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

Baseline Inventory Report

April 2015

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

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

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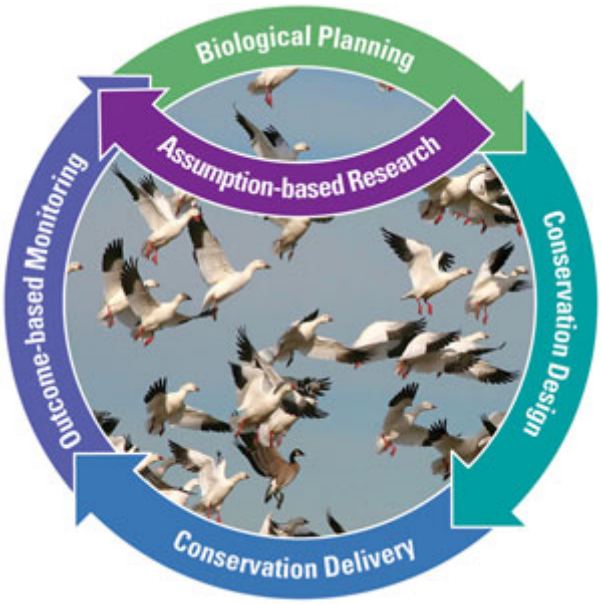

The Strategic Habitat Conservation framework

April 2015
U.S. Department of the Interior, U.S. Fish and Wildlife Service

Please cite this publication as:
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.

Cover photos (clockwise from upper left): Installing 10 x 10 m vegetation plots in tidal smooth cordgrass zone of Pinckney Island National Wildlife Refuge (credit: Forbes Boyle/USFWS); pickerelweed (*Pontederia cordata*) in freshwater tidal marsh of Waccamaw National Wildlife Refuge (credit: Theresa Thom/USFWS); collecting soil samples from vegetation plot on Roanoke River National Wildlife Refuge (credit: Forbes Boyle/USFWS); nested quadrat sampling within giant cutgrass marsh on Savannah National Wildlife Refuge (credit: Forbes Boyle/USFWS).

Acknowledgements: The authors thank the following individuals for their help with fieldwork and report review: Laurel Barnhill (USFWS), Lindsay Coldiron (USFWS), Carley Cofield, Brett Craig (USFWS), Vic Doig (USFWS), Conor Egan, Tashea Gillis, Chuck Hayes (USFWS), Mike Hoff (USFWS), Kevin Keeler (USFWS), Mike Keys (USFWS), Kathy Obendorfer, Mark Purcell (USFWS), Jean Richter (USFWS), Sherryreed Robinson, Craig Sasser (USFWS), Daniel Stanton, Jay Stanton, Jan Tripp (USFWS), Darryl Woodard (USFWS), and Larry Woodward (USFWS).

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1 Executive Summary

In 2013, the U.S. Fish and Wildlife Service (FWS) Southeast Region Inventory & Monitoring Network collected baseline vegetation data on Coastal Wetland Elevation Monitoring 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.

Vegetation was sampled at each of the monitoring sites using the methodology developed by the Carolina Vegetation Survey (CVS) (Peet et al. 1998). At each site, a total of three 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. Specific survey objectives included: a) determining average cover class and constancy for each vascular species within the sites, b) calculating average woody stem count and basal area by species within the sites, c) determining the appropriate U.S. Natural Vegetation Classification Standard association type for each site, and d) calculating species richness values across multiple spatial scales for each association.

This report summarizes data collected from each refuge within the SALCC geography in 2013, and represents the baseline vegetation inventory for the Coastal Wetland Elevation Monitoring Protocol. Noteworthy findings are listed below.

1. Vegetation and environmental data were captured in 60 10x10 m bounded and monumented plots across 20 Coastal Wetland Elevation Monitoring sites on 18 NWRs.

2. Baseline inventory efforts detected 137 taxonomic concepts, including a potential county record listing for Levy County, Florida (*Eupatorium mikanioides* on Lower Suwannee NWR). The 20 sites were classified into ten vegetation associations, including four with G2 (Imperiled) conservation status (NatureServe 2014), and seven 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, Spartina alterniflora, Schoenoplectus tabernaemontani, Sagittaria lancifolia* var*. media, Peltandra virginica, Zizaniopsis miliacea,* and *Galium tinctorium*.

