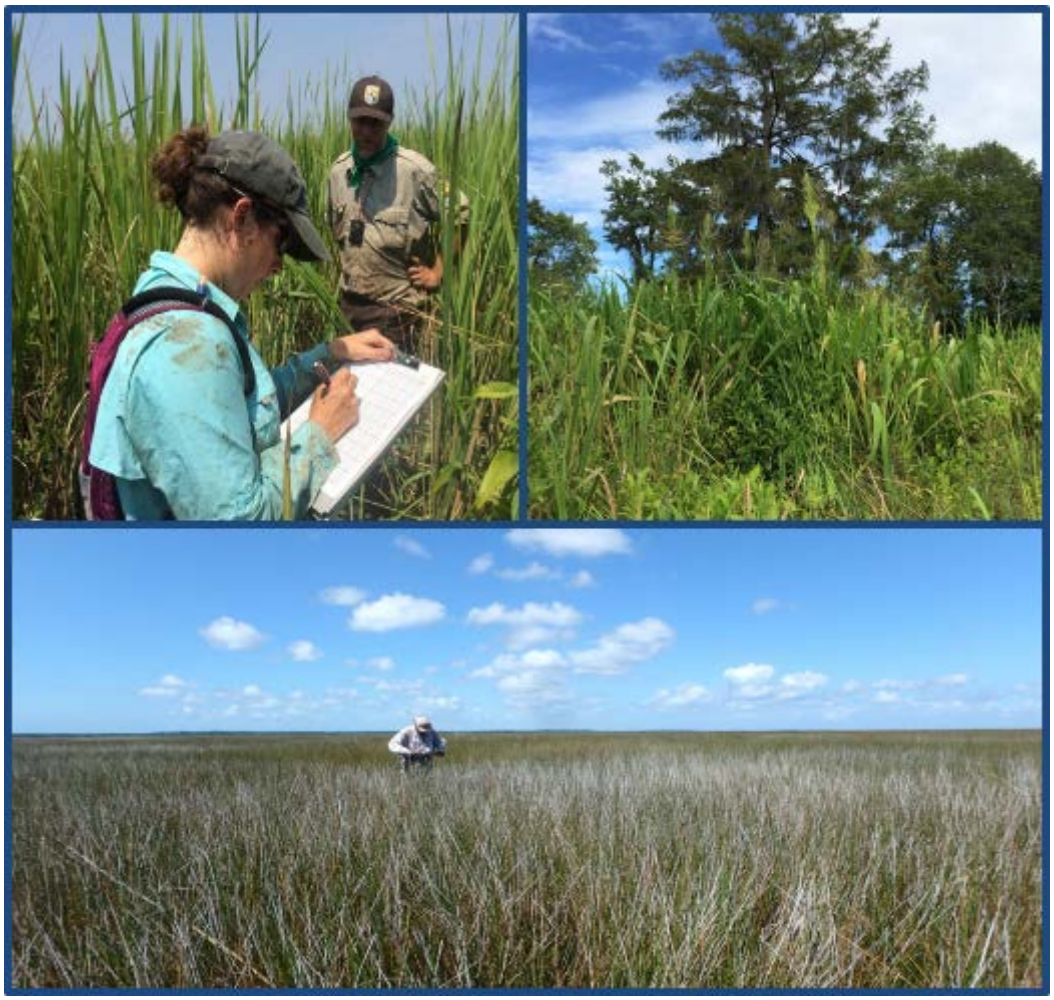
Vegetation of Coastal Wetland Elevation Monitoring Sites on National Wildlife Refuges in the South Atlantic Geography

1st Status Assessment Report

September 2016



U.S. Department of the Interior
U.S. Fish and Wildlife Service
Southeast Region Inventory & Monitoring Branch

Vegetation of Coastal Wetland Elevation Monitoring Sites on National Wildlife Refuges in the South Atlantic Geography: 1st Status Assessment Report

Cassandra E. Cook
U.S. Fish and Wildlife Service
Directorate Fellows Program Fellow
Okefenokee National Wildlife Refuge
2700 Suwannee Canal Dr.
Folkston, GA 31537

M. Forbes Boyle
U.S. Fish and Wildlife Service
Inventory & Monitoring Network
Okefenokee National Wildlife Refuge
2700 Suwannee Canal Dr.
Folkston, GA 31537

Nicole M. Rankin
U.S. Fish and Wildlife Service
Inventory & Monitoring Network
Cape Romain National Wildlife Refuge
5801 Highway 17 North
Awendaw, SC 29429

The Strategic Habitat Conservation framework

September 2016

U.S. Department of the Interior, U.S. Fish and Wildlife Service

Please cite this publication as:
Cook, C.E., Boyle, M.F., and N.M. Rankin. 2016. Vegetation of coastal wetland elevation monitoring sites on National Wildlife Refuges in the South Atlantic geography: 1st status assessment report. U.S. Fish and Wildlife Service, Southeast Region. Atlanta, GA. September 2016. 47 pp.

Cover photos (clockwise from upper left): Characterizing a vegetation plot in giant cutgrass marsh of Savannah National Wildlife Refuge (credit: Nicole Rankin/USFWS); freshwater tidal marsh of Waccamaw National Wildlife Refuge (credit: Nicole Rankin/USFWS); collecting soil samples from vegetation plot on Cedar Island National Wildlife Refuge (credit: Cassandra Cook/USFWS).

Acknowledgements: The authors thank the following individuals for their help with fieldwork and report review: Adam Bennetch (USFWS), Zoe Carroll (USFWS), Jonathan Chandler (USFWS), Kayleigh Cook (U. of South Carolina), Brett Craig (USFWS), Janet Ertel (USFWS), Kristen Grimshaw (James Madison U.), Wayne Harris (USFWS), Larry Hartis (USFWS), Chuck Hayes (USFWS), Mike Hoff (USFWS), Selena Ibarra (Duke U.), Kevin Keeler (USFWS), Kyle Kramer (USFWS), Alex McPhail (USFWS), Jena Moon (USFWS), Jean Richter (USFWS), Craig Sasser (USFWS), Brian Van Druten (USFWS), Sue Wilder (USFWS), and Larry Woodward (USFWS).

Table of Contents

Table of Contents

List of Figures

List of Tables

1 Executive Summary

In 2013, the U.S. Fish and Wildlife Service (FWS) Southeast Region Inventory & Monitoring Branch collected baseline vegetation data on Coastal Wetland Elevation Monitoring (CWEM) sites located throughout National Wildlife Refuges (NWR) within the South Atlantic Landscape Conservation Cooperative (SALCC) geography. This information will be used to assess vegetation species and community change over time in response to sea level rise and other landscape- to local- scale environmental perturbations. By tracking species composition and structure trends within a framework of natural vegetation types, managers will be able to make better ecologically-informed decisions with regards to the conservation and status of habitat condition on FWS and partner lands.

Baseline vegetation information was sampled at 20 CWEM sites in the summer of 2013. At each site, three Carolina Vegetation Survey (CVS) plots were used to capture a full vascular species list across multiple spatial scales, areal cover values for each species, stem diameter for woody species, and select environmental attributes (Peet et al. 1998). In 2016, 54 of the 60 baseline CWEM vegetation plots were resampled to determine the status of and trends in vascular plant composition and structure. In addition, five new plots were established at two CWEM sites located on Cape Romain NWR. Plots at the Lower Suwannee – Dan May Creek and Pocosin Lakes – Harvester Road Tall Pocosin sites were not sampled in 2016.

This report summarizes data collected from each refuge within the SALCC geography in 2016, and represents the second iteration of sampling for the Coastal Wetland Elevation Monitoring Protocol. Noteworthy findings are listed below.

1. Vegetation and environmental data were captured in 59 100 m^2 bounded and monumented plots across 18 Coastal Wetland Elevation Monitoring sites on 18 NWRs. Sampling activities occurred from 23 June to 22 August 2016.

2. Baseline inventory efforts detected 145 taxonomic concepts, including a potential county record listing for Georgetown County, South Carolina (*Ludwigia grandiflora* ssp*. hexapetala* on Waccamaw NWR). The 20 sites were classified into eight vegetation associations, including three with G2 (Imperiled) conservation status (NatureServe 2014), and six ecological types.

3. The most common associations sampled were the *Juncus roemerianus* Herbaceous Vegetation and *Spartina alterniflora* Carolinian Zone Herbaceous Vegetation types.

4. The most frequent species found during this survey included *Juncus roemerianus, Sporobolus alterniflorus,* and *Distichlis spicata.*

5. Plots located on the Roanoke River NWR site exhibited the highest species richness values (average=36.3) for the full plot-scale (100 m^2); plots located on Waccamaw River NWR exhibited the highest species richness values (average=12.9) for the nested quadrat-scale (10 m^2); and plots located on the Mackay Island NWR site exhibited the highest species richness values (average=8.75, 4.75, 2.75) for the nested quadrat-scale (1 m^2, 0.1 m^2, and 0.01 m^2).

6. The full dataset can be acquired from the FWS Service Catalog: reference code 44947.

7. A total of 16 FWS and non-FWS employees assisted with fieldwork for this survey. *THANK YOU*!

2 Introduction

2.1 Overview

Sea-level rise and its potential impacts to habitats and species are a concern for the National Wildlife Refuges (NWR) within the South Atlantic Landscape Conservation Cooperative (SALCC) geography. Relative sea-level has been rising along the Atlantic and Gulf of Mexico coasts, and recent climate models suggest an acceleration of sea-level rise on the Mid-Atlantic coast greater than the global average (Boon 2012; CCSP 2009). Existing National Oceanic and Atmospheric Administration water level gauges in the Atlantic region have measured relative sea-level rise rates ranging from 1.75 to 4.4 mm per year (CCSP 2009). Tidal salt and freshwater marshes are among the most susceptible ecosystems to accelerated sea-level rise, resulting in significant land loss and habitat conversion across coastal landscapes. The mean elevation of these wetland surfaces must increase to keep pace with the annual rise in sea level and subsidence of organic substrates. Understanding rates of wetland elevation change and relative sea-level rise will help managers at refuges answer critical questions (e.g., are marshes going to keep pace with relative sea-level rise?) and adjust management techniques towards future conditions.

In the winter of 2012/2013, the U.S. Fish and Wildlife Service (FWS) Southeast Region Inventory & Monitoring Branch (I&M) planned for a survey of NWR Coastal Wetland Elevation Monitoring (CWEM) sites within the SALCC geography in order to systematically describe vegetation composition and structure. A flexible, yet consistent, approach was needed to obtain initial inventory of floristic and environmental condition at each site owing to the diversity of vegetation types where CWEM Sites were established. The Carolina Vegetation Survey (CVS) is a collaborative, multi- institutional program established in the 1980's with the goal of describing and disseminating information on the vegetation of North and South Carolina. Objectives of this program include developing a landscape-scale biodiversity inventory, monitoring floristic shifts due to environmental impacts, identifying conservation priorities through regional description and mapping of natural communities, and designing templates populated with floristic data from natural vegetation types to guide restoration efforts. The CVS protocol for sampling vegetation was developed to be widely applicable for the diversity of ecosystems in the Southeastern U.S., and scalable for the goals and funding level of a project (Peet et al. 1998). Also, the observation unit described by the protocol—the CVS plot—was designed to include multiple scales of observation, in order to better detect relationships between vegetation and environment. Finally, the protocol was developed so that data collected from plots could be comparable with other sampling methodologies, and that the techniques could be utilized for one-time vegetation inventories or long-term monitoring studies. For these reasons, this protocol was chosen to describe vegetation condition and assess vegetation change at CWEM Sites across the SALCC geography. Other benefits of using the CVS protocol include the built-in CVS database structure for input, analysis, and archives of plot (vegetation and environment) information (Peet et al. 2012); the comparable datasets of over 4,000 plots from the SALCC geography; its ease of use; and the availability of on-line training materials.

In the summer of 2013, a total of 60 vegetation plots were established at 20 CWEM sites located on 18 NWRs within the SALCC. The 2013 sampling event represented a baseline inventory survey, as described by the Inventory and Monitoring Survey Protocol Handbook, and has established "a beginning time-step (baseline) or reference information for subsequent monitoring" (USFWS 2013). Results from the 2013 survey effort can be found in the "Vegetation of Coastal Wetland Elevation Monitoring Sites on National Wildlife Refuges in the South Atlantic Geography: Baseline Inventory Report" (Boyle et al. 2015), FWS Service Catalog Reference Code #68327. In 2016, two additional CWEM sites located on Cape Romain NWR were added to the sampling frame.

