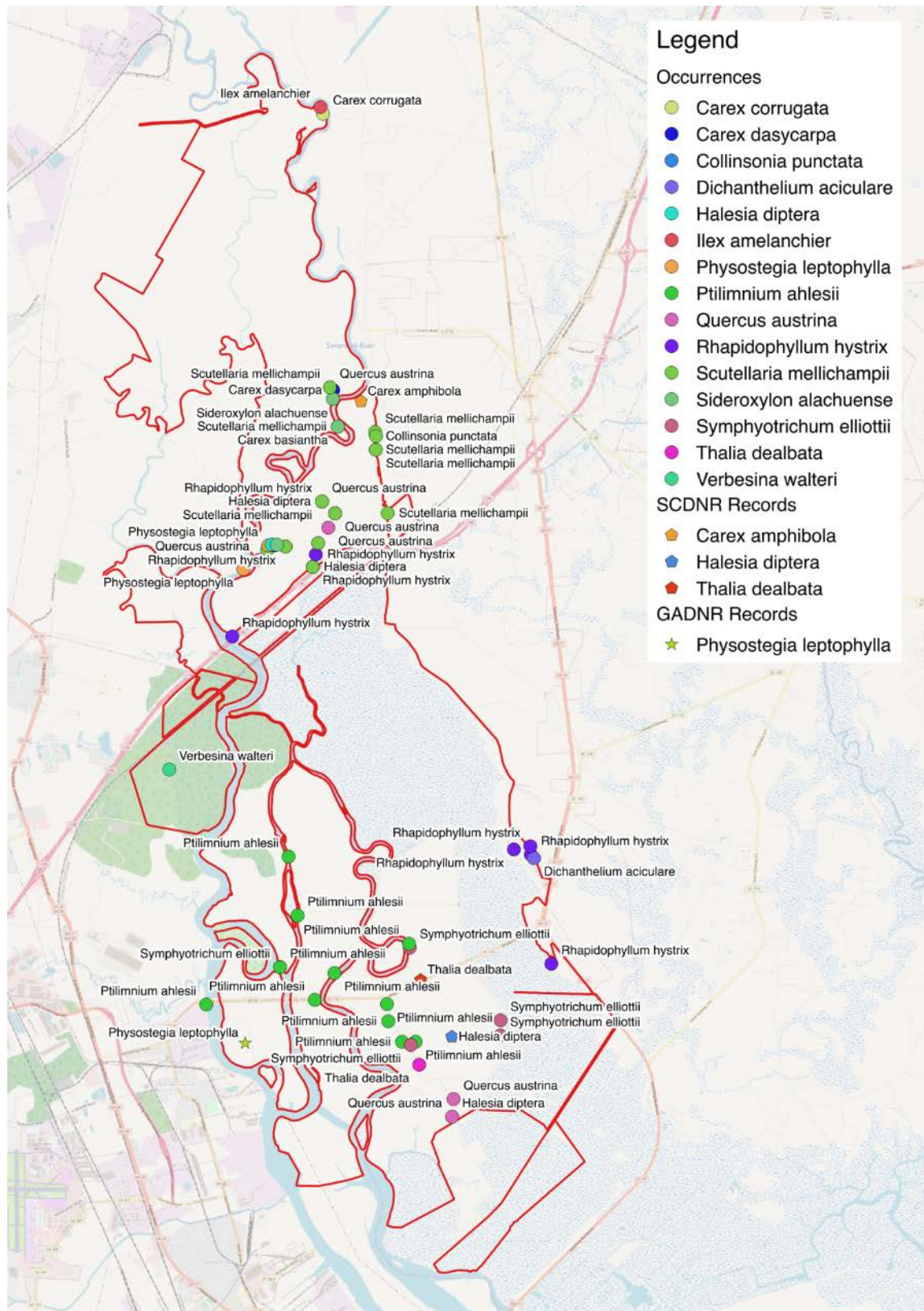


Figure 22: Rare plants of Savannah NWR

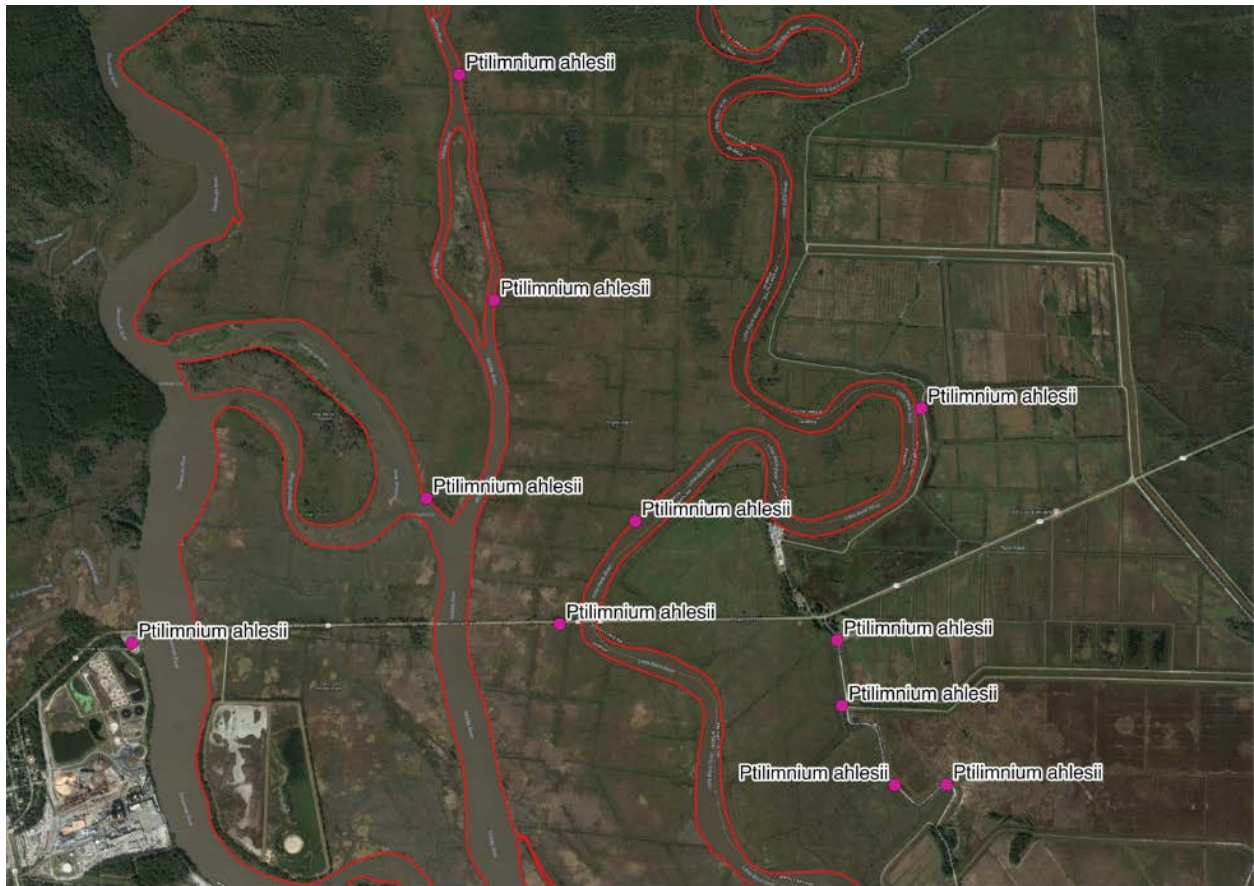


Figure 23: *Ptilimnium ahlesii* at Savannah NWR



Figure 24: *Ptilimnium ahlesii* habitat on Wildlife Drive

Waccamaw National Wildlife Refuge

Surveys were conducted nearly throughout the refuge. Sandy Island was not surveyed because of previous rare plant mapping (e.g. Nelson 2006). A focus was placed on un-surveyed portions of the refuge. Survey efforts were mainly concentrated along waterways accessed by boat, especially the Pee Dee and Waccamaw Rivers and smaller waterways west and south of Sandy Island. Land based surveys were conducted where access permitted, particularly at the Bridge Tract and at Jackson Bluff, and at boat landings.

Two Federal At-risk species were found at Waccamaw NWR. One of these, *Ptilimnium ahlesii*, was a new detection. *Nuphar sagittifolia*, a species already known from the refuge, was mapped. Additionally, 11 species tracked by SCDNR were found (Table 10). Two additional SCDNR tracked species have been found in the refuge, but were not observed during this study, *Sabatia kennedyana* and *Stachys tenuifolia*. Rare plant species locations are shown in Figure 27.

A list of rare plant species that have been recorded in the refuge only on Sandy Island is included below (Table 11). This list has been generated from Nelson (2006), the SCDNR Heritage Trust Program database, and specimen data on the SERNEC portal. The list includes 14 species tracked by SCDNR. No Federally-listed or At-risk species have been found there.

Table 10: Rare Plant Species of Waccamaw NWR, excluding Sandy Island

Scientific Name	Common Name	Recorded	USFWS	SCDNR	Global Status
<i>Carex amphibola</i>	Eastern narrow-leaved sedge	Yes		SNR	G5
<i>Carex crus-corvi</i>	Crowfoot sedge	Yes		S2	G5
<i>Carex elliotii</i>	Elliott's sedge	Yes		S1	G4?
<i>Dichanthelium aciculare</i>	Needle-leaved witchgrass	Yes		SNR	G5
<i>Epidendrum magnoliae</i>	Green-fly orchid	Yes		S3?	G4
<i>Hymenocallis pygmaea</i>	Pygmy spiderlily	Yes		SNR	G1G2?
<i>Ilex amelanchar</i>	Sarvis holly	Yes		S3	G4
<i>Nuphar sagittifolia</i>	Narrowleaf pondlily	Yes	At-Risk	S2	G5T2
<i>Physostegia leptophylla</i>	Tidal marsh obedient-plant	Yes		SNR	G4?
<i>Pilea fontana</i>	Blackfruit clearweed	Yes		SNR	G5
<i>Ptilimnium ahlesii</i>	Carolina bishopweed	Yes	At-Risk	S1	G1
<i>Sabatia kennedyana</i>	Plymouth gentian	No		S2	G3?
<i>Sagittaria weatherbiana</i>	Weatherby's arrowhead	Yes		S1	G5T3T4
<i>Stachys tenuifolia</i>	Smooth hedge-nettle	No		S1	G5
<i>Symphotrichum elliotii</i>	Southern swamp aster	Yes		S3	G4