5. Plots located on the Roanoke River NWR site exhibited the highest species richness values (average=34.3) for the full plot-scale (100 m^2); plots located on the Waccamaw NWR site exhibited the highest species richness values (average=17, 9.1, 3.3, and 1.5) for the nested quadrat-scale (10 m^2, 1 m^2, 0.1 m^2, and 0.01 m^2).

6. The full dataset can be acquired from FWS Service Catalog: reference code #34503.

7. A total of 20 FWS and non-FWS employees assisted with fieldwork for this survey. *THANK YOU*!

2 Introduction

2.1 Overview

The Coastal Plain of the southeastern United States has the highest diversity of freshwater wetland plant communities in North America and its maritime fringing zone increases the complexity by adding wetlands of tidal and salt influence. Dominant wetland vegetation of this maritime zone includes expansive forested river deltas, pine flatwoods, non-tidal shrublands and herbaceous-dominated associations occurring in dune swales and low non-riverine flats, and vast tidally-influenced marshes occurring across a gradient from hypersaline to oligohaline and freshwater environmental condition.

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 Network (I&M) began planning for a survey of NWR Coastal Wetland Elevation Monitoring Sites (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 archive of plot (vegetation and environment) information (Peet et al. 2012); the comparable datasets of CVS vegetation plots from other locations scattered across the Southeastern U.S., including well over 4,000 plots from the SALCC geography; and its ease of use and existing training materials.

2.2 Objectives

Vegetation sampling on CWEM Sites within the SALCC geography in the summer of 2013 represents a baseline inventory survey as described by the Inventory and Monitoring Survey Protocol Handbook (USFWS 2013). Furthermore, this inventory "may also establish a beginning time-step (baseline) or reference information for subsequent monitoring. For example, a well-designed inventory may be repeated at a later time to assess the status and trends in the same location, which would then be considered monitoring" (USFWS 2013).

Specific sampling objectives of this baseline inventory survey include:

- Determine average cover class and constancy (i.e., frequency of occurrence) for each vascular species within the 20 CWEM Sites within the SALCC geography,
- Calculate average woody stem count and basal area by species within the 20 SALCC geography CWEM Sites,
- For each of the 20 SALCC geography CWEM Sites, determine the appropriate US Natural Vegetation Classification Standard (NVCS) association type, *and*
- Calculate species richness values across multiple spatial scales for each vegetation association.

3 Methods

3.1 Taxonomic Standard

Species nomenclature for this report follows Weakley's (2012) 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 its 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., *Ilex* [*coriacea + glabra*]). 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 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. Broad habitats and NWRs included: salt and brackish marsh (Pea Island, Alligator River, Swanquarter, Cedar Island, 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.

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.