2.2 Objectives

Vegetation resampling on CWEM sites in the summer of 2016 represents the first status assessment survey of the 2013-established plots (2013: Baseline Survey; 2016: First Status Assessment), except for the baseline survey established at the two newly added CWEM sites at Cape Romain NWR. The long-term survey objective of this project is to assess trends in vegetation cover, frequency, richness, and other importance or density values as they relate to topographical and environmental shifts resulting from sea-level rise and other disturbance factors.

Specific sampling objectives of this second monitoring effort include:

- Determine average cover class and constancy (i.e., frequency of occurrence) for each vascular species within the 22 CWEM sites within the SALCC geography,
- Calculate average woody stem count and basal area by species within the 22 SALCC geography CWEM sites,
- Calculate species richness values across multiple spatial scales for each vegetation association, *and*
- Determine average soil nutrient and texture values from A-horizon samples within the 22 CWEM sites.

3 Methods

3.1 Taxonomic Standard

Species nomenclature for this report follows Weakley's (2015) "Flora of the Southern and Mid-Atlantic States". This was chosen as standard because Weakley's Flora maps taxonomic concepts used by authors of over 1,000 taxonomic treatments, facilitating incorporation with archived datasets and updating nomenclature. Efforts were made to identify every plant to species-level accuracy. In a few cases, species were not determined and multiple, potential species names were given nested with square brackets for a genus (e.g., [*Bidens + Coreopsis*]). For all cases, if the available characteristics of the plant did not allow for identification to genus, species, or variety/subspecies, then the lowest taxonomic level identifiable was used.

3.2 Study Area

In December 2011 and January 2012, Southeast Region I&M staff, NWR biologists and managers, and partners determined priority habitat types for rod surface elevation table (RSET) benchmarks and associated monitoring stations (CWEM sites) on 18 coastal NWRs within the SALCC geography (Figure 1). A total of 20 CWEM Sites were established on 18 NWRs in the spring, summer, and fall of 2012. These sites were established within a priority habitat through a spatially balanced random sampling design. In late 2016, two study sites located on Cape Romain NWR were incorporated into the project. In total, this monitoring effort is represented by 19 NWRs, 22 sites, and 65 RSET benchmarks. Broad habitats and NWRs included: salt and brackish marsh (Pea Island, Alligator River, Swanquarter, Cedar Island, Cape Romain, Pinckney Island, Wassaw, Harris Neck, Blackbeard, Wolf Island, St. Marks, and Lower Suwannee NWRs); freshwater and oligohaline marsh (Mackay Island, Currituck, Waccamaw, Ernest F. Hollings ACE Basin [ACE Basin], Savannah, and Lower Suwannee NWRs); pocosin (Alligator River and Pocosin Lakes NWRs); and forested wetland (Roanoke River NWR). Individual refuge-scale maps of CWEM Sites, including RSET benchmark location and vegetation plot placement, are located in Appendix 1.

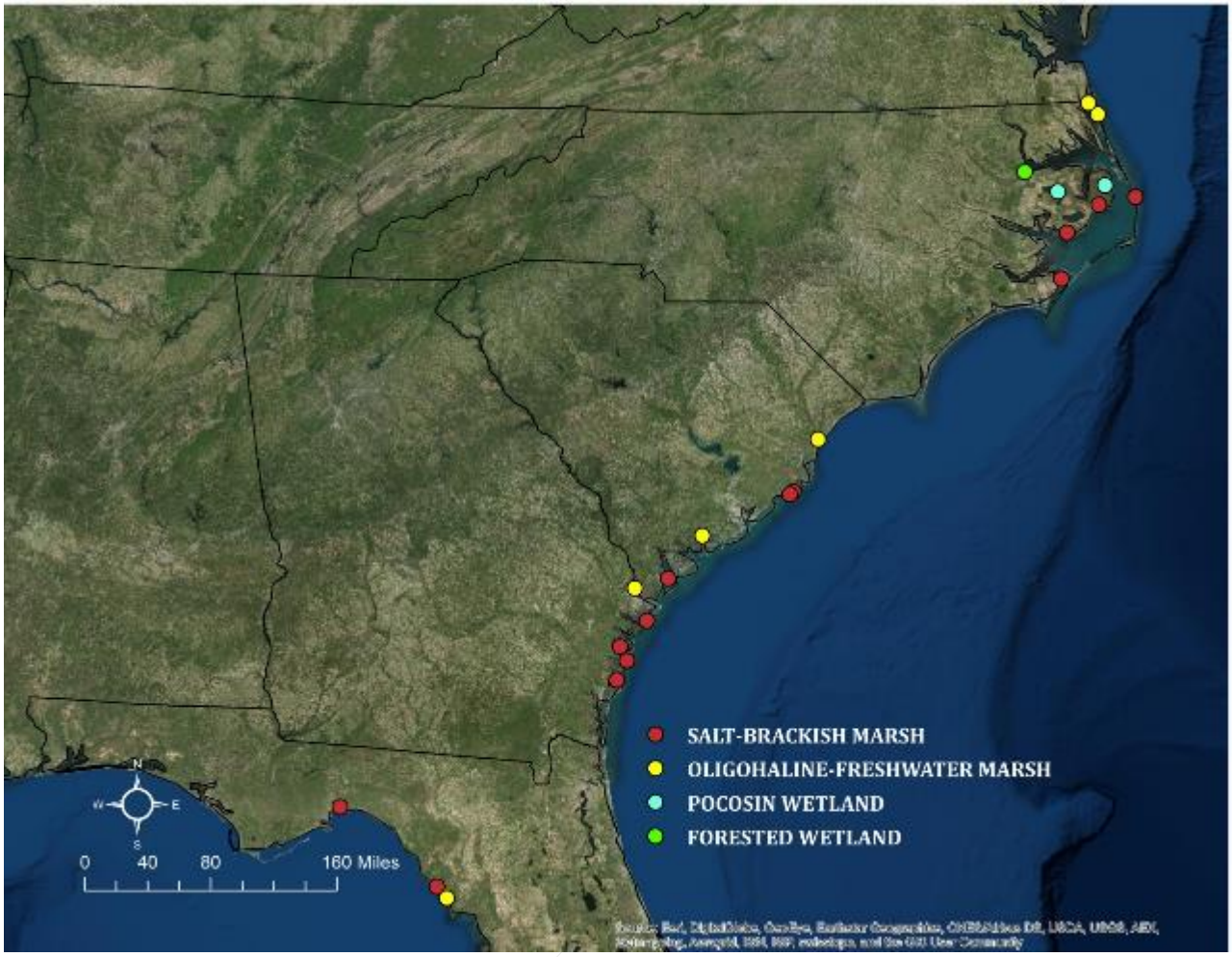


Figure 1. Distribution of the SALCC geography CWEM Sites within coastal North Carolina, South Carolina, Georgia, and Florida National Wildlife Refuges. From north to south site placement, refuges include Mackay Island, Currituck, Roanoke River, Alligator River (2), Pocosin Lakes, Pea Island, Swanquarter, Cedar Island, Waccamaw, Cape Romain (2), ACE Basin, Pinckney Island, Savannah, Wassaw, Harris Neck, Blackbeard Island, Wolf Island, St. Marks, and Lower Suwannee (2).

3.3 Sampling Unit and Design

In vegetation science, a plot is often the sampling unit of a survey (Kent and Coker 1992). A plot is a bounded feature with a pre-defined shape and size within which vegetation and abiotic (environmental) attributes are measured. For this project, vegetation and environmental attributes were collected using the single module plot size (10x10 m) described by the CVS protocol (Peet et al. 1998; Lee et al. 2008). A plot was established adjacent to each of the three RSET benchmarks within a CWEM site.

3.4 Sampling Methodology

Plot sampling for vegetation is influenced by differences with vegetation type, scale of the project, and funding availability. The CVS protocol provides a standard approach that is simultaneously flexible to account for these differences yet consistent to provide compatible data across the broad range of vegetation within the Southeastern United States. The protocol has been in use since 1988 by a multitude of institutions (universities, U.S. National Park Service (NPS), U.S. Forest Service (FS), and NatureServe), and the information collected through the use of the survey methods represents one of the richest vegetation plot databases in the country. A CVS plot consists of any number of 100 m^2

modules (or subplots). For rapid assessment purposes, a single module plot is appropriate. Also, a single module plot is often employed to describe homogenous vegetation types with very little species turnover (e.g., mono-specific stands of salt and brackish tidal marshes). Three general pieces of information were captured from within each plot for this project: 1) species list and cover data, 2) woody stem density, and 3) plot metadata and environmental attributes. Each of these is described in detail below. For additional detailed field methods, see Boyle et al. (*In review*).

Plot Layout and Survey Timing

The layout consisted of a 100 m^2 square plot typically with the dimensions of 10 x 10 m (Figure 2). In one instance, at Waccamaw NWR, a plot with dimensions of 20 x 5 m was used in order to fit the plot between the RSET benchmark and the river. Plots were placed with their edge closest to the RSET benchmark no more than 20 m linear distance and geographically oriented so that they were between the benchmark and nearest open water (Boyle et al. *In review*). Plot corners were originally monumented using 12" long sections of ½" diameter galvanized steel conduit driven into the ground, with 3-6" of the top exposed. Plots were resampled between June and August 2016.

Resampling

A handheld Garmin GPS unit and a Schonstedt model GA-72Cd magnetic locator were used to relocate existing plot corners. The GPS unit was used to navigate to corner 1 of a plot, or its general location (<10 m accuracy) (Boyle et al *In Review*). Once nearby, visual inspection of the ground was conducted to locate the 2013 corner monument (galvanized steel conduit). If the conduit wasn't found using visual inspection, the magnetic locator was used to assist relocation efforts. Once corner 1 was located, known x- and y-axis plot bearings from the 2013 sampling effort were used in conjunction with open-reel fiberglass tapes to orient towards the direction of the remaining three corners of the plot. The magnetic locator also was used to locate the conduit marking the remaining three corners. Upon successful detection of conduit at all four corners, plot corners 1 and 3 were monumented using 5' long sections of ½" diameter fiberglass rods driven into the ground, with 2.5-3' of the top exposed.

Site Relocation Issues

Locating the metal conduit was often difficult and time consuming when there was thick vegetation. Site factors such as high sedimentation rates, burns, or high salinity can influence the longevity and detectability of the conduit. Many of the highly saline sites had conduit erode away or break off, and at many sites the conduit was underground or underwater (Figure 3). However, the metal detector was able to pick up a signal for conduit underground or underwater.

If the search effort for the baseline plot's corner 1 exceeded 20 minutes, then a new plot was established as near to the original location as possible. To reestablish a new plot, the GPS unit was used to get within a reasonable proximity to the original location for corner 1, and the same x-axis bearing from the original plot was used to construct the plot boundary between corner 1 and 4.