Table 11: Rare Plant Species Unique to Sandy Island within Waccamaw NWR

Scientific Name	Common Name	SCDNR	Global Status
<i>Aristida condensata</i>	Big three-awn	G4?	G4?

<i>Ceratiola ericoides</i>	Florida rosemary	S1	G4
<i>Cladium mariscoides</i>	Twig-rush	S1	G5
<i>Cyperus lecontei</i>	Leconte's flatsedge	S1	G4?
<i>Eleocharis robbinsii</i>	Robbins's spikerush	S2	G4G5
<i>Eleocharis vivipara</i>	Viviparous spikerush	S1	G5
<i>Lachnocaulon beyrichianum</i>	Southern bigbutton	S2	G4
<i>Litsea aestivalis</i>	Pondspice	S3	G3?
<i>Pityopsis pinifolia</i>	Sandhill goldenaster	S2	G4
<i>Rhynchospora inundata</i>	Narrow-fruit horned beaksedge	S2?	G4?
<i>Sagittaria isoetiformis</i>	Quillwort arrowhead	S3	G4?
<i>Syngonanthus flavidulus</i>	Yellow hatpins	S2	G5
<i>Xyris elliotii</i>	Elliott's yellow-eyed grass	S2	G4
<i>Xyris flabelliformis</i>	Savanna yellow-eyed grass	S1	G4

- Ptilimnium ahlesii* (Carolina bishopweed). This species was found only in the southern portions of the refuge (Figure 28). It occupies freshwater tidal habitats close to the coast. Populations were mapped both on and off refuge, searches being conducted from Samworth Wildlife Management Area (WMA), the Great Pee Dee River, Waccamaw River, and connecting waterways. The species is rare in and around the refuge. Nine total colonies were found with about 90 plants. Two of these colonies were on the refuge itself, one on the south tip of Sandy Island along the Waccamaw River east of Sandy Island Lagoon. Another colony was found on Guendalose Creek, west of Thoroughfare Creek. Four colonies were on Samworth WMA and three on private lands. All were found in Southern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh. Species associates are similar to those in ACE Basin and Savannah refuges, including *Schoenoplectus tabernaemontani*, *Zizania aquatica*, *Zizaniopsis miliacea*, *Typha angustifolia*, *Physostegia leptophylla*, *Pontederia cordata*, and *Symphotrichum elliotii*. It is often growing very close to *Nuphar sagittifolia*, which is in deeper water.
- Nuphar sagittifolia* (Narrowleaf pondlily). A total of 189 km of waterway were mapped, comprising mainly natural waterways, but it also includes some artificial channels. Searches were conducted by boat on 109 km of waterway from Samworth Wildlife Management Area which is south of the refuge, on the Great Pee Dee River, Waccamaw River, and connecting waterways, up to US701 on the Pee Dee River, and nearly to Jackson Bluff on the Waccamaw River. In addition, 80 km of waterways were analyzed for the presence of the species using aerial photography.