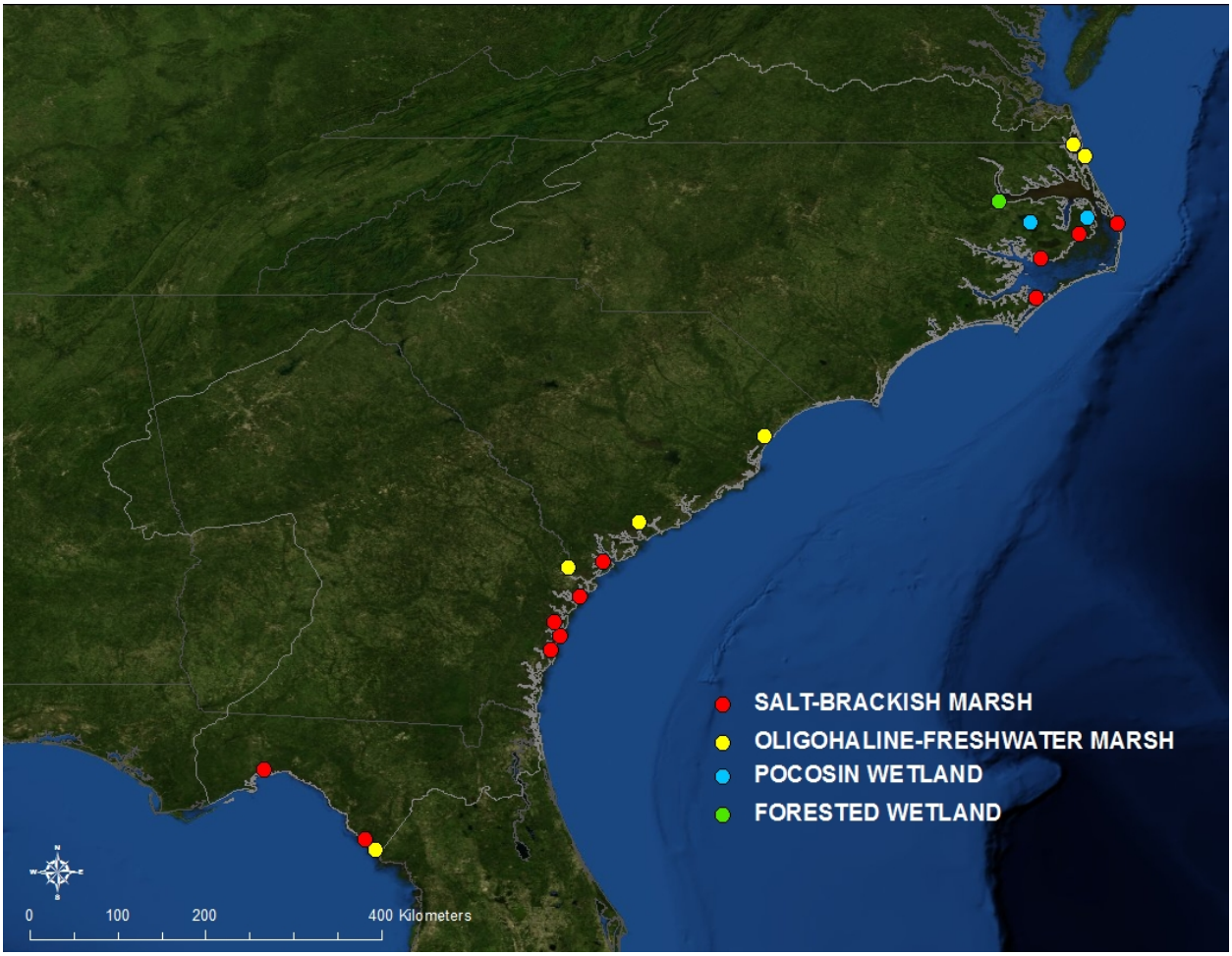

Figure 1. Distribution of the SALCC geography CWEM Sites within coastal North Carolina, South Carolina, Georgia, and Florida National Wildlife Refuges. From north to south site placement, refuges include Mackay Island, Currituck, Roanoke River, Alligator River (2), Pocosin Lakes, Pea Island, Swanquarter,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

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 rectangular 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 monumented using 12" long sections of ½" diameter galvanized steel conduit driven into the ground, with 3-6" of the top exposed. Plots were established and inventoried between April and September 2013.

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 2). 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 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, 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.

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).