Species List and Cover Measures

Nested quadrats were established in the four corners of each plot to measure species presence across different spatial scales (Figure 3). Presence of a species was defined as having some part of the individual plant's stem emerging from the ground (or water) within the plot boundaries. For a nested quadrat, a series of four nested boxes were used to record species presence at different spatial scales, beginning with 10 x 10 cm (0.01 m^2) and increasing in area on a $\log_{10}$ scale: 32 x 32 cm (0.1 m^2), 1 x 1 m (1 m^2), and 3.16 x

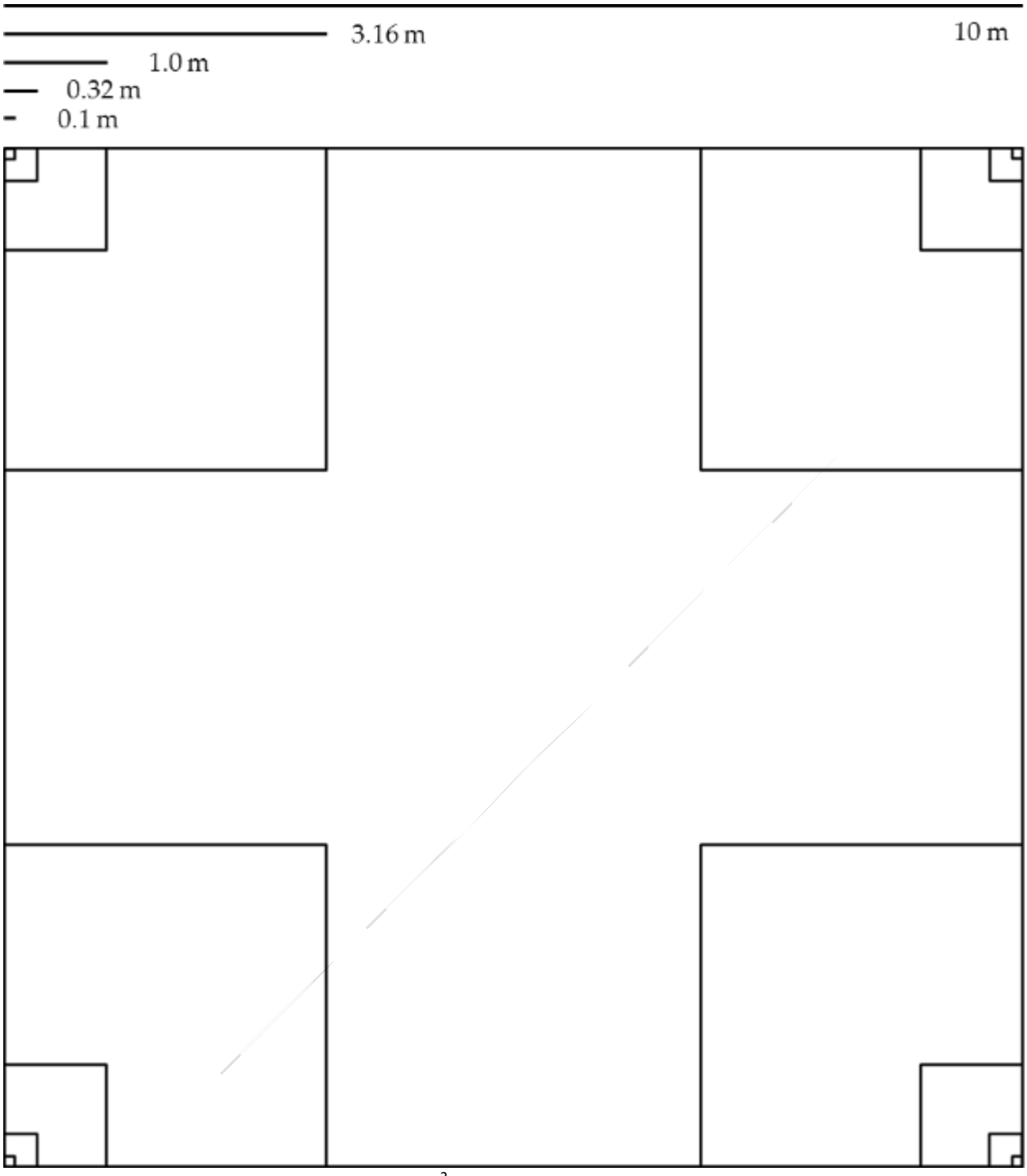


Figure 2. The standard single module (100 m^2) plot of the CVS with four nested subplots located at each corner. Nested subplots range in size from 0.01, 0.1, 1, and 10 m^2.

3.16 m (10 m^2). A species tally began in the smallest nested box (0.01 m^2), then moved to the next largest box (0.1 m^2) with species recorded if not located in the previously sampled smaller box (i.e., species located in the 0.01 m^2 box were not recorded for the larger boxes because the smaller box is entirely contained by those). Species tallies continued for the remaining nested boxes (1 m^2 and 10 m^2) for that corner. The other three corners were tallied using the same method (small scale to large scale). Finally,

Figure 3. When plots were established in 2013, ½ inch diameter x 1 foot length electric metallic tube conduit was used to monument plot corners. The left image illustrates a newly installed conduit; in comparison, the image on the right illustrates a similar section of conduit after three years within a salt marsh (rusted metal to the right of the white fiberglass rod).

species not recorded in any of the four corners but located within the plot were tallied (100 m^2 quadrat).

Areal percent cover was visually estimated for each species observed within the plot using the 10-scale cover classes proposed by Peet et al. (1998) (Table 1). Cover classes were also estimated for each of three vertical strata (Herb, Shrub, and Tree) for which a species occurred.

Table 1. The ten-point cover class system described by Peet et al. (1998) for the CVS protocol.

Cover Class	Cover Range (%)	Analysis Value
1	0.0 – 0.1	0.050
2	0.1 – 1.0	0.505
3	1.0 – 2.0	1.500
4	2.0 – 5.0	3.500
5	5.0 – 10.0	7.500
6	10.0 – 25.0	17.500
7	25.0 – 50.0	37.500
8	50.0 – 75.0	62.500

9	75.0 – 95.0	85.000
10	> 95.0	97.500

Woody Stem Measures

On each plot, woody plants greater than 1.37 m in height were counted and a diameter class of these individual stems was estimated at breast height (1.37 m) (Table 2). Woody plants include all trees, shrubs, woody lianas, and woody grasses.

Soil Measures

A single soil sample of 300-500 grams was taken from the top 10 cm of mineral soil below the litter or humus layer in the center of each plot. Samples were dried in an oven equipped with exhaust fans at an internal temperature of 40° C for 96 hours. Once moisture was removed, samples were bagged and mailed to Brookside Laboratories, Inc., New Knoxville, OH for chemical and physical analysis. Chemical extractions were conducted using the Mehlich III method (Mehlich 1984) and physical properties (particle size analysis, soil texture) were determined by the hydrometer method (Bouyoucos 1962). Soil variables returned included:

- Total Exchange Capacity (ME/100 grams)
- pH (H_2O 1:1)
- Organic Matter (360° C LOI) %
- Estimated Nitrogen Release (lb/acre)
- Soluble Sulfur (ppm)
- Bray II Phosphorous (lb/acre)
- Exchangeable Cations, including Ca, Mg, K, Na (ppm)
- Percent Base Saturation
- Extractable Minor Nutrients, including B, Fe, Mn, Cu, Zn, Al (ppm)
- Clay, Silt, Sand %

Table 2. Diameter classes described by Peet et al. (1998) for the CVS protocol and corresponding values used to calculate basal area (m^2/acre).

Diameter Class (cm)	Analysis Value
0.0 – 1.0	0.50
1.0 – 2.5	1.75
2.5 – 5.0	3.75
5.0 – 10.0	7.50
10.0 – 15.0	12.50
15.0 – 20.0	17.50
20.0 – 25.0	22.50
25.0 – 30.0	27.50
30.0 – 35.0	32.50
35.0 – 40.0	37.50
> 40.0	Nearest cm (e.g., 40, 41, 42….53, 54)

Other Environmental and Plot Metadata Measures

A number of abiotic and summary data were additionally recorded for each plot. These included:

Location Information: UTM coordinates (easting, northing, datum and zone) of the plot were reported using a Global Positioning System (GPS) device. An accuracy estimate (nearest m) was

also recorded for this position.
Photo Documentation: Photos were made at each corner of the plot oriented towards (within) the plot. The clearest photo of each CWEM Site has been included in Appendix 1.
Vertical Strata: The height range (m) and total areal cover (%) was reported for each vegetation stratum present within the plot (Tree, Shrub, Herb, Floating or Submerged Aquatic). Strata definitions are from Jennings et al. (2004) and are described in detail in Boyle et al. (*In review*).
Earth Surface: Percent cover of the generally immobile underlying material within the plot was recorded. Categories included histosol (organic), mineral soil, gravel/cobble (rocks < 10" diameter), boulder (rocks > 10" diameter), and bedrock.
Ground Cover: Percent cover of organic ground cover within the plot was recorded. Categories included course woody debris (fallen trees > 5 cm diameter), fine woody debris (fallen trees, woody vegetation < 5 cm diameter), litter (leaf litter), duff (includes the F (fermentation) and H (hummus) layers below the litter layer), bryophytes/lichen and water.
Other Environmental and Metadata: Additional descriptions of environmental data and plot metadata (e.g, plot identification, observers) are described in Boyle et al. (*In review*).

3.5 Data Analysis

First status assessment data are summarized based on the sampling objectives described in section 2.2 of this document. The tabular data in this report are typically presented by either CWEM site or vegetation association.

Data Entry, Verification, and Editing

The CVS has developed a data entry tool within Microsoft Access that allows for efficient entry of cover, woody stem, and plot/environmental datasets. Quality control procedures were automatically performed to ensure that data entry was accurate. This entry tool was obtained from the CVS Sampling Methodology and Data Management website: http://cvs.bio.unc.edu/methods.htm. Data were manually entered into the data entry tool during the summer of 2016.

Data Security and Archiving

A copy of the data entry tool containing the cover, woody stem, and plot/environmental data of each of the plots was provided to the CVS Central Archive Database (owner: University of North Carolina) in the fall of 2016. Furthermore, these same datasets have been exported from Microsoft Access, converted to .csv files, and uploaded as a record (along with this and subsequent monitoring reports) into the FWS Service Catalog (ServCat): reference code #44947. Raw and .jpg images of each plot are currently stored on the server at Okefenokee NWR and a representative .jpg image of each plot is also stored in ServCat: reference code #81599.

Plot Vegetation Classification

Plots and CWEM sites were both qualitatively assigned to two vegetation types, using the NVCS association as the scalable unit. By definition, the association is "the lowest level… in the NVCS hierarchy that describes a characteristic range of species composition, diagnostic species occurrence, habitat conditions, and physiognomy reflecting topo-edaphic, climate, substrates, hydrology, and disturbance regimes" (FGDC 2008). Associations were determined for each plot by examining its diagnostic species composition and geomorphology. Plots and CWEM sites were then assigned to a second vegetation type--ecological type--as described by the CVS's "Vegetation of the Carolinas" project (website: http://cvs.bio.unc.edu/vegetation.htm). An ecological type is similar to the NVCS mid-level group, where each unit "shares a common set of growth forms and diagnostic species…preferentially sharing a similar set of regional edaphic, topographic, and disturbance factors" (FGDC 2008). The "Vegetation of the

Carolinas" project has linked many NVCS associations described for the southeastern U.S. to their ecological types (i.e., hierarchical classification: multiple associations nested under (fewer) ecological types). Thus, by using the "Vegetation of the Carolinas" website, associations described in the first stage of the classification could be queried and resulting ecological types linked to each plot.

Analysis Methods

Apart from summaries of vegetation composition, vegetation structure, and woody stem tallies by CWEM Sites and vegetation association, very little statistical analysis was applied to these data. This report represents the first status assessment (and baseline assessment for the two Cape Romain NWR sites) for the Multi-Regional Protocol Framework for Monitoring Coastal Wetland Elevation and Vegetation Community Dynamics, Region 2 & 4 (Rankin et al. 2016). Trend analysis will be conducted after three iterations of status assessments have been completed. Summaries in this report include: a) vegetation association and ecological type, vertical strata height and cover, and total species richness by CWEM site (Table 3), b) average cover class and constancy (frequency of occurrence in 3 plots of an CWEM site) of each species by CWEM site (Tables 4, 5, and 6), c) average stem count (density) and basal area (m^2/ha) for woody plants rooted in CWEM site plots (Table 7), d) average species richness across multiple spatial scales (0.01, 0.1, 1, 10, and 100 m^2) for vegetation associations (Table 8), e) soil macronutrient and texture values by CWEM site (Table 9), and e) species encountered (Appendix 2).

Average cover class values (Tables 4, 5, and 6) were calculated for each species by converting cover classes in each of the three plots of a CWEM site to mid-point percentage values, averaging these values across the three plots, and then converting this value back to its representative cover class. Stem density values represent the average count of each woody species (> 1.37 m in height) of the three plots of a CWEM site (Table 7). Total basal area for each species was determined by calculating basal area of each diameter class (per species) and summing these values. The basal area values reported in Table 7 represent the average basal area of each woody species of the three plots of a CWEM site. Finally, average nested quadrat richness values (Table 8) were described for each association by first calculating the average richness for each quadrat within a plot, and second, taking the average of these values by association type.

4 Results

Because of Hurricane Hermine, which made landfall during the scheduled sampling period, we were unable to access the Lower Suwannee – Dan May Creek site in 2016. Additionally, the plots originally established on the Pocosin Lakes – Harvester Road Tall Pocosin site were not relocated in 2016 due to erroneous GPS interpretation. Thus, only 18 of the 20 CWEM sites were visited, and only 54 of the 60 vegetation plots were sampled. We detected 145 taxonomic concepts (including unknown taxa, species, subspecies, and varieties) during our sampling effort (Appendix 2), including a potential county record listing for Georgetown County, South Carolina (*Ludwigia grandiflora* ssp*. hexapetala* on Waccamaw NWR). Site descriptions and summaries of vegetation composition and structure for each ecological type are provided in the next sections.