Figure 25: *Nuphar sagittifolia*, Guendalose Creek

This species was found to be present on waterways throughout the refuge. Of the 189 km of mapped waterway the species was present along 166 km (88%) (Figure 30). In southern, more coastal areas it is essentially ubiquitous, forming dense, continuous colonies along rivers, interconnecting creeks of all sizes, and cuts along rice impoundments. It is typically found in deeper water adjacent to

tidal marshes with *Zizaniopsis miliacea*, *Zizania aquatica*, *Schoenoplectus tabernaemontani*, *Typha* spp., and *Physostegia leptophylla*. Further upstream habitats in the refuge secede to freshwater swamp forests, with dense tree cover lining waterways. In general the species becomes less dense northward. Where present upstream it reaches its densest growth on point bars, mouths of streams, and tidally connected oxbow lakes.

One day was also spent surveying upstream from the refuge, on the Waccamaw River between SC-9 and Worthams Ferry. The species was completely absent here.

Other Notable Species

- *Hymenocallis pygmaea* (Pygmy spiderlily): This herb is endemic to a small area of South and North Carolina where it is known only from the Waccamaw River Drainage. It was observed frequently in the northern portions of the refuge along both the Waccamaw and Pee Dee Rivers. Plants were found to grow in shallow water in bottomland swamp forests both right on the river bank, and up to 2.5 km inland. It was also observed to be frequent upstream of the refuge on the Waccamaw River between SC-22 and the North Carolina line.
- *Ptilimnium costatum* (Big bishopweed): This native herb was found along Guendalose Creek in freshwater tidal marsh in an old rice field. Prior to this discovery it was collected only a single time in South Carolina in 2000 (Nelson 21639, USCH). This collection was made just east of the refuge at Brookgreen Gardens along Brookgreen Creek. While not tracked by SCDNR it should be considered for adding to the tracked species list.
- *Thalictrum pubescens* (Common tall meadowrue): This herb was observed in three locations southwest of Sandy island, on Guendalose Creek, on its connector canal to the Pee Dee River, and on Bullins Creek. It was also collected on Guendalose Creek in 1998 (Nelson, 19350, USCH). Otherwise, this species is very rare in South Carolina, despite a range from the coast to the mountains. While not tracked by SCDNR it should be considered for adding to the tracked species list.



Figure 15: *Hymenocallis pygmaea*

Six At-risk species have been found near the refuge. Upstream on the Waccamaw River *Coreopsis integrifolia*, *Fimbristylis perpusilla*, and *Ludwigia brevipes* have been recorded. These populations are from above Conway, SC, between SC-22 and the North Carolina line. Based on surveys collected there and in the refuge in 2017 it is unlikely that these taxa will be found in the refuge due to a lack of habitats. They require seasonally drawdown zones that are not found within the refuge due to tidal influences. Historically, pine savannas and pocosins east and west of the refuge, such as at the destroyed Socastee Savanna, contained At-risk species, including *Dionaea muscipula* and *Sporobolus teretifolius*, as well as the Endangered *Schwalbea americana*. While these taxa all occurred within 2-3 km of the refuge they are not expected to be found within its current borders due to a lack of suitable habitat.