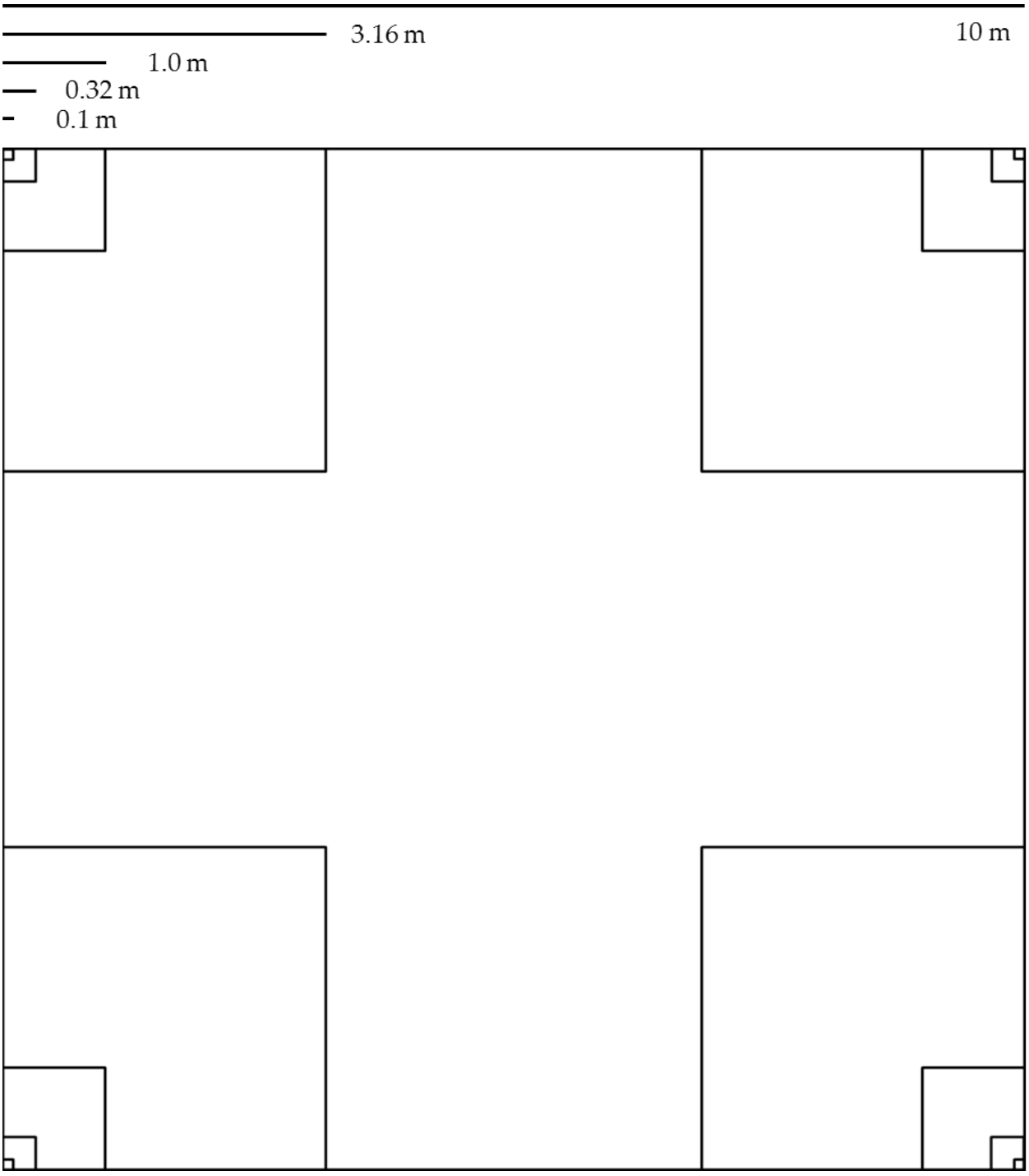

Figure 2. The standard single module (100 m^2) plot of the CVS with four nested subplots located at each corner. Nested subplots range in size from 0.01, 0.1, 1, and 10 m^2.

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 – 0.1	0.05
2	0.1 – 1	0.505
3	1 – 2	1.5
4	2 – 5	3.5
5	5 – 10	7.5
6	10 – 25	17.5
7	25 – 50	37.5
8	50 – 75	62.5
9	75 – 95	85
10	> 95	97.5

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 – 1	0.5
1 – 2.5	1.75
2.5 – 5	3.75
5 – 10	7.5
10 – 15	12.5
15 – 20	17.5
20 – 25	22.5
25 – 30	27.5
30 – 35	32.5
35 – 40	37.5
> 40	Nearest cm (e.g., 40, 41, 42….53, 54)

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 environmental data collected and descriptions of plot metadata reported (e.g, plot identification, observers, etc) are described in Boyle et al. (*In review*).

3.5 Data Analysis

Baseline inventory 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 and fall of 2013.

Data Security and Archiving

A copy of the data entry tool containing the cover, woody stem, and plot/environmental data of each of these 60 plots was provided to the CVS Central Archive Database (owner: University of North Carolina) in the fall of 2014. 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 #34503. 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.

Metadata

Plot identification, observers, sampling date, general site name, plot location, and other summary fields were entered into the aforementioned Microsoft Access entry tool, and were also listed in a Microsoft Excel summary spreadsheet (row = individual plot). Copies of the spreadsheet or entry tool are available from this report's lead author (maxwell_boyle@fws.gov).

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. 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), 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

We detected 137 taxonomic concepts (including unknown taxa, species, subspecies, and varieties) during this baseline inventory (Appendix 2), including a potential county record listing for Levy County, Florida (*Eupatorium mikanioides* on Lower Suwannee NWR – Dan May Creek site). The 20 CWEM Sites were classified into ten vegetation associations and seven ecological types (Table 3). The most common associations / ecological types sampled were the *Juncus roemerianus* Herbaceous Vegetation / Brackish Marsh and *Spartina alterniflora* Carolinian Zone Herbaceous Vegetation / Tidal Salt Marsh. 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

The only site classified as this ecological type was found on Alligator River NWR – Koehring Road Pocosin (Table 3). These plots were classified to the *Pinus serotina* / *Ilex glabra* / *Woodwardia virginica* Woodland association. This community type is found on peat domes of the Atlantic Coastal Plain and maintained by periodic fire. It can be extensive in size, with stands often greater than 10,000 acres.