4.1 Pond Pine Forest and Woodland (*Alligator River NWR*)

The dominating feature of the vegetation on this site was the dense (98%), well-developed shrub stratum that reached 4 m in height (Table 3). Shrub species documented here included *Ilex glabra, Lyonia lucida,* and *Smilax laurifolia* (Table 4). The canopy was composed of well-developed and large diameter *Pinus*

serotina (Table 7). Subcanopy trees included *Aralia spinosa, Magnolia virginiana* var. *virginiana, Sassafras albidum,* and *Persea palustris*. Herbs were present but not frequent within these plots. The few herbs that did occur here included *Anchistea virginica* and *Lorinseria areolata*. Surface soils exhibited extremely acidic pH values (average=3.6), and contained high levels of organic matter (average=70%) (Table 9).

4.2 Pocosin

(*Pocosin Lakes NWR*)

No data available.

4.3 Blackwater Swamp Forests

(*Roanoke River NWR*)

A total of 57 vascular plant species were found in the three plots from Roanoke River NWR (Table 3). Large-scale (full plot) species diversity was highest in this association than any other association reported during this survey (Table 8). Average number of species found in each of the 100 m^2 plots was 36.3. The vegetation within this site occurred across all three reported strata-- herbaceous, shrub, and tree (Table 3). Diagnostic canopy trees included *Quercus laurifolia, Acer rubrum* var. *rubrum*, *Fraxinus pennsylvanica, Nyssa biflora*, and *Liquidambar styracifolia*; subcanopy trees included *Ilex verticillata, Carpinus caroliniana*, *Fraxinus caroliniana,* and canopy species; shrub and woody vines that were frequent included *Itea virginica, Smilax walteri, Toxicodendron radicans* var. *radicans,* and *Clethra alnifolia*; finally, herbaceous species that were frequent included *Viola esculenta*, *Persicaria arifolia, Saururus cernuus*, and *Centella asiatica* (Table 4).

4.4 Oligohaline Tidal Marsh

(*ACE Basin NWR, Currituck NWR, Mackay Island NWR, Savannah NWR*)

Graminoid vegetation dominated the *Zizaniopsis miliacea* Tidal Herbaceous association at ACE Basin and Savannah NWR. Diagnostic species included the association nominal, *Zizaniopsis miliacea*, *Schoenoplectus tabernaemontani,* and *Typha spp.* (Table 5). Other species documented from these sites included *Sagittaria lancifolia* var. *media, Symphyotrichum tenuifolium, Peltandra virginica*, and *Persicaria punctata* (Table 5). The Currituck NWR site was dominated by *Juncus roemerianus*, and the alien, invasive *Phragmites australis* ssp. *australis* (Table 5). Other herbaceous species found in these plots included *Persicaria pensylvanica, Hibiscus moscheutos,* and *Galium tinctorium* (Table 5). Small-scale species diversity was highest at Mackay Island NWR than any other site reported during this survey (Table 8). Average number of species found in the 1 m^2 nested quadrat was 6.9; 0.1 m^2 nested quadrat was 3.7; and 0.01 m^2 nested quadrat was 2.1. The site was dominated by *Sporobolus pumilis, Schoenoplectus pungens* var. *pungens*, and *Juncus roemerianus* (Table 5). Shrub and tree growth forms were not present in any plots of this ecological type. Except for the Currituck NWR site, the remaining sites were characterized by loamy sand or sandy loam surface soils, with silt percentages ranging from 13% to 30% (Table 9).

4.5 Freshwater Tidal Marsh

(*Waccamaw NWR*)

The only site classified as this ecological type was found on Waccamaw NWR – Sandy Island Marsh (Table 3). These marshes occupy tidal sites above mean low water along freshwater coastal rivers and estuaries. Soils of these marshes can be variable, ranging from silts to very coarse sands. These plots were classified to the *Zizania aquatica* Tidal Herbaceous Vegetation association.

A total of 41 vascular plant species was found in the three plots from Waccamaw NWR (Table 3). Meso-

scale species diversity was highest in this association than any other association reported during this survey (Table 8). Average number of species found in the 10 m^2 nested quadrat was 12.9. Diagnostic species included *Zizania aquatic*, *Ptilimnium capillaceum*, *Cuscuta compacta*, and *Schoenoplectus tabernaemontani* (Table 5). Alien species, such as *Alternanthera philoxeroides, Murdannia keisak*, and *Ludwigia peruviana*, were found in abundance on this site (Table 5). Herbaceous strata height reached to 2 m, while a present, but open, tree strata height reached to 3.1 m (Table 3).

4.6 Brackish Marsh

(*Alligator River NWR, Cedar Island NWR, Lower Suwannee NWR, Pea Island NWR, St. Marks NWR, Swanquarter NWR*)

Most of these sites were often low in species, and dominated by dense stands of *Juncus roemerianus* (Table 6). This association occupies an intermediate position on the salinity gradient between brackish and oligohaline marshes. Shrub and tree growth forms were not present in any plots of this ecological type. Soil pH values in the top 10 cm of the surface were relatively high compared to the rest of the entire dataset, ranging from moderately acidic (pH=5.8) to neutral (pH=6.7) (Table 9). Organic matter content was variable in these sites, with highest values observed in *Juncus*-dominated sites of the Embayed Section of North Carolina (Cedar Island and Swanquarter NWR), and lowest values observed in the embayed section of the East Gulf Coastal Plain Section of Florida (Lower Suwannee and St. Marks NWR) (Table 9).

4.7 Tidal Salt Marshes

(*Blackbeard Island NWR, Cape Romain NWR, Harris Neck NWR, Pinckney Island NWR, Wassaw NWR, Wolf Island NWR*)

In these sites, *Sporobolus alterniflorus* was the diagnostic species, and occurred as the only species in plots from five of the six sites (Table 6). Strata height maximum values ranged from 0.4 to 0.6 m (Table 3).

Table 3. Vegetation community type, species richness, and vertical strata characteristics for each of the CWEM sites. Species richness values indicate total species count from a site; strata data are presented as average values (cover, minimum height, and maximum height) from three plots at each site. NatureServe's conservation status rankings are listed in parentheses following association names (NatureServe 2014). Rankings are as follows: G2 (Imperiled), G3 (Vulnerable), G4 (Apparently Secure), and G5 (Secure).

CWEM Site	Association Name	Ecological Type	Species (N)	Herbaceous Height (m)	Herbaceous Cover (%)	Shrub Height (m)	Shrub Cover (%)	Tree Height (m)	Tree Cover (%)
ACE Basin NWR - Grove Marsh/Edisto River	*Zizaniopsis miliacea* Tidal Herbaceous Vegetation (G4)	Oligohaline Tidal Marshes	12	0 - 1.5	80	--	--	--	--
Alligator River NWR - Koehring Road Pocosin	*Pinus serotina / Ilex glabra / Woodwardia virginica* Woodland (G2)	Pond Pine Forests and Woodlands	19	0 - 0.5	9	0.5 - 4	98	2.5 - 28	47
Alligator River NWR - Long Shoal River	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	8	0 - 1.6	41	--	--	--	--
Blackbeard Island NWR - Blackbeard Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 - 0.4	34	--	--	--	--
Cape Romain NWR - Horsehead Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 - 0.45	75	--	--	--	--
Cape Romain NWR - Raccoon Key	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 - 0.4	77	--	--	--	--
Cedar Island NWR - Wet Marsh	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	6	0 - 1	85	--	--	--	--
Currituck NWR - Swan Island	*Juncus roemerianus - Pontederia cordata* Herbaceous Vegetation (G2)	Oligohaline Tidal Marshes	18	0 - 2	75	--	--	--	--
Harris Neck NWR - Harris Neck Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	2	0 - 0.7	74	--	--	--	--
Lower Suwannee NWR - Shired Creek	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	3	0 - 1.2	95	--	--	--	--
Mackay Island NWR - Great Marsh	*Schoenoplectus pungens - (Osmunda regalis var. spectabilis)* Herbaceous Vegetation (G2)	Oligohaline Tidal Marshes	28	0 - 1.5	90	--	--	--	--

Table 3. Continued

CWEM Site	Association Name	Ecological Type	Species (N)	Herbaceous Height (m)	Herbaceous Cover (%)	Shrub Height (m)	Shrub Cover (%)	Tree Height (m)	Tree Cover (%)
Pea Island NWR - South Pea Island Marsh	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	3	0 - 0.9	95	--	--	--	--
Pinckney Island NWR - Mackay Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 - 0.7	75	--	--	--	--
Roanoke River NWR - Goodman Island	*Taxodium distichum - Nyssa aquatica - Nyssa biflora / Fraxinus caroliniana / Itea virginica* Forest (G3)	Blackwater Swamp Forests	57	0 - 1	68	1 - 3	31	2 - 28	92
Savannah NWR - Little Back River	*Zizaniopsis miliacea* Tidal Herbaceous Vegetation (G4)	Oligohaline Tidal Marshes	23	0 - 2.4	90	--	--	--	--
St. Marks NWR - Goose Creek Bay	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	3	0 - 0.8	62	--	--	--	--
Swanquarter NWR - Juniper Bay Marsh	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	2	0 - 1.2	50	--	--	--	--
Waccamaw NWR - Sandy Island Marsh	*Zizania aquatica* Tidal Herbaceous Vegetation (G4)	Freshwater Tidal Marsh	39	0 - 3	99	--	--	2 - 15	3
Wassaw NWR - Wassaw Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 - 0.6	62	--	--	--	--
Wolf Island NWR - Altamaha Sound	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 - 0.35	85	--	--	--	--

Table 4. Average cover class and constancy (%) for vascular plant species by CWEM Sites classified as Pond Pine Forests and Woodland, Pocosin, and Blackwater Swamp Forest Ecological Types. Cover and constancy were calculated from the three plots located at each CWEM Site.

	Alligator River NWR - Koehring Road Pocosin		Roanoke River NWR - Goodmans Island	
	cov	con	cov	con
Acer rubrum var. rubrum	3	67	5	100
Alnus serrulata	--	--	2	67
Anchistea virginica	3	100	--	--
Aralia spinosa	3	67	--	--
Arisaema pusillum	--	--	2	33
Berchemia scandens	--	--	2	67
Bignonia capreolata	--	--	2	33
Boehmeria cylindrica	--	--	2	67
Carex grisea	--	--	2	100
Carex lupulina	--	--	2	67
Carex seorsa	--	--	2	33
Carex stricta	--	--	5	100
Carpinus caroliniana	--	--	6	100
Centella asiatica	--	--	2	100
Cicuta maculata	--	--	2	67
Clematis crispa	--	--	2	33
Clethra alnifolia	--	--	3	33
Commelina virginica	--	--	2	100
Cornus stricta	--	--	2	33
Crataegus	--	--	2	33
Fraxinus caroliniana	--	--	6	100
Fraxinus pennsylvanica	--	--	6	100
Galium tinctorium	--	--	2	33
Gelsemium sempervirens	2	100	--	--
Gordonia lasianthus	2	33	--	--
Ilex glabra	9	100	--	--
Ilex opaca	--	--	2	33
Ilex verticillata	--	--	6	100
Iris virginica var. virginica	--	--	2	33
Itea virginica	--	--	3	100

Table 4. Continued.

	Alligator River NWR - Koehring Road Pocosin		Roanoke River NWR - Goodmans Island	
	cov	con	cov	con
Leersia oryzoides	--	--	2	100
Liquidambar styraciflua	--	--	5	100
Lobelia sp.	--	--	2	33
Lonicera sempervirens	--	--	2	33
Lorinseria areolata	2	33	--	--
Lyonia lucida	3	100	--	--
Magnolia virginiana var. virginiana	3	100	2	33
Morella cerifera	--	--	2	33
Murdannia keisak	--	--	2	33
Muscadinia rotundifolia var. rotundifolia	3	67	--	--
Nyssa biflora	--	--	7	67
Onoclea sensibilis var. sensibilis	--	--	2	33
Osmunda spectabilis	--	--	2	33
Osmundastrum cinnamomeum	--	--	2	33
Parthenocissus quinquefolia	2	67	2	67
Peltandra virginica	--	--	2	100
Persea palustris	5	100	4	100
Persicaria arifolia	--	--	7	100
Persicaria setacea	--	--	2	33
Pinus serotina	7	100	--	--
Platanthera lacera	--	--	2	33
Poa autumnalis	--	--	2	100
Quercus laurifolia	--	--	4	100
Rhus copallinum var. copallinum	2	67	--	--
Sassafras albidum	4	100	--	--
Saururus cernuus	--	--	4	100
Smilax glauca	2	100	--	--
Smilax laurifolia	2	100	2	33
Smilax rotundifolia	--	--	2	33
Smilax walteri	--	--	3	100

Table 4. Continued.