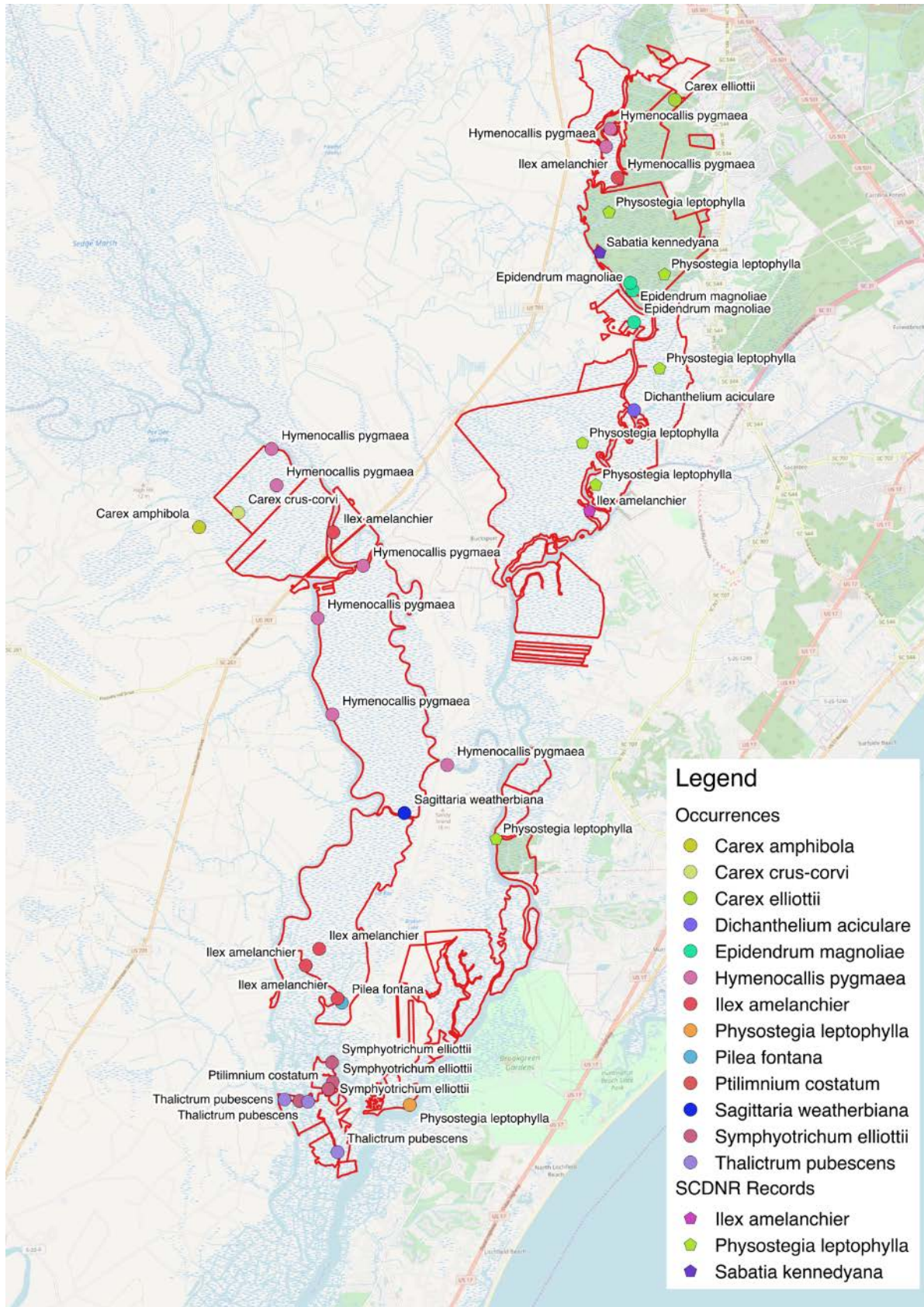


Figure 16: Rare Plants of Waccamaw NWR

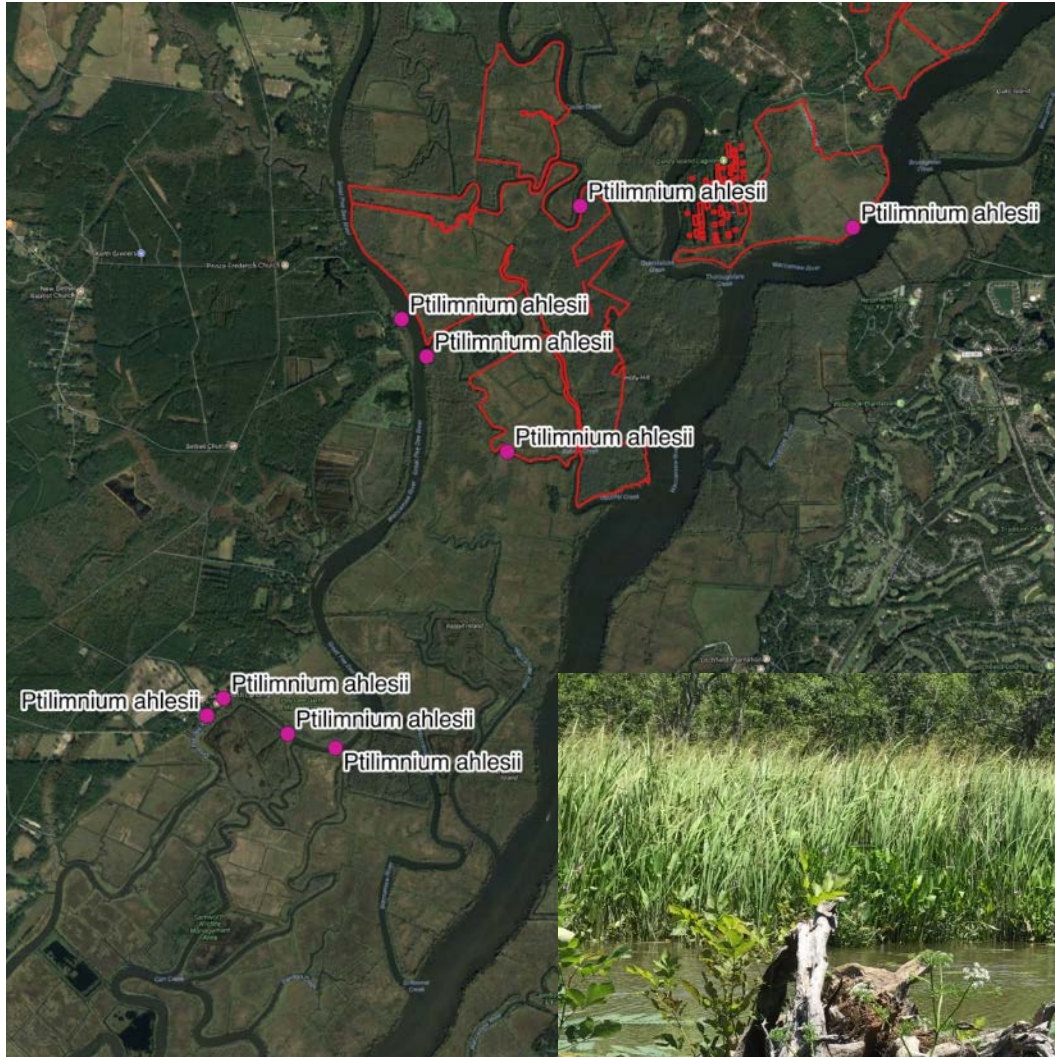


Figure 17: *Ptilimnium ahlesii* at Waccamaw NWR



Figure 18: *Ptilimnium ahlesii* on stump in Pee Dee River

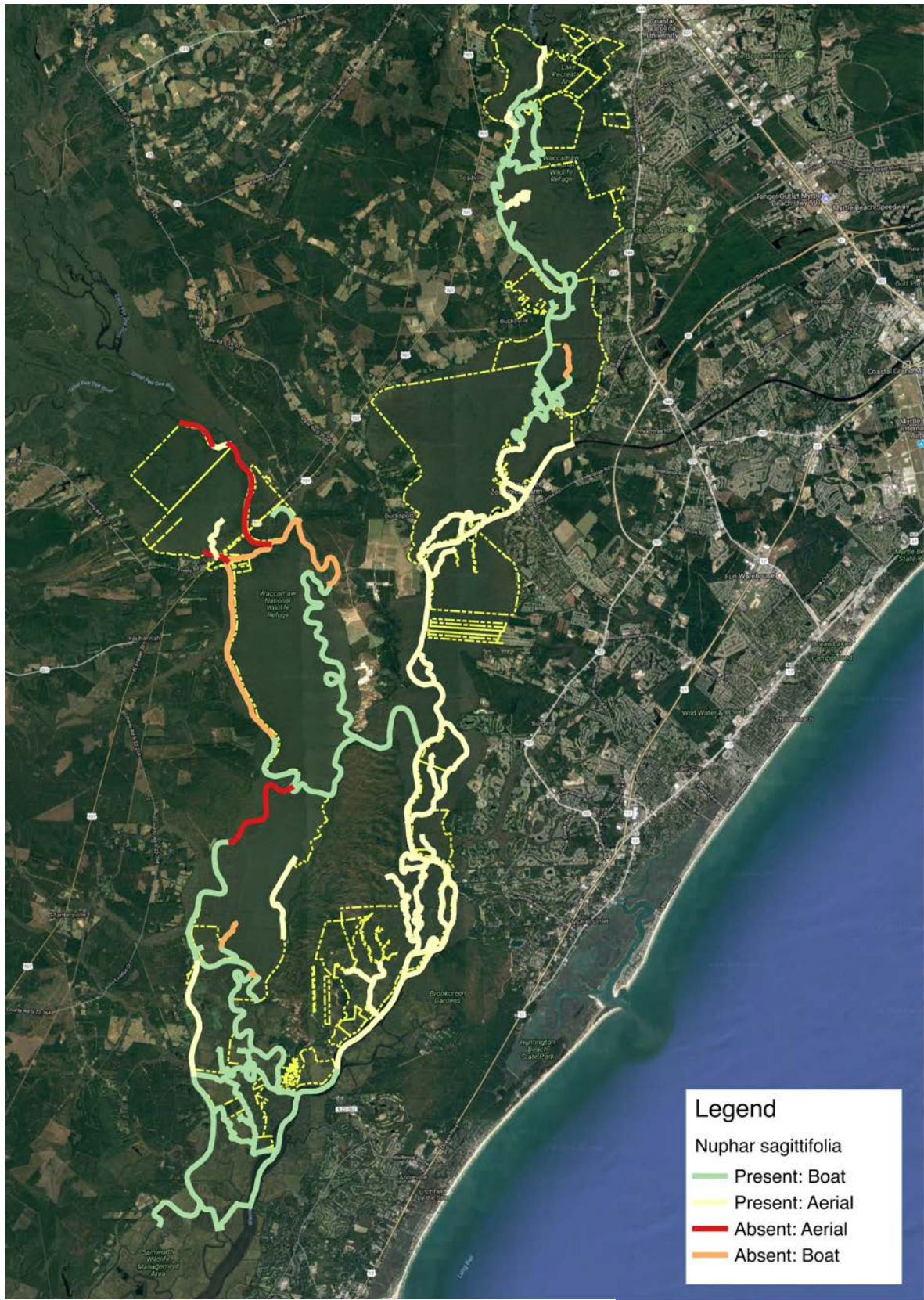


Figure 30: *Nuphar sagittifolia* at Waccamaw NWR



Figure 31: Nuphar sagittifolia on a point bar at low tide, Waccamaw River



Figure 32: Nuphar sagittifolia signature on Google Earth Imagery, May 2017, Waccamaw River

DISCUSSION

This study resulted in the discovery of five Federal At-risk species on three refuges. In general, meta-populations of these species in these refuges are secure in the short term. However, they all face long-term threats. Threats to these At-risk species overlap with those of regionally rare plant species that occur on all seven refuges. With the exception of Santee NWR because of its inland location, all refuges face problems associated with sea level rise. Rare plant species which occupy freshwater tidal habitats, including the At-risk *Nuphar sagittifolia* and *Ptilimnium ahlesii* will be particularly sensitive to rising water levels and saltwater intrusion. Regional changes to hydrology could have similar effects, including harbor dredging, river dredging or channel modifications, dam construction, or regional pressure on freshwater aquifers for human and industrial consumption.

All rare plant species face pressures from invasive organisms. Invasive pest plants can alter habitat structures and functions, displacing rare species. The most problematic invasive plant species to rare plants on these refuges include *Eichhornia crassipes*, *Ligustrum sinense*, *Microstegium vimineum*, *Murdannia keisak*, *Myriophyllum aquaticum*, *Panicum repens*, *Phragmites australis*, *Pistia stratiotes*, *Sesbania punicea*, and *Triadica sebifera*. Wild hog populations pose threats to all rare plants except aquatic species. Direct impacts of wild hog rooting were observed on populations of *Coreopsis integrifolia*, *Isoetes hyemalis*, and *Macbridea caroliniana*.

Prescribed burning is a critical management tool in many ecosystems of the coastal plain, including many in these refuges, and should be used as a tool to maintain populations of rare plant species. The At-Risk species detected in this study were all found in habitats where regular burns are not necessary. While freshwater tidal marshes, habitat for *Nuphar sagittifolia* and *Ptilimnium ahlesii*, may burn on occasion, the role of fire is poorly understood, and may primarily occur where immediately adjacent to pyric ecosystems such as pine savannas, but otherwise rarely burn (Schafale and Weakley, 1990). The other At-risk species found in refuges occupy forested wetlands, also a habitat that does not rely on fires, although they probably burned into their periphery and may have historically been important for ecotonal species such as *Coreopsis integrifolia* in some locations (McMillan et al. 2002). Several regionally rare species, however, were found in pyric ecosystems, such as *Burmanna biflora* and *Eupatorium anomalum*, in longleaf pine savannah and a coastal pine savanna. Such habitats should be burned regularly to maintain habitat for these species.