The dominating feature of the vegetation on this site was the dense (97%), well-developed shrub stratum that reached 3.7 m in height (Table 3). Shrub species documented here included *Ilex coriacea, 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, Gordonia lasianthus, Sassafras albidum,* and *Persea palustris*. Herbs were present but not frequent within these plots. The few herbs that did occur here included *Woodwardia areolata, Woodwardia virginica,* and *Listera australis*.

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	10	0 – 2.5	93	--	--	--	--
Alligator River NWR - Koehring Road Pocosin	*Pinus serotina* / *Ilex glabra* / *Woodwardia virginica* Woodland (G2)	Pond Pine Forests and Woodlands	21	0 – 0.1	2	0.1 – 3.7	97	3.7 – 25.3	28
Alligator River NWR - Long Shoal River	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	4	0 – 2.5	95	--	--	--	--
Blackbeard Island NWR - Blackbeard Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 – 0.6	38	--	--	--	--
Cedar Island NWR - West Marsh	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	4	0 – 1.8	98	--	--	--	--
Currituck NWR - Swan Island	*Juncus roemerianus* - *Pontederia cordata* Herbaceous Vegetation (G2)	Oligohaline Tidal Marshes	13	0 – 3	95	--	--	--	--
Harris Neck NWR - Harris Neck Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	3	0 – 0.4	38	--	--	--	--
Lower Suwannee NWR - Dan May Creek	*Cladium mariscus* ssp. *jamaicense* Tidal Herbaceous Vegetation (G4)	Brackish Marshes	9	0 – 2	69	--	--	--	--
Lower Suwannee NWR - Shired Creek	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	2	0 – 1.5	90	--	--	--	--
Mackay Island NWR - Great Marsh	*Schoenoplectus pungens* - (*Osmunda regalis* var. *spectabilis*) Herbaceous Vegetation (G2)	Oligohaline Tidal Marshes	17	0 – 1.4	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	2	0 – 1.1	95	--	--	--	--
Pinckney Island NWR - Mackay Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 – 0.3	53	--	--	--	--
Pocosin Lakes NWR - Harvester Road Tall Pocosin	*Ilex glabra - Lyonia lucida - Zenobia pulverulenta* Shrubland (G2)	Pocosins	15	0 – 0.5	2	0.2 – 1.5	84	1.5 – 10	32
Roanoke River NWR - Goodman Island	*Taxodium distichum - Nyssa aquatica - Nyssa biflora / Fraxinus caroliniana / Itea virginica* Forest (G3)	Blackwater Swamp Forests	55	0 – 1	45	1 – 2.7	39	2.7 – 27.7	87
Savannah NWR - Little Back River	*Zizaniopsis miliacea* Tidal Herbaceous Vegetation (G4)	Oligohaline Tidal Marshes	11	0 – 2.5	88	--	--	--	--
St. Marks NWR - Goose Creek Bay	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	3	0 – 1.3	90	--	--	--	--
Swanquarter NWR - Juniper Bay Marsh	*Juncus roemerianus* Herbaceous Vegetation (G5)	Brackish Marshes	2	0 – 1.5	93	--	--	--	--
Waccamaw NWR - Sandy Island Marsh	*Zizania aquatica* Tidal Herbaceous Vegetation (G4)	Freshwater Tidal Marsh	41	0 – 2	98	--	--	2 – 3.1	4
Wassaw NWR - Wassaw Creek	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 – 0.5	32	--	--	--	--
Wolf Island NWR - Altamaha Sound	*Spartina alterniflora* Carolinian Zone Herbaceous Vegetation (G5)	Tidal Salt Marshes	1	0 – 0.5	40	--	--	--	--

4.2 Pocosin

The only site classified as this ecological type was found on Pocosin Lakes NWR – Harvester Road Tall Pocosin (Table 3). These plots were classified to the *Ilex glabra - Lyonia lucida - Zenobia pulverulenta* Shrubland association. This type of low pocosin occurs on peat domes of poor nutrient status that are maintained by occasional fire. This site may eventually link to the *Pinus serotina / Lyonia lucida - Ilex glabra* - (*Cyrilla racemiflora*) Shrubland association, which describes high pocosin vegetation. It was classified as the low pocosin type because of the current shrub height only reaches 1.5 m due to the recent (~2008) disturbance from the Evans Road Wildfire.