	Alligator River NWR - Koehring Road Pocosin		Roanoke River NWR - Goodmans Island	
	cov	con	cov	con
Taxodium distichum	--	--	2	67
Thalictrum pubescens	--	--	2	33
Tillandsia usneoides	--	--	2	33
Toxicodendron radicans var. radicans	2	100	3	100
Ulmus americana var. americana	--	--	5	67
Vaccinium formosum	2	33	--	--
Vaccinium fuscatum	2	100	2	33
Viburnum recognitum	--	--	2	67
Viola edulis	--	--	2	67
Vitis labrusca	--	--	2	67

Table 5. Average cover class and constancy (%) for vascular plant species by CWEM Sites classified as Oligohaline Tidal Marsh and Freshwater Tidal Marsh Ecological Types. Cover and constancy were calculated from the three plots located at each CWEM Site.

	ACE Basin NWR - Grove Marsh/Edisto River		Currituck NWR - Swan Island		Mackay Island NWR - Great Marsh		Savannah NWR - Little Back River		Waccamaw NWR - Sandy Island Marsh	
	cov	con	cov	con	cov	con	cov	con	cov	con
[Bidens + Coreopsis]	--	--	--	--	2	100	--	--	--	--
Alnus serrulata	--	--	--	--	--	--	--	--	2	33
Alternanthera philoxeroides	--	--	--	--	--	--	--	--	4	100
Amaranthus cannabinus	--	--	--	--	--	--	--	--	2	100
Apios americana	--	--	--	--	--	--	--	--	2	100
Baccharis halimifolia	--	--	--	--	--	--	--	--	2	33
Bidens connata	--	--	--	--	--	--	--	--	2	33
Boehmeria cylindrica	--	--	--	--	--	--	--	--	2	100
Carex lurida	--	--	--	--	--	--	--	--	2	33
Centella asiatica	--	--	2	67	2	33	2	33	--	--
Cicuta maculata	--	--	--	--	2	33	2	33	3	100
Cinna arundinacea	--	--	--	--	--	--	--	--	2	67
Coleataenia rigidula ssp. rigidula	--	--	--	--	2	100	--	--	--	--
Cuscuta compacta	--	--	--	--	--	--	2	33	--	--
Cyperus pseudovegetus	--	--	--	--	--	--	2	67	--	--
Distichlis spicata	--	--	--	--	3	67	--	--	--	--
Eleocharis obtusa	--	--	--	--	4	67	--	--	--	--
Eupatorium perfoliatum	--	--	--	--	--	--	2	67	--	--
Fraxinus pennsylvanica	--	--	--	--	--	--	--	--	2	33
Galium tinctorium	--	--	2	67	3	100	--	--	2	100
Habenaria repens	--	--	--	--	--	--	--	--	2	33
Hibiscus moscheutos	--	--	2	33	3	67	--	--	--	--
Impatiens capensis	--	--	--	--	--	--	--	--	2	100
Iva frutescens	2	67	--	--	--	--	--	--	--	--
Juncus roemerianus	--	--	7	100	2	67	--	--	--	--
Kosteletzkya pentacarpos	--	--	2	33	2	67	--	--	2	67
Lobelia elongata	--	--	--	--	2	33	--	--	--	--
Ludwigia alternifolia	--	--	--	--	2	100	--	--	--	--

Table 5. Continued.

	ACE Basin NWR - Grove Marsh/Edisto River		Currituck NWR - Swan Island		Mackay Island NWR - Great Marsh		Savannah NWR - Little Back River		Waccamaw NWR - Sandy Island Marsh	
	cov	con	cov	con	cov	con	cov	con	cov	con
Ludwigia grandiflora ssp. hexapetala	--	--	--	--	--	--	--	--	6	67
Ludwigia palustris	--	--	--	--	2	67	--	--	--	--
Ludwigia repens	--	--	--	--	--	--	2	67	--	--
Lycopus	--	--	2	67	--	--	--	--	--	--
Lycopus virginicus	--	--	--	--	--	--	--	--	2	100
Lythrum lineare	--	--	2	33	3	100	--	--	--	--
Mikania scandens	--	--	2	33	2	100	2	100	--	--
Murdannia keisak	--	--	--	--	--	--	--	--	3	100
Onoclea sensibilis var. sensibilis	--	--	--	--	--	--	--	--	2	67
Orontium aquaticum	--	--	--	--	--	--	--	--	2	33
Osmunda spectabilis	--	--	--	--	2	33	--	--	--	--
Panicum	--	--	--	--	--	--	2	33	--	--
Peltandra virginica	4	100	--	--	--	--	--	--	3	100
Persicaria arifolia	--	--	--	--	--	--	--	--	6	100
Persicaria hydropiper	--	--	--	--	2	33	--	--	--	--
Persicaria hydropiperoides	--	--	--	--	--	--	--	--	2	67
Persicaria pensylvanica	--	--	2	100	2	100	2	67	--	--
Persicaria punctata	--	--	--	--	--	--	3	100	--	--
Persicaria sagittata	--	--	--	--	--	--	--	--	2	67
Persicaria setacea	--	--	--	--	--	--	--	--	3	100
Phragmites australis	--	--	6	33	--	--	--	--	--	--
Phyla lanceolata	--	--	--	--	--	--	--	--	2	67
Physostegia leptophylla	--	--	--	--	--	--	2	33	--	--
Pluchea camphorata	2	67	--	--	--	--	--	--	--	--
Pluchea foetida var. foetida	--	--	--	--	--	--	2	33	--	--
Poaceae	2	33	--	--	--	--	--	--	--	--
Pontederia cordata	--	--	--	--	--	--	3	100	2	100
Proserpinaca palustris var. palustris	--	--	--	--	2	67	--	--	2	33

Table 5. Continued.

	ACE Basin NWR – Grove Marsh/Edisto River		Currituck NWR – Swan Island		Mackay Island NWR - Great Marsh		Savannah NWR - Little Back River		Waccamaw NWR - Sandy Island Marsh	
	cov	con	cov	con	cov	con	cov	con	cov	con
Ptilimnium capillaceum	--	--	--	--	2	33	--	--	2	100
Rhynchospora macrostachya	--	--	--	--	--	--	2	67	--	--
Rosa multiflora	--	--	--	--	--	--	--	--	2	67
Sacciolepis striata	--	--	--	--	--	--	--	--	2	67
Sagittaria graminea	--	--	--	--	--	--	2	67	--	--
Sagittaria lancifolia var. media	4	100	2	67	7	100	2	67	2	33
Sagittaria latifolia var. latifolia	--	--	--	--	--	--	2	33	--	--
Sagittaria weatherbiana	2	67	--	--	--	--	--	--	--	--
Salix caroliniana	--	--	--	--	--	--	--	--	2	33
Samolus parviflorus	--	--	1	33	--	--	--	--	--	--
Saururus cernuus	--	--	--	--	--	--	2	33	--	--
Schoenoplectus americanus	--	--	--	--	--	--	2	33	--	--
Schoenoplectus pungens	2	33	3	67	9	100	--	--	--	--
Schoenoplectus tabernaemontani	6	100	--	--	2	67	5	100	3	100
Solidago rugosa	--	--	2	33	--	--	--	--	--	--
Sporobolus alterniflorus	--	--	--	--	2	67	--	--	--	--
Sporobolus cynosuroides	7	100	6	67	--	--	--	--	--	--
Sporobolus pumilus	--	--	2	33	6	100	--	--	--	--
Symphyotrichum elliottii	--	--	--	--	--	--	--	--	2	100
Symphyotrichum novi-belgii	--	--	2	67	--	--	--	--	--	--
Symphyotrichum tenuifolium	2	100	--	--	--	--	--	--	--	--
Thelypteris palustris	--	--	--	--	3	33	--	--	--	--
Typha angustifolia	4	100	3	100	3	100	--	--	--	--
Typha domingensis	--	--	--	--	--	--	--	--	3	100
Typha latifolia	--	--	--	--	3	33	6	100	--	--
Zizania aquatica	--	--	--	--	--	--	--	--	7	100
Zizaniopsis miliacea	7	100	--	--	--	--	8	100	3	100

Table 6. Average cover class and constancy (%) for vascular plant species by CWEM Sites classified as Tidal Salt Marsh and Brackish Marsh Ecological Types. Cover and constancy were calculated from the three plots located at each CWEM Site.

	Alligator River NWR - Long Shoal River		Blackbeard Island NWR - Blackbeard Creek		Cape Romain NWR - Horsehead Creek		Cape Romain NWR - Raccoon Key		Cedar Island NWR - West Marsh		Harris Neck NWR - Harris Neck Creek		Lower Suwannee NWR - Shired Creek		Pea Island NWR - South Pea Island Marsh		Pinckney Island NWR - Mackay Creek		St. Marks NWR - Goose Creek Bay		Swanquarter NWR - Juniper Bay Marsh		Wassaw NWR - Wassaw Creek		Wolf Island NWR - Altamaha Sound	
	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con	cov	con
Borrichia frutescens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	100	--	--	--	--	--	--	--	--	--	--
Distichlis spicata	3	33	--	--	--	--	--	--	4	100	--	--	2	67	--	--	--	--	2	33	2	100	--	--	--	--
Fuirena squarrosa	3	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus roemerianus	6	100	--	--	--	--	--	--	8	100	--	--	9	100	9	100	--	--	8	100	8	100	--	--	--	--
Phragmites australis	6	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pluchea odorata	--	--	--	--	--	--	--	--	2	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salicornia bigelovii	2	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Solidago mexicana	--	--	--	--	--	--	--	--	2	33	2	33	--	--	2	100	--	--	3	100	--	--	--	--	--	--
Sporobolus alterniflorus	5	67	7	100	8	100	9	100	3	33	9	100	4	100	--	--	9	100	--	--	--	--	8	100	9	100
Sporobolus pumilus	2	33	--	--	--	--	--	--	3	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Symphyotrichum tenuifolium	1	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 7. Average density and basal area (m^2/ha) for woody vascular plant species by CWEM Sites. Density and basal area were calculated from the three plots located at each CWEM Site. Woody stems were not found in CWEM Sites that are not listed in this table.