Presence of rare plant species, particularly Federal At-risk and those ranked as S1 to S2 by state heritage programs, should be factored into long-term management planning for each refuge. Vegetation management activities including mowing, logging, prescribed burning, and water management should ideally take into consideration impacts on rare plants. The discovery of populations of rare species populations on each refuge indicates that past management actions have been favorable to these species. Ongoing management should take into consideration flowering and fruiting times, for examples, in planning activities such as mowing or brush hogging to ensure annual or periodic seed set and dispersal.

Specifics on each At-risk species found in the study are included below, as are discussions of each refuge.

At-Risk Species in Refuges

- *Coreopsis integrifolia* (Chipola dye-flower)

This herb is endemic to the coastal plain of South Carolina, Georgia, and Florida (Sorrie et al., 2013; Weakley 2015). It is known from three to five locations in South Carolina, 13 locations in Georgia, and twelve in Florida (Amy Jenkins, personal communication, 2018). While habitats for the species are variable, McMillan et al. (2002) report that it prefers transition zones between pyric ecosystems and swamp forests, or pocosins along blackwater streams.

One new meta-population of this species was discovered during this study, in ACE Basin NWR in the Upper Combahee unit. Two colonies were found, with a total population of 3,000-5,000 plants. One population of 10 stems occurs in high quality bottomland forest habitat (Atlantic Coastal Plain Small Blackwater River Floodplain Forest) on the Combahee River. Despite searches of about 4 km of suitable habitat along the Combahee River this was the only colony found in intact habitat. The majority of the population occurs along two connecting management roads, in an extensive linear colony. Plants grow densely in shallow swales along the roads, creeping into roadbeds. This population was first found in November 2016, one month after extensive floods hit the region because of Hurricane Matthew. High water levels in the Combahee River resulted in the complete inundation of this population, covering them with a layer of mud, but plants were resprouting and some were in flower.

The species also occurs near the Savannah NWR, 4.25 km northeast of the refuge on Purrysburg Rd. in Jasper County South Carolina, a colony found by Ethan Kauffman. This colony, inspected September 2016, is under a powerline easement and consists of several hundred plants. Additional populations could potentially occur along the Savannah River, but probably only north of the current refuge boundary.

Threats and Recommendations: Threats to this species include improper vegetation management, invasive plant species, and wild hogs. The riverside population is threatened by the invasive tree *Triadica sebifera* which occurs at very low densities along the river. A greater threat is rooting by wild hogs, which could quickly eradicate the small colony and impact the larger colony as well. The larger population is growing along management roads that are mowed periodically. Evidenced by the large population size, past management regimes have apparently been conducive to the health of the population. Continued mowing should be continued to minimize densities of woody plants, and conducted in the winter through spring when plants are not in flower or fruit. The invasive tree *T. sebifera* should be eliminated here, and wild hogs controlled.