Like most pocosin vegetation types in the southeastern U.S., the shrub stratum within this site hosts the highest number and coverage of species. Shrub height ranges from 0.2 to 1.5 m in these plots, with an average cover of 84% (Table 3). Shrub species included *Ilex coriacea, Ilex glabra, Lyonia lucida, Vaccinium formosum*, and *Smilax laurifolia* (Table 4). A sparse and short (10 m maximum height) tree stratum is present in this site (Table 3). Tree species present include *Pinus serotina, Gordonia lasianthus*, and *Persea palustris* (Table 4).

4.3 Blackwater Swamp Forests

The only site classified as this ecological type was found on Roanoke River NWR – Goodman Island (Table 3). These plots were classified to the *Taxodium distichum - Nyssa aquatica - Nyssa biflora / Fraxinus caroliniana / Itea virginica* Forest association. This type occurs on alluvial positions that are flooded by overbank flow for extended durations.

A total of 55 vascular plant species was found in the three plots from Roanoke River NWR (Table 3). Large-scale 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 34.3. The vegetation within this site occurred within herbaceous, shrub, and tree strata (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 erecta* (Table 4).

4.4 Oligohaline Tidal Marsh

This ecological type was found on four of the 20 CWEM Sites (Table 3). Two of these were classified to the *Zizaniopsis miliacea* Tidal Herbaceous Vegetation association (ACE Basin and Savannah NWRs); the site at Currituck NWR was classified to the *Juncus roemerianus - Pontederia cordata* Herbaceous Vegetation; and the site at Mackay Island NWR was classified to the *Schoenoplectus pungens* - (*Osmunda regalis* var. *spectabilis*) Herbaceous Vegetation. Tidal oligohaline marshes typically occur between brackish and freshwater marsh zones along maritime rivers and creeks. These marshes can have varying ranges of salinity, depending on geomorphic position and pulses from storm surge or other wind-related events.

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). Lastly, the Mackay Island NWR site was dominated by *Spartina patens, Schoenoplectus pungens* var. *pungens*, and *Juncus roemerianus* (Table 5). Shrub and tree growth forms were not present in any plots of this ecological type.

4.5 Freshwater Tidal Marsh

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). Small-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 17; 1 m^2 nested quadrat was 9.1; 0.1 m^2 nested quadrat was 3.3; and 0.01 m^2 nested quadrat was 1.5. 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

This ecological type was found on seven of the 20 CWEM Sites (Table 3). Six of these were classified to the *Juncus roemerianus* Herbaceous Vegetation association, and the other found at the Lower Suwannee NWR – Dan May Creek site was classified to the *Cladium mariscus* ssp. *jamaicense* Tidal Herbaceous Vegetation association. Brackish marshes typically occur between salt and intermediate (freshwater and oligohaline) marshes, on more elevated positions within the coastal landscape. These marshes can have varying ranges of salinity, depending on geomorphic position and pulses from storm surge. They are often regularly flooded by brackish to oligohaline water.

Most of these sites were often low in species, and dominated by dense stands of *Juncus roemerianus* (Table 6). The exception was the Dan May Creek site at Lower Suwannee NWR. This site was dominated by a moderately dense stand of *Cladium jamaicense* growing with other species such as *Schoenoplectus tabernaemontani*, *Sagittaria lancifolia* var. *lancifolia*, and *Persicaria hydropiperoides*. 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.

4.7 Tidal Salt Marshes

This ecological type was found on five of the 20 CWEM Sites (Table 3). All of these were classified to the *Spartina alterniflora* Carolinian Zone Herbaceous Vegetation association. These tidal marshes occur on regularly flooded low geomorphic positions with moderate salinity levels. There is typically very little species diversity within these sites, and often *Spartina alterniflora* occurs in nearly monospecific stands.