	Alligator River NWR - Koehring Road Pocosin				Roanoke River NWR - Goodmans Island				Waccamaw NWR - Sandy Island Marsh			
	Count (mean)	Count (St Dev)	BA (mean)	BA (St Dev)	Count (mean)	Count (St Dev)	BA (mean)	BA (St Dev)	Count (mean)	Count (St Dev)	BA (mean)	BA (St Dev)
Acer rubrum var. rubrum	0.67	0.58	0.07	0.06	7.67	8.33	2.20	0.18	--	--	--	--
Alnus serrulata	--	--	--	--	--	--	--	--	9.00	15.59	0.89	1.54
Aralia spinosa	8.67	8.08	0.24	0.24	--	--	--	--	--	--	--	--
Baccharis halimifolia	--	--	--	--	--	--	--	--	0.67	1.15	0.02	0.03
Berchemia scandens	--	--	--	--	0.67	0.58	0.04	0.06	--	--	--	--
Carpinus caroliniana	--	--	--	--	37.00	53.23	2.08	3.03	--	--	--	--
Clethra alnifolia	--	--	--	--	7.33	12.70	0.08	0.14	--	--	--	--
Cornus stricta	--	--	--	--	1.33	2.31	0.02	0.04	--	--	--	--
Crataegus	--	--	--	--	0.67	1.15	0.01	0.02	--	--	--	--
Fraxinus caroliniana	--	--	--	--	2.67	2.89	0.84	0.66	--	--	--	--
Fraxinus pennsylvanica	--	--	--	--	11.00	10.58	12.11	7.41	--	--	--	--
Gelsemium sempervirens	6.67	2.89	0.01	0.01	--	--	--	--	--	--	--	--
Ilex glabra	486.00	165.95	8.32	3.63	--	--	--	--	--	--	--	--
Ilex verticillata	--	--	--	--	9.00	9.54	0.70	0.97	--	--	--	--
Itea virginica	--	--	--	--	1.00	1.00	0.00	0.00	--	--	--	--
Liquidambar styraciflua	--	--	--	--	2.33	1.53	2.32	0.58	--	--	--	--
Lyonia ligustrina var. foliosiflora	--	--	--	--	--	--	--	--	--	--	--	--
Lyonia lucida	3.33	5.77	0.01	0.01	--	--	--	--	--	--	--	--
Magnolia virginiana var. virginiana	6.67	7.64	0.09	0.08	0.33	0.58	0.00	0.00	--	--	--	--
Morella cerifera	--	--	--	--	0.67	1.15	0.04	0.08	--	--	--	--
Muscadinia rotundifolia var. rotundifolia	3.33	5.77	0.01	0.01	--	--	--	--	--	--	--	--
Nyssa biflora	--	--	--	--	3.67	4.04	20.72	17.98	--	--	--	--
Parthenocissus quinquefolia	1.67	2.89	0.00	0.01	0.67	1.15	0.00	0.00	--	--	--	--
Persea palustris	29.33	25.32	1.96	1.91	4.33	5.77	0.83	1.44	--	--	--	--
Pinus serotina	3.00	0.00	32.22	4.24	--	--	--	--	--	--	--	--
Quercus laurifolia	--	--	--	--	4.67	2.08	3.81	5.70	--	--	--	--
Rhus copallinum var. copallinum	0.67	0.58	0.07	0.06	--	--	--	--	--	--	--	--
Salix caroliniana	--	--	--	--	--	--	--	--	2.33	4.04	0.11	0.18
Sassafras albidum	4.00	3.61	0.41	0.34	--	--	--	--	--	--	--	--
Smilax glauca	10.00	5.00	0.02	0.01	--	--	--	--	--	--	--	--
Smilax laurifolia	16.67	24.66	0.03	0.05	0.33	0.58	0.00	0.00	--	--	--	--
Smilax walteri	--	--	--	--	21.33	9.45	0.04	0.02	--	--	--	--
Toxicodendron radicans var. radicans	--	--	--	--	3.67	3.21	0.03	0.03	--	--	--	--
Ulmus americana var. americana	--	--	--	--	1.33	1.15	2.01	1.85	--	--	--	--
Vaccinium fuscatum	--	--	--	--	0.67	1.15	0.00	0.00	--	--	--	--
Viburnum recognitum	--	--	--	--	1.00	1.73	0.02	0.03	--	--	--	--
Vitis labrusca	--	--	--	--	1.00	1.00	0.02	0.01	--	--	--	--
Zenobia pulverulenta	--	--	--	--	--	--	--	--	--	--	--	--

Table 8. Average, minimum, and maximum species richness by CWEM Site vegetation associations across five spatial scales. Bold text indicates highest average value for a particular spatial scale.

	0.01 m²	*0.1 m²*	*1 m²*	*10 m²*	*100 m²*
Juncus roemerianus - Pontederia cordata Herbaceous Vegetation	1.0 (0.75 - 1.25)	2.3 (1.5 - 2.75)	3.5 (1.75 - 4.5)	5.5 (2.5 - 7.25)	10.3 (3 - 16)
Juncus roemerianus Herbaceous Vegetation	1.0 (0.25 - 2)	1.4 (0.25 - 2)	1.7 (0.25 - 2.5)	2.3 (1.5 - 3.5)	3.1 (2 - 6)
Pinus serotina / Ilex glabra / Woodwardia virginica Woodland	0.3 (0.25 - 0.5)	1.3 (1 - 1.5)	2.9 (2.25 - 3.5)	7 (6 - 8)	16.3 (15 - 19)
Schoenoplectus pungens - (*Osmunda regalis* var. *spectabilis)* Herbaceous Vegetation	**2.1 (1.5 - 2.75)**	**3.7 (2.75 - 4.75)**	**6.9 (5 - 8.75)**	12 (8.75 - 14)	19.7 (13 - 25)
Spartina alterniflora Carolinian Zone Herbaceous Vegetation	0.8 (0 - 1)	0.9 (0 - 1)	0.9 (0 - 1)	1 (0.25 - 1.25)	1.1 (1 - 2)
Taxodium distichum - Nyssa aquatica - Nyssa biflora / Fraxinus caroliniana / Itea virginica Forest	1.3 (1.25 - 1.25)	2.2 (1.75 - 2.75)	4.5 (3.25 - 5.5)	12.8 (10.5 - 16.75)	**36.3 (28 - 50)**
Zizania aquatica Tidal Herbaceous Vegetation	1.1 (1 - 1.25)	3.2 (2.5 - 4)	6.6 (5 - 8.25)	**12.9 (12.5 - 13.5)**	28 (25 - 31)
Zizaniopsis miliacea Tidal Herbaceous Vegetation	1.0 (0.5 - 1.75)	3.2 (2.5 - 3.75)	5.8 (5 - 6.75)	8.2 (6.75 - 10.5)	11.7 (8 - 18)

Table 9. Select soil nutrient and texture properties by CWEM Site. Values represent site averages. pH=potential of hydrogen, $-\log_{10}[H^+]$; OM%=organic matter percentage; PBS=percent base saturation; Clay%=percentage of particle sizes <0.002 mm diameter; Silt%=percentage of particle sizes 0.002-0.05 mm diameter; and Sand%=percentage of particle sizes >0.05 mm diameter.

CWEM Site	pH	OM%	PBS	Clay%	Silt%	Sand%	CWEM Site	pH	OM%	PBS	Clay%	Silt%	Sand%
ACE Basin NWR - Grove Marsh/Edisto River	4.8	18	44	17	30	53	Mackay Island NWR - Great Marsh	5.3	52	58	3	13	85
Alligator River NWR - Koehring Road Pocosin	3.6	70	21	3	21	77	Pea Island NWR - South Pea Island Marsh	6.7	16	91	3	4	93
Alligator River NWR - Long Shoal River	6.8	12	92	3	24	73	Pinckney Island NWR - Mackay Creek	5.3	4	59	4	16	80
Blackbeard Island NWR - Blackbeard Creek	6.0	11	81	12	17	72	Roanoke River NWR - Goodman Island	5.0	46	50	2	19	78
Cape Romain NWR - Horsehead Creek	3.2	11	17	22	28	50	Savannah NWR - Little Black River	4.3	34	32	14	19	67
Cape Romain NWR - Raccoon Key	3.4	11	18	14	38	48	St. Marks NWR - Goose Creek Bay	6.0	3	81	4	10	85
Cedar Island NWR - Wet Marsh	5.8	65	75	4	17	79	Swanquarter NWR - Juniper Bay Marsh	6.2	43	83	4	19	77
Currituck NWR - Swan Island	5.5	21	65	3	5	93	Waccamaw NWR - Sandy Island Marsh	4.8	35	44	4	17	79
Harris Neck NWR - Harris Neck Creek	5.7	39	72	14	18	68	Wassaw NWR - Wassaw Creek	5.1	4	59	3	18	79
Lower Suwannee NWR - Shired Creek	5.8	6	75	2	5	93	Wolf Island NWR - Altamaha Sound	5.1	11	56	8	20	72

5 Conclusions

These vegetation and environmental data were taken from a wide variety of community types, including tidal marshes with both low and high species diversity, nonalluvial peatland forests and shrublands, and tidal blackwater riparian forests. Floristic composition and structure data were variable across the 20 CWEM Sites, but showed repeating patterns when summarized by both coarse-scale and fine-scale vegetation types. Species richness patterns among this dataset followed those from other floristic surveys conducted in the same and similar vegetation types along the Atlantic and Gulf Outer Coastal Plain and maritime fringe. Soil nutrient and texture properties that were described from these sites are also tracked over time, and may serve as abiotic indicators of vegetation structure and composition.

This dataset currently serves as a status assessment of vegetation condition on NWR CWEM Sites within the SALCC geography. Because the CVS plots established at each site were monumented at fixed locations, repeat sampling will provide high, spatially-precise vegetation change information through time. Given the widespread anthropogenic influences and natural threats including sea level rise and saltwater intrusion that are occurring and will continue to occur on coastal NWRs, quantifying patterns in species cover, frequency, diversity and movement will be of increasing importance to understanding how these ecosystems respond to environmental change.

The NWR System Improvement Act of 1997 specifically charges the Secretary of the Interior to "monitor the status and trends of fish, wildlife, and plants in each refuge." Service Manual Policy 701 FW 2 (Inventory and Monitoring in the National Wildlife Refuge System) states that "Through this policy, the Service seeks to….gather baseline data and record benchmark conditions used to support refuge planning,….estimate the status of, and trends in fish, wildlife, plant populations, and their habitats,….(and) provide surveillance to detect changes in the structure and function of ecological systems" (Section 2.3 E). The materials and information presented in this report can be used by managers to fulfill these mandates.

6 Literature Cited

Boon, J.D. 2012. Evidence of sea level acceleration at U.S. and Canadian tide stations, Atlantic Coast, North America. Journal of Coastal Research 28(6):1437-1445.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis of soils. Agron. J. 54:464-465.

Boyle, M.F., N.M. Rankin, and W.D. Stanton. 2015. Vegetation of coastal wetland elevation monitoring sites on National Wildlife Refuges in the South Atlantic geography: baseline inventory report. U.S. Fish and Wildlife Service, Southeast Region. Atlanta, GA. April 2015. 47 pp.

Boyle, M.F., N.M. Rankin, and L. Barnhill. *In review*. Coastal Wetland Elevation Monitoring Protocol for the U.S. Fish and Wildlife Service, Southeast Region: SOP #X, Vegetation Monitoring. U.S. Department of the Interior, U.S. Fish and Wildlife Service, National Wildlife Refuge System, Southeast Region Inventory and Monitoring Network.

CCSP. 2009. Coastal sensitivity to sea-level rise: a focus on the Mid-Atlantic Region. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Climate Change Research [J. G. Titus (Coordinating Lead Author), K.E. Anderson, D.R. Cahoon, D.B. Gesch,

S.K. Gill, B.T. Gutierrez, E.R. Thieler, and S.J. Williams (Lead Authors)]. U.S. Environmental Protection Agency, Washington, D.C. USA, 320 pp.

FGDC. 2008. National Vegetation Classification Standard. FGDC-STD-005-2008 (Version 2). Vegetation Subcommittee, Federal Geographic Data Committee, FGDC Secretariat, U.S. Geological Survey, Reston, VA. 199 pp.

Jennings, M.D., D. Faber-Langendoen, R.K. Peet, O.L. Loucks, D.C. Glenn-Lewin, A. Damman, M.G. Barbour, R. Pfister, D. Grossman, D. Roberts, D. Tart, M. Walker, S.S. Talbot, J. Walker, G.S. Hartshorn, G. Waggoner, M.D. Abrams, A. Hill, and M. Rejmanek. 2004. Guidelines for describing Associations and Alliances of the U.S. National Vegetation Classification, Version 4. The Ecological Society of America, Vegetation Classification Panel. Washington, D.C.

Kent, M., and P. Coker. 1992. Vegetation description and analysis. Bellhaven Press, London.

Lee, M. T., R. K. Peet, S. D. Roberts, and T. R. Wentworth. 2008. CVS-EEP protocol for recording vegetation data, all levels of plot sampling. Carolina Vegetation Survey, Version 4.2.

Mehlich, A. 1984. Mehlich-3 soil test extractant: a modification of Mehlich-2 extractant. Commun. Soil Sci. Plant Anal. 15:1409-1416.

NatureServe. 2014. NatureServe Explorer: an online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: October 8, 2014).

Peet, R.K., T.R. Wentworth, and P.S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274.

Peet, R.K., M.T. Lee, M.F. Boyle, T.R. Wentworth, M.P. Schafale, and A.S. Weakley. 2012. Vegetation-plot database of the Carolina Vegetation Survey. Biodiversity and Ecology 4:243-253.

Rankin, N.M., J.A. Moon, and M.F. Boyle. 2016. Multi-regional protocol framework for monitoring of coastal wetland elevation and vegetation community dynamics, Region 2 & Region 4 (draft).

U.S. Fish and Wildlife Service (USFWS). 2013. How to develop survey protocols, a handbook (Version 1.0). Fort Collins, CO: US Department of Interior, Fish and Wildlife Service, National Wildlife Refuge System, Natural Resources Program Center.