- *Isoetes hyemalis* (Wintergreen quillwort)

This semi-aquatic fern-ally is endemic to the southeastern United States from Virginia to Alabama, mainly in the coastal plain and rarely in the lower piedmont (Brunton et al., 1994). It is rare throughout its range, with about half a dozen locations in South Carolina. It is a species of swamp forests in shallow running water in creeks and sloughs, and river shores (Brunton et al. 1994). The taxonomy of *I. hyemalis* may not be resolved; some

populations currently referred to the species may represent other undescribed taxa (P. Schafran, email, March 7, 2018).

This species was found at Ernest F. Hollings ACE Basin NWR in the Upper Combahee Unit in Beaufort County, a new refuge record and new county in South Carolina. These populations occurred in natural and artificial habitats, including the bank of the Combahee River and in an interior bottomland forest (both Atlantic Coastal Plain Small Blackwater River Floodplain Forest), and roadside swale.

Threats and Recommendations: Threats include invasive plant species, wild hogs, and improper vegetation management. The exotic tree *Triadica sebifera* occurs close to or with all populations and could alter habitat structure. Wild hog damage was visible in all colonies, and could be a major threat. One population is growing along management roads that are mowed periodically. Because the species is present there past management regimes have apparently been conducive to the health of the population. Continued mowing should be continued to minimize densities of woody plants. Cessation of mowing would lead to invasions of a woody shrub layer that could displace the species.

- *Macbridea caroliniana* (Carolina birds-in-a-nest)
This herb is endemic from southeastern North Carolina to southern Georgia. It appears to be more common than previously thought throughout its range (Gaddy 2015). LeBlond and Sorrie (2002) report 57 known populations and visited 38 of them. There are about 12 populations known in Georgia (Gaddy 2015), and 118 element occurrence records in the SCDNR database (but many being duplicates or extirpated).

One population of this species was found at Ernest F. Hollings ACE Basin NWR in the Upper Combahee Unit in Beaufort County, a new refuge record and new county in South Carolina. This colony was found in a low swale along a management road and consisted of several hundred plants. Unlike the populations of *Coreopsis integrifolia* and *Isoetes hyemalis* which are growing in swales next to bottomland forest, this species is growing in a swale next to a dense *Pinus taeda* plantation.

Threats and Recommendations: Threats to this species include invasive plant species, wild hogs, and improper vegetation management. The exotic tree *Triadica sebifera* occurs close to the population. Wild hog damage was extensive in this colony and could be a major threat to its persistence. This management road and swale is mowed periodically which maintains desirable open conditions. Because the species is present past management regimes have apparently been conducive to the health of the population. Mowing should be continued to minimize densities of woody plants, preferably in the winter after plants have dispersed seeds or in early spring. This population occurs next to a loblolly pine plantation; logging activities could impact the population, both due to mechanical disturbance and alteration of canopy light levels. If this tract is logged an undisturbed buffer should be considered, and logging equipment should not be driven over the plants.

- *Nuphar sagittifolia* (Narrowleaf pondlily)
This aquatic is endemic to the coastal plain from eastern Virginia to South Carolina (Padgett 2007). It grows in blackwater streams and in lakes, either in flowing or still water, from inland areas downstream to freshwater tidal habitats. In South Carolina it is restricted to the Pee Dee watershed, including the Pee Dee, Waccamaw, Black, and Lynch rivers. Within these watersheds it can be locally abundant.

The species was found to be abundant and widespread at Waccamaw NWR, where it occupied 88% of waterways that were surveyed. While there has been some discussion of the taxonomic distinctiveness of the species because of apparent intermediates with *N. advena* (Beal and Southall, 1977; Depoe and Beal, 1969) all colonies at Waccamaw were representative of the species, with long narrow leaf blades.

Threats and Recommendations: While this species is abundant in the vicinity of Waccamaw NWR changes in hydrology and the potential upstream migration of the halocline pose a long-term threat. Sea level rise would be a major contributor to such changes, as well as both upstream water deliver changes, downstream changes (e.g. dredging of Winyah Bay), or regional water drawdowns for human consumption and industrial/agricultural use (Brown, 2016). Changes in salinity and increases in water levels could dramatically change environmental conditions within this small geographic area. Populations of exotic pest plants could impact some colonies, such as *Eichhornia crassipes* and *Panicum repens*. These exotic species should be controlled, especially incipient infestations such as *P. repens*. The population of this species in the refuge should be monitored to track long term changes in density and distribution.

- *Ptilimnium ahlesii* (Carolina bishopweed):
This herb was described as a new species in 2004 (Weakley & Nesom, 2004). Its range is restricted to coastal areas from Chatham County, Georgia to Pender County, North Carolina. Because the species was only recently described little data has been published on habitat requirements, number of populations, or abundances. While Weakley & Nesom (2004) cite 14 collections, few of these were collected recently, and almost no historical populations had been visited recently.

The single known collection of this species from Georgia was collected in the Savannah National Wildlife Refuge in 1966 by J. Bozeman (6100, NCU). This location was revisited in 2016 by Jacob Thompson (GADNR) and relocated. There were no historical reports from other national wildlife refuges. During this study a substantial amount of effort was made to relocating previous collection localities near refuges and in searching potential habitats within and adjacent to refuges. New populations were found within the Savannah National Wildlife Refuge, and the species was newly discovered in Ernest F. Hollings ACE Basin and Waccamaw National Wildlife Refuges. Overall, 41 colonies were found, with a total population of at least 850 plants. Of these 22 were within refuges representing about 600 plants.

All populations were associated with freshwater tidal marshes. The tidal reach of rivers in the study area (Savannah, Combahee, Pee Dee, Waccamaw) can extend far upstream.

Thepaut et al. (2016) found tidal influence 101 km up the Waccamaw River. However, *P. ahlesii* was only found to occupy a small intertidal zone. At the Savannah NWR this was ca 4.0 km, and ca 6.5 km at Waccamaw NWR. The range of the species appears to be limited to this smaller zone by a combination of salinity and habitat structure. Downstream habitat is limited by salinity. Upstream habitats secede from marsh dominated landscapes to shrub and then forest dominated habitats. Shading by these hardwoods eliminates open canopy gaps above high tide lines where seeds can germinate in the spring. Seed dispersal or other factors may also limit upstream occupancy because even in small marshes on point bars, adjacent to forested swamps, no *P. ahlesii* was found.

Within the freshwater tidal marsh ecosystem *P. ahlesii* is restricted to several microhabitats, all apparently where seed can be deposited in summer and then germinate in spring. All colonies were found just above water lines. Usually this was just above high tide line, such as along natural levees along tidal waterways, a microhabitat slightly drier than surrounding marshes which are inundated at high tides, or on old stumps within water channels. Alternatively, plants could be found just above high tide levels where tidal marshes intersected roads or manmade levees. Populations were also found in floating vegetation mats, especially along the Combahee River. These mats form where protected from river currents, with a substrate of decaying thatch (especially from grasses such as *Zizania*, *Zizaniopsis*, and *Spartina*) and varying assemblages of native and exotic wetland herbaceous species.