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

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		Pocosin Lakes NWR - Harvester Road Tall Pocosin		Roanoke River NWR - Goodman Island	
	cov	con	cov	con	cov	con
[Glyceria + Leersia]	--	--	--	--	3	100
Acer rubrum var. rubrum	2	67	--	--	5	100
Alnus serrulata	--	--	--	--	2	33
Andropogon glomeratus var. glomeratus	--	--	2	33	--	--
Aralia spinosa	4	67	--	--	--	--
Arisaema triphyllum ssp. pusillum	--	--	--	--	2	33
Aronia arbutifolia	--	--	2	33	--	--
Berchemia scandens	--	--	--	--	2	67
Boehmeria cylindrica	--	--	--	--	2	33
Carex grisea	--	--	--	--	2	33
Carex lupulina	--	--	--	--	3	33
Carex seorsa	--	--	--	--	2	67
Carex stricta	--	--	--	--	5	67
Carpinus caroliniana	--	--	--	--	6	100
Centella erecta	--	--	--	--	2	100
Cephalanthus occidentalis	--	--	--	--	2	33
Cicuta maculata var. maculata	--	--	--	--	2	67
Clematis crispa	--	--	--	--	2	67
Clethra alnifolia	--	--	--	--	4	67
Cornus stricta	--	--	--	--	2	33
Crataegus	--	--	--	--	3	33
Cyrilla racemiflora	--	--	--	--	2	33
Erechtites hieracifolia	--	--	1	33	--	--
Eubotrys racemosa	--	--	--	--	2	33
Fraxinus caroliniana	--	--	--	--	5	100
Fraxinus pennsylvanica	--	--	--	--	7	100
Galium tinctorium	--	--	--	--	2	33
Gelsemium sempervirens	2	100	--	--	--	--

Table 4. Continued.

	Alligator River NWR - Koehring Road Pocosin		Pocosin Lakes NWR - Harvester Road Tall Pocosin		Roanoke River NWR - Goodman Island	
	cov	con	cov	con	cov	con
Gordonia lasianthus	2	67	6	67	--	--
Ilex [coriacea + glabra]	9	100	7	100	--	--
Ilex opaca var. opaca	--	--	--	--	2	33
Ilex verticillata	--	--	--	--	7	100
Iris virginica var. virginica	--	--	--	--	2	33
Itea virginica	--	--	--	--	3	67
Liquidambar styraciflua	--	--	--	--	4	100
Listera australis	2	33	--	--	--	--
Lonicera sempervirens	--	--	--	--	2	33
Ludwigia repens	--	--	--	--	2	67
Lyonia ligustrina var. foliosiflora	--	--	2	33	--	--
Lyonia lucida	4	100	7	100	--	--
Magnolia virginiana var. virginiana	2	67	--	--	--	--
Morella cerifera	--	--	--	--	3	33
Murdannia keisak	--	--	--	--	2	33
Nyssa biflora	--	--	--	--	6	67
Onoclea sensibilis var. sensibilis	--	--	--	--	2	33
Osmunda regalis var. spectabilis	--	--	--	--	2	33
Parthenocissus quinquefolia	2	67	--	--	2	67
Peltandra virginica	--	--	--	--	2	100
Persea palustris	5	100	3	67	3	100
Persicaria arifolia	--	--	--	--	3	100
Persicaria setacea	--	--	--	--	2	100
Pinus serotina	7	100	5	100	--	--
Poa autumnalis	--	--	--	--	2	67
Pteridium aquilinum	--	--	2	67	--	--
Quercus laurifolia	--	--	--	--	6	100
Rhus copallinum var. copallinum	2	67	2	33	--	--
Rubus	2	33	--	--	--	--
Sagittaria [graminea + weatherbiana]	--	--	--	--	2	67

Table 4. Continued.

	Alligator River NWR - Koehring Road Pocosin		Pocosin Lakes NWR - Harvester Road Tall Pocosin		Roanoke River NWR - Goodman Island	
	cov	con	cov	con	cov	con
Sagittaria latifolia var. latifolia	--	--	--	--	2	33
Sassafras albidum	4	100	--	--	--	--
Saururus cernuus	--	--	--	--	4	100
Smilax glauca	2	33	2	33	--	--
Smilax laurifolia	5	100	4	67	2	67
Smilax walteri	--	--	--	--	4	100
Taxodium distichum	--	--	--	--	2	33
Thalictrum pubescens var. pubescens	--	--	--	--	2	33
Tillandsia usneoides	--	--	--	--	2	33
Toxicodendron radicans var. radicans	3	100	--	--	4	100
Ulmus americana var. americana	--	--	--	--	3	100
Vaccinium formosum	--	--	5	100	--	--
Vaccinium fuscatum	3	67	--	--	2	33
Viburnum recognitum	--	--	--	--	2	33
Viola esculenta	--	--	--	--	2	100
Vitis rotundifolia var. rotundifolia	3	100	--	--	--	--
Woodwardia areolata	2	67	--	--	--	--
Woodwardia virginica	2	100	2	33	--	--