Weakley, A.S. 2015. Flora of the southern and Mid-Atlantic states: working draft of 21 May 2015. University of North Carolina Herbarium, North Carolina Botanical Garden, University of North Carolina, Chapel Hill, NC. 1320 pp.

APPENDICES

Appendix 1. RSET Benchmark (red circle) and 100 m^2 vegetation plot (yellow square) locations and representative image from each of the CWEM Sites in the SALCC Geography.

ACE Basin NWR – Grove Marsh/Edisto River

Sample Date: 8 August 2016

Alligator River NWR – Koehring Road Pocosin

Sample Date: 14 July 2016

Alligator River NWR – Long Shoal River

Sample Date: 20 July 2016

Blackbeard Island NWR – Blackbeard Creek

Sample Date: 18 August 2016

Cape Romain NWR – Horsehead Creek

Sample Date: 15 August 2016

Cape Romain NWR – Raccoon Key

Sample Date: 15 August 2016

Cedar Island NWR – West Marsh

Sample Date: 4 August 2016

Currituck NWR – Swan Island

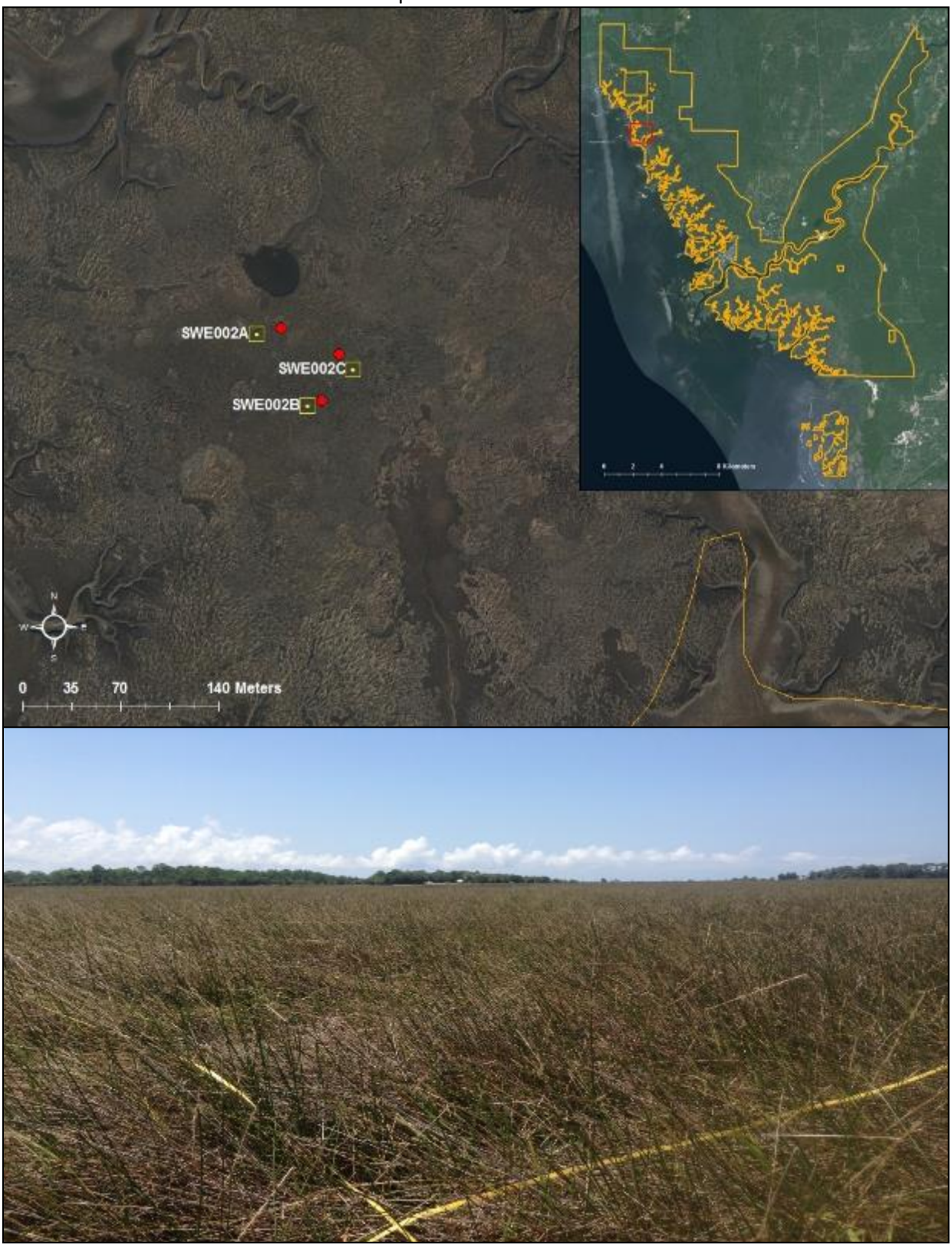
Sample Date: 26 July 2016

Harris Neck NWR – Harris Neck Creek

Sample Date: 16 August 2016

Lower Suwannee NWR – Shired Creek

Sample Date: 23 June 2016



Mackay Island NWR – Great Marsh

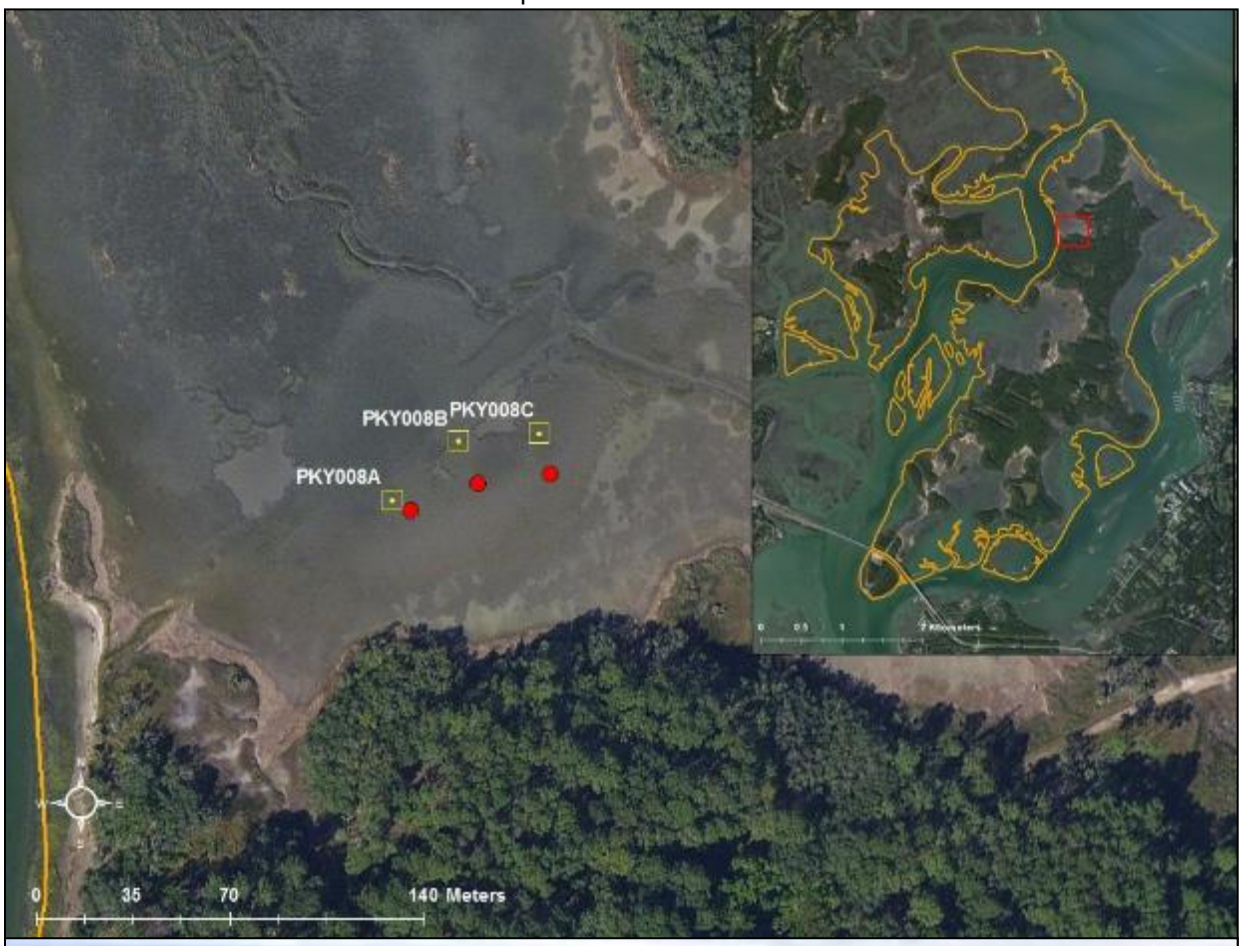
Sample Date: 26 July 2016

Pea Island NWR – South Pea Island Marsh

Sample Date: 18 July 2016

Pinckney Island NWR – Mackay Creek

Sample Date: 30 June 2016



Roanoke River NWR – Goodman Island

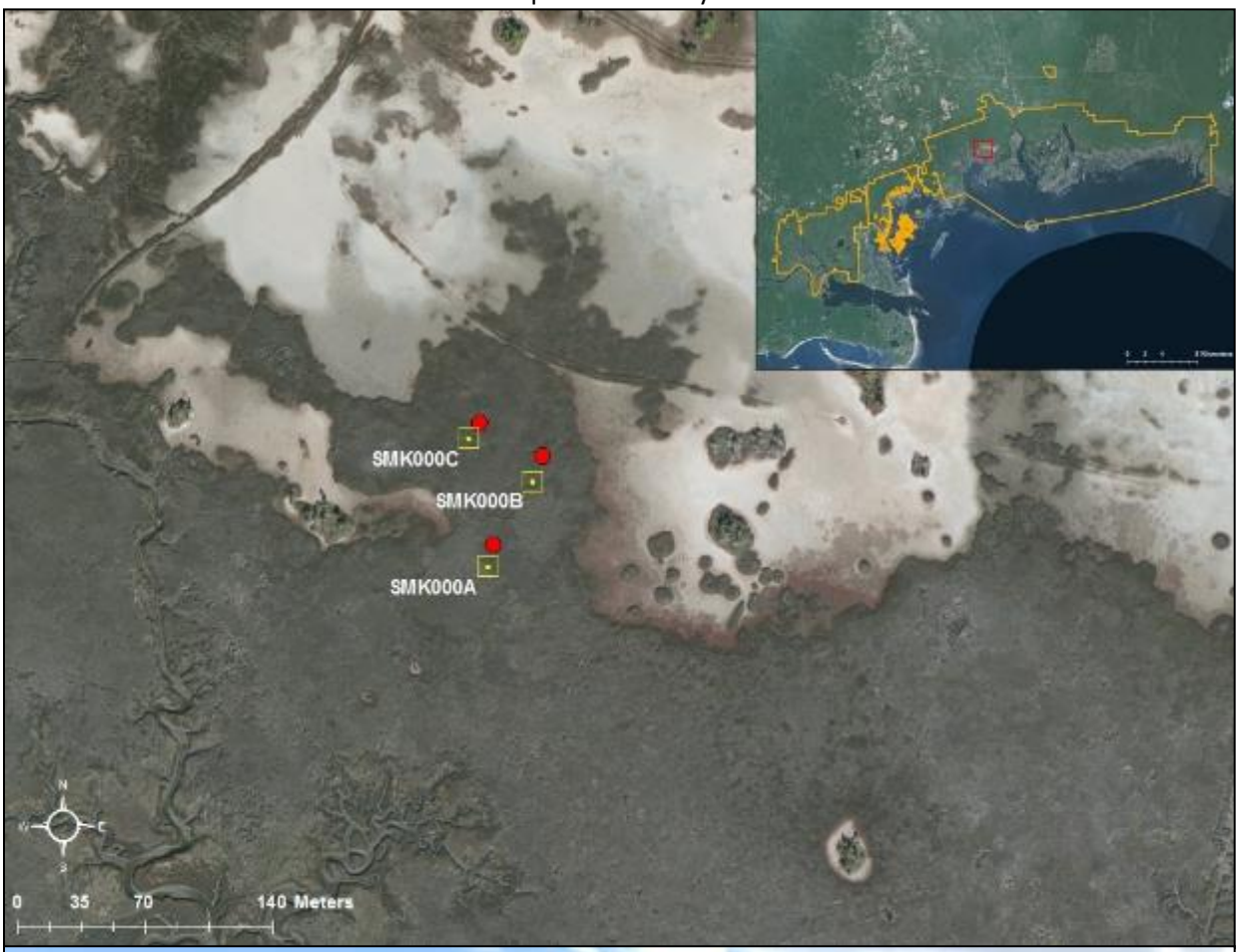
Sample Date: 12 July 2016

Savannah NWR – Little Back River

Sample Date: 28 June 2016

St. Marks NWR – Goose Creek Bay

Sample Date: 6 July 2016



Swanquarter NWR – Juniper Bay Marsh

Sample Date: 2 August 2016

Waccamaw NWR – Sandy Island Marsh

Sample Date: 9 August 2016

Wassaw NWR – Wassaw Creek

Sample Date: 22 August 2016

Wolf Island NWR – Altamaha Sound

Sample Date: 17 August 2016

Appendix 2. List of vascular plants detected and frequency of occurrence within the 54 CWEM Site vegetation plots in the SALCC Geography in the summer 2016. Scientific names follow Weakley's (2015) Flora of the Southern and Mid-Atlantic States. Alien species are marked with an asterisk**.**