Despite finding the species in three refuges it does appear to be rare within the survey area. Where colonies were found they usually consisted of only a few plants, and rarely to as many as 100. Further surveys are warranted outside of refuges. The range of the species could extend further south into Georgia, such as on freshwater tidal portions of the Ogeechee and Altamaha rivers.

The survey window for this species is very short. Plants are most easily seen when in full flower, but the flowering period is restricted to a few weeks, mainly in May. After the plants fruit their habit structure changes dramatically, in many places the groundcover being completely overtopped by *Zizania aquatica* and other tidal marsh species, as described by Odom et al. (1984).

This species has been reported for Santee NWR based on an herbarium specimen (Nelson 32060, USCH). I examined this specimen and determined that it represents *P. capillaceum*, based on fruit size and leaf segment width. There is no valid record of *P. ahlesii* for Santee NWR.

The distinctness of this species from *P. capillaceum* has been questioned (Feist, 2010), because of a lack of molecular differences (Feist and Downie, 2008). Extensive observations were made of both of *P. ahlesii* and *P. capillaceum* while working on refuges, and herbarium specimens were collected of each species while in flower and fruit. Characters cited to distinguish the two taxa by Weakley and Nesom (2004) include fruit size and shape, flowers/umbellet, petal length, leaf segment widths, and flower

season. I found that some of these characters are unreliable, including flowering season and flowers/umbellets. However, fruit size and leaf segment widths were consistently distinct. When not in flower plants could be distinguished at a glance based on leaf segment width, which is wider in *P. ahlesii*. Fruiting material is the most reliable character to distinguish the two species.

Threats and Recommendations: Large-scale ecosystem changes, e.g., as influenced by sea level rise, could have a major impact on this species. It occupies a narrow habitat that is defined by a combination of low to zero salinity, tidal fluctuations, and sunny habitats. Along tidal waterways this zone is limited by salinity downstream and by forest cover and tidal range upstream. With a combination of sea level rise and salt water intrusion, influenced by climate change, altered water deliveries, or regional water table drawdowns, much of the habitat currently available to the species could be lost. Exotic plant species pose both a threat or a benefit depending on life form. Woody exotics, such as *Sesbania punicea*, are a threat. This species is invading *P. ahlesii* habitat at the Savannah NWR. Dense populations could shade out colonies of the species. The exotic woody grass *Phragmites australis* poses a serious long term threat to this species. This grass is established across the coast of South Carolina into Georgia, and population sizes are expanding rapidly. This species is becoming a major problem in freshwater tidal habitats and could eliminate populations of invasive floating aquatics provided habitat for the species in floating mats on the Combahee River in the ACE Basin National Wildlife Refuge, especially *Alternanthera philoxeroides* and *Myriophyllum aquaticum*. If herbicide treatments are planned they should be tested on a small scale, late in the growing season after *P. ahlesii* has senesced. *P. ahlesii*. Other native floating aquatics should sustain a floating mat habitat for the species. Because some colonies grow at the edges of levees, roads, and boat ramp, populations could be impacted by vegetation management activities, including mowing, herbicide application, or mechanical disturbance. These artificial habitats should continue to be maintained with an open canopy where plants are exposed to full sun, any disturbances should be done late in the growing season after *P. ahlesii* has senesced. While tidal marshes not adjacent to pyric ecosystems probably burn rarely (Schafale and Weakley, 1990), fire could potentially be used as a management tool. Populations should be monitored in the long term for intrusion of woody species that could displace open marsh habitat. Fires could be applied as an experiment to reduce woody cover, if needed.

Refuges

- **Cape Romain NWR**

No At-risk species were found in the refuge; one Federally Threatened species, *Amaranthus pumilus*, formerly occurred in the refuge and reintroduction efforts for it are underway. The lack of At-risk species is due to the lack of suitable habitats, mainly influenced by the geographic position of the refuge. The At-risk species most likely to be found in the refuge is *Forestiera godfreyi*. This shrub is restricted to coastal shell middens, a habitat that is not well represented in the refuge. The refuge was found to provide habitat for 13 species tracked by SCDNR, as well as one regionally rare species. These 14 rare species were widely distributed mainly on Bulls Island, across the island, in several habitats. The majority (eight) are associated with impounded wetlands, especially

along roads, and in wet roadside ditches. Four are associated with dunes and backdune swales. Three are associated with hammocks on upland sand ridges, and one with bahia grass lawn.

- **Ernest F. Hollings ACE Basin NWR**

Four At-risk species were found, the most species for any refuge, including *Coreopsis integrifolia*, *Isoetes hyemalis*, *Macbridea caroliniana*, and *Ptilimnium ahlesii*. These were found in the Bonny Hall, Upper Combahee, and Combahee Fields units. *P. ahlesii* was found to be infrequent in the refuge in freshwater tidal areas of the Bonny Hall and Combahee Fields units. Populations were mainly on the Combahee River, but one was along the edge of SC-33. The other three species were found in the Bonny Hall Unit, both in bottomland swamp forest and in shallow roadside swales next to management roads. Thirteen rare plant species tracked by SCDNR were recorded. These were found, additionally, on the Grove Plantation, Jehossee Island, and Yemassee South units. One plant species new to South Carolina was found in the Grove Plantation Unit, Baby jump-up (*Mecardonia procumbens*), likely an accidental introduction.

- **Harris Neck NWR**

No At-risk species were found in the refuge. Three species tracked by GADNR were found. Two of these tracked species, *Aeschynomene viscidula* and *Andropogon longiberbis* were associated with areas that were logged due to a bark beetle infestation and die off. These upland areas are now generally weedy, but with a higher native graminoid and herb diversity and density than probably existed previously because of the now open canopy and exposed soil. *A. viscidula* had previously been found on the refuge, but was on a road edge, also a sunny, open habitat. Maintenance of open canopy areas will be important for these species. The third tracked species, *Eleocharis montevidensis*, was found in Snipe Pond. The species was common there, and because it is rhizomatous should persist there by maintaining hydrological conditions and an open canopy.

- **Pinckney Island NWR**

No At-risk species were found in the refuge. The lack of At-risk species is due to the lack of suitable habitats, mainly influenced by the geographic position of the refuge. The At-risk species most likely to be found in the refuge is *Forestiera godfreyi*. This shrub is restricted to coastal shell middens, a habitat that is not well developed in the refuge, although some shell deposits do occur there, e.g. on Dick Pond Point and to a lesser degree on Last End Point. These shell areas do not have the same elevation profile as other known locations for the species in the state. The refuge does provide habitat for nine species tracked by SCDNR. These species were found to be widely distributed across Pinckney Island in several habitats, including shell deposits, coastal grassland, low coastal hammocks, and disturbed wetlands.