Family	Scientific Name	Common Name	Frequency
Adoxaceae	*Viburnum recognitum*	Southern arrowwood	2
Alismataceae	*Sagittaria graminea*	Grassy arrowhead	2
Alismataceae	*Sagittaria lancifolia var. media*	Bulltongue arrowhead	11
Alismataceae	*Sagittaria latifolia var. latifolia*	Arrowhead	1
Alismataceae	*Sagittaria weatherbiana*	Weatherby's arrowhead	2
Altingiaceae	*Liquidambar styraciflua*	Sweet gum	3
Amaranthaceae	*Alternanthera philoxeroides*	Alligator-weed*	3
Amaranthaceae	*Amaranthus cannabinus*	Salt-marsh water-hemp	3
Anacardiaceae	*Rhus copallinum var. copallinum*	Winged sumac	2
Anacardiaceae	*Toxicodendron radicans var. radicans*	Eastern poison ivy	6
Apiaceae	*Centella asiatica*	Coinleaf	7
Apiaceae	*Cicuta maculata*	Water-hemlock	7
Apiaceae	*Ptilimnium capillaceum*	Eastern bishopweed	4
Aquifoliaceae	*Ilex glabra*	Gallberry	3
Aquifoliaceae	*Ilex opaca*	American holly	1
Aquifoliaceae	*Ilex verticillata*	Winterberry	3
Araceae	*Arisaema pusillum*	Small jack-in-the-pulpit	1
Araceae	*Orontium aquaticum*	Golden club	1
Araceae	*Peltandra virginica*	Green arrow-arum	9
Araliaceae	*Aralia spinosa*	Devil's-walking-stick	2
Asteraceae	*[Bidens + Coreopsis]*	[Beggar-ticks + Tickseed]	3
Asteraceae	*Baccharis halimifolia*	Silverling	1
Asteraceae	*Bidens connata*	Northern tickseed-sunflower	1
Asteraceae	*Borrichia frutescens*	Seaside oxeye	3
Asteraceae	*Eupatorium perfoliatum*	Common dog-fennel	2
Asteraceae	*Iva frutescens*	Jesuit's bark	2
Asteraceae	*Mikania scandens*	Climbing hempweed	7
Asteraceae	*Pluchea camphorata*	Camphorweed	2
Asteraceae	*Pluchea foetida var. foetida*	Stinking camphorweed	1
Asteraceae	*Pluchea odorata*	Sweetscent	2
Asteraceae	*Solidago mexicana*	Southern seaside goldenrod	8
Asteraceae	*Solidago rugosa*	Wrinkleleaf goldenrod	1
Asteraceae	*Symphyotrichum elliottii*	Southern swamp aster	3
Asteraceae	*Symphyotrichum novi-belgii*	New York Aster	2
Asteraceae	*Symphyotrichum tenuifolium*	Perennial salt-marsh aster	4
Balsaminaceae	*Impatiens capensis*	Orange jewelweed	3
Betulaceae	*Alnus serrulata*	Tag alder	3
Betulaceae	*Carpinus caroliniana*	American hornbeam	3
Bignoniaceae	*Bignonia capreolata*	Crossvine	1
Blechnaceae	*Anchistea virginica*	Virginia chainfern	3
Blechnaceae	*Lorinseria areolata*	Netted chainfern	1
Bromeliaceae	*Tillandsia usneoides*	Spanish-moss	1
Campanulaceae	*Lobelia elongata*	Longleaf lobelia	1
Campanulaceae	*Lobelia sp.*	Lobelia	1
Caprifoliaceae	*Lonicera sempervirens*	Coral honeysuckle	1
Chenopodiaceae	*Salicornia bigelovii*	Dwarf glasswort	1
Clethraceae	*Clethra alnifolia*	Coastal sweet-pepperbush	1
Commelinaceae	*Commelina virginica*	Virginia dayflower	3
Commelinaceae	*Murdannia keisak*	Murdannia*	4
Convolvulaceae	*Cuscuta compacta*	Compact dodder	1

Family	Scientific Name	Common Name	Frequency
Cornaceae	*Cornus stricta*	Southern swamp dogwood	1
Cupressaceae	*Taxodium distichum*	Bald-cypress	2
Cyperaceae	*Carex grisea*	Inflated narrow-leaf sedge	3
Cyperaceae	*Carex lupulina*	Hop sedge	2
Cyperaceae	*Carex lurida*	Shallow sedge	1
Cyperaceae	*Carex seorsa*	Weak stellate sedge	1
Cyperaceae	*Carex stricta*	Upright sedge	3
Cyperaceae	*Cyperus pseudovegetus*	Marsh flatsedge	2
Cyperaceae	*Eleocharis obtusa*	Spikerush	2
Cyperaceae	*Fuirena squarrosa*	Hairy umbrella-sedge	2
Cyperaceae	*Rhynchospora macrostachya*	Tall horned beaksedge	2
Cyperaceae	*Schoenoplectus americanus*	Chairmaker's bullrush	1
Cyperaceae	*Schoenoplectus pungens*	Common threesquare	6
Cyperaceae	*Schoenoplectus tabernaemontani*	Softstem bulrush	11
Ericaceae	*Lyonia lucida*	Shining fetterbush	3
Ericaceae	*Vaccinium formosum*	Southern highbush blueberry	1
Ericaceae	*Vaccinium fuscatum*	Hairy highbush blueberry	4
Fabaceae	*Apios americana*	Common groundnut	3
Fagaceae	*Quercus laurifolia*	Laurel oak	3
Gelsemiaceae	*Gelsemium sempervirens*	Carolina jessamine	3
Haloragaceae	*Proserpinaca palustris var. palustris*	Coastal mermaid-weed	3
Iridaceae	*Iris virginica var. virginica*	Southern blue flag	1
Iteaceae	*Itea virginica*	Virginia-willow	3
Juncaceae	*Juncus roemerianus*	Black needle rush	23
Lamiaceae	*Lycopus*	Bugleweed	2
Lamiaceae	*Lycopus virginicus*	Virginia bugleweed	3
Lamiaceae	*Physostegia leptophylla*	Slenderleaf false dragonhead	1
Lauraceae	*Persea palustris*	Swamp bay	6
Lauraceae	*Sassafras albidum*	Sassafras	3
Lythraceae	*Lythrum lineare*	Narrowleaf loosestrife	4
Magnoliaceae	*Magnolia virginiana var. virginiana*	Northern sweet bay	4
Malvaceae	*Hibiscus moscheutos*	Eastern rose-mallow	3
Malvaceae	*Kosteletzkya pentacarpos*	Seashore-mallow	5
Myricaceae	*Morella cerifera*	Common wax-myrtle	1
Nyssaceae	*Nyssa biflora*	Swamp tupelo	2
Oleaceae	*Fraxinus caroliniana*	Water ash	3
Oleaceae	*Fraxinus pennsylvanica*	Green ash	4
Onagraceae	*Ludwigia alternifolia*	Seedbox	3
Onagraceae	*Ludwigia grandiflora ssp. hexapetala*	Large-flower primrose-willow	2
Onagraceae	*Ludwigia palustris*	Common water-primrose	2
Onagraceae	*Ludwigia repens*	Creeping seedbox	2
Onocleaceae	*Onoclea sensibilis var. sensibilis*	Sensitive fern	3
Orchidaceae	*Habenaria repens*	Water-spider orchid	1
Orchidaceae	*Platanthera lacera*	Fringed orchid	1
Osmundaceae	*Osmunda spectabilis*	Royal fern	2
Osmundaceae	*Osmundastrum cinnamomeum*	Cinnamon Fern	1
Pinaceae	*Pinus serotina*	Pond pine	3
Poaceae	*Cinna arundinacea*	Common woodreed	2
Poaceae	*Coleataenia rigidula ssp. rigidula*	Redtop panicgrass	3
Poaceae	*Distichlis spicata*	Saltgrass	12

Family	Scientific Name	Common Name	Frequency
Poaceae	*Leersia oryzoides*	Rice cutgrass	3
Poaceae	*Panicum*	Panic grass	1
Poaceae	*Phragmites australis*	Common reed*	3
Poaceae	*Poa autumnalis*	Autumn bluegrass	3
Poaceae	*Poaceae*	Grass	1
Poaceae	*Sacciolepis striata*	American cupscale	2
Poaceae	*Sporobolus alterniflorus*	Saltmarsh cordgrass	23
Poaceae	*Sporobolus cynosuroides*	Giant cordgrass	5
Poaceae	*Sporobolus pumilus*	Saltmeadow cordgrass	8
Poaceae	*Zizania aquatica*	Southern wild-rice	3
Poaceae	*Zizaniopsis miliacea*	Giant cutgrass	9
Polygonaceae	*Persicaria arifolia*	Heart-leaf tearthumb	6
Polygonaceae	*Persicaria hydropiper*	Marshpepper knotweed	1
Polygonaceae	*Persicaria hydropiperoides*	Waterpepper	2
Polygonaceae	*Persicaria pensylvanica*	Pinkweed	8
Polygonaceae	*Persicaria punctata*	Dotted smartweed	3
Polygonaceae	*Persicaria sagittata*	Arrowleaf tearthumb	2
Polygonaceae	*Persicaria setacea*	Swamp smartweed	4
Pontederiaceae	*Pontederia cordata*	Pickerelweed	6
Primulaceae	*Samolus parviflorus*	Water-pimpernel	1
Ranunculaceae	*Clematis crispa*	Southern leatherflower	1
Ranunculaceae	*Thalictrum pubescens*	Common tall meadowrue	1
Rhamnaceae	*Berchemia scandens*	Supplejack	2
Rosaceae	*Crataegus*	Hawthorn	1
Rosaceae	*Rosa multiflora*	Multiflora rose	2
Rubiaceae	*Galium tinctorium*	Three-lobed bedstraw	9
Salicaceae	*Salix caroliniana*	Carolina willow	1
Sapindaceae	*Acer rubrum var. rubrum*	Eastern red maple	5
Saururaceae	*Saururus cernuus*	Lizard's-tail	4
Smilacaceae	*Smilax glauca*	Whiteleaf greenbrier	3
Smilacaceae	*Smilax laurifolia*	Blaspheme-vine	4
Smilacaceae	*Smilax rotundifolia*	Roundleaf greenbrier	1
Smilacaceae	*Smilax walteri*	Coral greenbrier	3
Theaceae	*Gordonia lasianthus*	Loblolly bay	1
Thelypteridaceae	*Thelypteris palustris*	Marsh fern	1
Typhaceae	*Typha angustifolia*	Narrowleaf cattail	9
Typhaceae	*Typha domingensis*	Southern cattail	3
Typhaceae	*Typha latifolia*	Common cattail	4
Ulmaceae	*Ulmus americana var. americana*	American elm	2
Urticaceae	*Boehmeria cylindrica*	False-nettle	5
Verbenaceae	*Phyla lanceolata*	Marsh frogfruit	2
Violaceae	*Viola edulis*	Salad violet	2
Vitaceae	*Muscadinia rotundifolia var. rotundifolia*	Muscadine	2
Vitaceae	*Parthenocissus quinquefolia*	Virginia-creeper	4
Vitaceae	*Vitis labrusca*	Fox grape	2