- **Santee NWR**

No At-risk species were found in the refuge. The lack of At-risk species is due to the lack of suitable habitats. This is the only inland refuge in the project, and all habitats here are heavily impacted by the creation of Lake Marion and in management of habitats for waterfowl. Several At-risk species are within the range of the refuge and could have

occurred there before the lake was created including *Lobelia boykinii*, *Tiedmannia canbyi*, *Macbridea caroliniana*, and *Schwalbea americana*. The refuge was found to provide habitat for four species tracked by SCDNR, as well as two regionally rare species. Five rare plant species previously known from the refuge were not relocated, probably due to changes in habitat conditions over the period of several decades. The six rare plant species that were found were mainly associated with wetlands created for waterfowl management. One of these, *Lysimachia terrestris* is not tracked as a rare species by SCDNR but should be considered for listing; the colony at the refuge is the only population in South Carolina known to the author.

- **Savannah NWR**

One At-risk species was found in the refuge, *Ptilimnium ahlesii*. Prior to this study it was known in the refuge from a single colony in Georgia. During the study a total of 10 new colonies were found in 2017, including one off-refuge. All populations were found in freshwater tidal marshes, especially on slightly elevated berms just above high tide level at edges of tidal creeks, as well as along edges of artificial levees/tidal marshes. Fifteen rare plant species tracked by SCDNR or GADNR were recorded. These were found across the refuge, in freshwater tidal marshes, rice impoundments, and upland hardwood forests.

A floristic inventory of the refuge was compiled by E.O. and Marie B. Mellinger (1960), based on observation and collections made from 1957 to 1960. They report xx rare species tracked in either South Carolina or Georgia that were not found during the 2016-2017 study. Herbarium specimens confirm the identify of many of these and provide locality data (e.g. which state) to supplement that given in their report. Table 12 lists species that were probably identified correctly by the Mellingers and which occurred in the state where they are now ranked by heritage programs. A number of these rare species records could not be corroborated with specimen data available online. Regardless, the number of rare species that they did observe which were not observed recently is noteworthy. This list does not include any Federally-listed or At-risk species, but many regionally rare ones. Some of these were simply missed, e.g. *Listera australis* is both inconspicuous and flowers in habitats that were surveyed in 2017, but after its very early (mainly February-April) flowering period. Other species are probably absent because of long-term vegetation changes, e.g. due to sea level rise. Others species tracked in South Carolina that were listed, e.g. *Galactia elliottii*, were only found east of US-17A in an area that is no longer within the refuge boundaries.

Table 12: Rare Species Recorded only by Mellinger & Mellinger (1960) from the Savannah NWR

Scientific Name	Common Name	State/Rank	NaturServe
<i>Aphyllon uniflorum</i>	Cancer-root	SC(S2)	G5
<i>Bacopa innominata</i>	Tropical water-hyssop	SC(S1)	G3G5
<i>Carex hyalinolepis</i>	Shoreline sedge	SC(S2)	G4G5
<i>Eleocharis vivipara</i>	Viviparous spikerush	SC(S1)	G5
<i>Epidendrum magnoliae</i>	Green-fly orchid	SC(S3?)	G4
<i>Habenaria quinqueseta</i>	Long-horned habenaria	SC(S1)	G4G5
<i>Hypericum tubulosum</i>	Southern marsh St. John's-wort	GA(S1S3)	G4?
<i>Juncus subcaudatus</i>	Somewhat-tailed rush	SC(S1)	G5

<i>Listera australis</i>	Southern twayblade	SC(S1)	G4
<i>Lycopus americanus</i>	American bugleweed	GA(S1)	G5
<i>Rhexia aristosa</i>	Awed meadow-beauty	SC(S3)	G3G4
<i>Rhexia cubensis</i>	West indies meadow-beauty	SC(S1)	G4G5
<i>Rhynchospora scirpoides</i>	Long-beak beaksedge	SC(S1)	G4
<i>Sagittaria weatherbiana</i>	Weatherby's arrowhead	SC(S1)	G5T3T4
<i>Spermacoce glabra</i>	Smooth buttonweed	GA(S2?)	G4G5

Of particular interest in this refuge are upland hardwood forests. These have formed in two conditions; either as bluffs along the edge of the Savannah River floodplain, or as discrete islands within the floodplain that are surrounded by tidal swamp forests. These islands are referred to as South Atlantic Swamp Islands (USNVC 2017), or “Spruce Pine - Live Oak - Pignut Hickory / American Hornbeam / Saw Palmetto Swamp Forest”. These islands are found both in the south end of the refuge (Pools 14-18), and then north of I-95. In management pools the islands have been degraded due to hydrological changes, human settlement, and invasive pest plants and are of lower quality, but still contain populations of rare plants (*Halesia diptera* and *Quercus austrina*). North of I-95 the islands are of much higher quality, occupy more area, and have higher elevations of up to about 26 m. These northern islands have a diverse understory flora with many rare and otherwise interesting plant species. These islands (and floodplain bluffs) contain dense growths of needle palm. Reaching its northern range in Beaufort County, SC, the refuge probably contains more of this species than all other populations in the state combined. Other rare species include, *Carex dasycarpa*, *Collinsonia punctata* (bluff only), *Scutellaria mellichampii*, *Sideroxylon alachuense*, and *Verbesina walteri* (bluffs only). Aside from these state ranked species, unusual species not normally found in the coastal plain include *Carex basiantha*, *Carex cumberlandensis*, and *Tradescantia subaspera*.

- **Waccamaw NWR**

Two At-risk species were found in the refuge, *Ptilimnium ahlesii* and *Nuphar sagittifolia*. *P. ahlesii* is rare in the refuge and is restricted to its southern portions in freshwater tidal marshes. *N. sagittifolia* is ubiquitous. It reaches its greatest abundance in the southern freshwater tidal marshes, but is still common northward in waterways through freshwater tidal swamps. The refuge (excluding Sandy Island) was found to provide habitat for 16 species tracked by SCDNR, as well as two regionally rare species. These 18 rare species were widely distributed and occurred in several habitats. The majority (8) were associated with bottomland forests. Five species were associated with freshwater tidal marshes, two with upland forests at Jackson Bluff, and one in a weedy field.

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DATA APPENDIX OR SUPPLEMENTAL INFORMATION

An excel file (OccurrenceData.xlsx) provides point data collected on or near refuges of all rare plant species. Three ESRI shape files are provided for species locations, including point features (NewRecordsPoints.shp), polygon (NewRecordsPolygons.shp), and polyline (Nupha_sagittifolia.shp); projection in NAD83/ UTM Zone 17N.