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
Alnus serrulata	--	--	--	--	--	--	--	--	3	33
Alternanthera philoxeroides	--	--	--	--	--	--	--	--	6	100
Amaranthus cannabinus	--	--	--	--	--	--	--	--	2	100
Apios americana	--	--	--	--	--	--	--	--	3	100
Baccharis halimifolia	--	--	--	--	--	--	--	--	2	33
Bidens coronata	--	--	--	--	--	--	--	--	3	67
Boehmeria cylindrica	--	--	--	--	--	--	--	--	2	100
Borrichia frutescens	--	--	--	--	--	--	2	33	--	--
Centella erecta	--	--	2	33	2	67	2	67	--	--
Cicuta maculata var. maculata	--	--	--	--	--	--	--	--	3	67
Cinna arundinacea	--	--	--	--	--	--	--	--	2	67
Cuscuta compacta	--	--	--	--	--	--	--	--	4	100
Cyperaceae	--	--	--	--	2	67	--	--	--	--
Cyperus pseudovegetus	--	--	--	--	--	--	2	67	--	--
Eleocharis	--	--	--	--	2	67	--	--	--	--
Erechtites hieracifolia	--	--	--	--	--	--	--	--	2	67
Eupatorium capillifolium	--	--	2	33	--	--	--	--	--	--
Fimbristylis castanea	--	--	--	--	2	33	--	--	--	--
Fraxinus pennsylvanica	--	--	--	--	--	--	--	--	2	33
Galium tinctorium	--	--	2	67	2	100	--	--	3	100
Habenaria repens	--	--	--	--	--	--	--	--	2	33
Hibiscus moscheutos	--	--	2	33	2	100	--	--	2	33
Impatiens capensis	--	--	--	--	--	--	--	--	2	100
Ipomoea	--	--	--	--	--	--	2	33	--	--
Juncus roemerianus	--	--	9	100	6	67	--	--	--	--
Kosteletzkya virginica	--	--	--	--	--	--	--	--	2	100
Ludwigia	--	--	2	33	--	--	--	--	2	33
Ludwigia palustris	--	--	--	--	2	100	--	--	--	--
Ludwigia peruviana	--	--	--	--	--	--	--	--	5	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
Lycopus virginicus	--	--	--	--	--	--	--	--	2	100
Mikania scandens	--	--	2	33	2	67	--	--	3	100
Murdannia keisak	--	--	--	--	--	--	--	--	5	100
Onoclea sensibilis var. sensibilis	--	--	--	--	--	--	--	--	3	67
Orontium aquaticum	--	--	--	--	--	--	--	--	2	67
Osmunda regalis var. spectabilis	--	--	--	--	2	33	--	--	--	--
Peltandra virginica	6	100	--	--	--	--	--	--	3	100
Persicaria arifolia	--	--	--	--	--	--	--	--	4	100
Persicaria hydropiperoides	--	--	--	--	--	--	--	--	2	100
Persicaria pensylvanica	--	--	2	67	2	100	--	--	--	--
Persicaria punctata	--	--	--	--	--	--	5	100	--	--
Persicaria sagittata	--	--	--	--	--	--	--	--	3	100
Persicaria setacea	--	--	--	--	--	--	--	--	2	67
Phragmites australis ssp. australis	--	--	6	67	--	--	--	--	--	--
Phyla lanceolata	--	--	--	--	--	--	--	--	2	67
Pluchea camphorata	2	67	--	--	--	--	--	--	--	--
Pontederia cordata	6	100	--	--	--	--	3	100	3	67
Proserpinaca palustris var. palustris	--	--	--	--	--	--	--	--	2	33
Ptilimnium capillaceum	--	--	--	--	--	--	--	--	4	100
Sacciolepis striata	--	--	--	--	--	--	--	--	2	67
Sagittaria graminea	2	67	--	--	--	--	--	--	--	--
Sagittaria lancifolia var. media	6	100	--	--	2	100	2	100	--	--
Salix caroliniana	--	--	--	--	--	--	--	--	3	33
Samolus parviflorus	--	--	2	33	--	--	--	--	--	--
Saururus cernuus	--	--	--	--	--	--	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
Schoenoplectus pungens var. pungens	--	--	2	33	8	100	--	--	--	--
Schoenoplectus tabernaemontani	6	100	--	--	--	--	6	100	4	100
Spartina alterniflora	--	--	2	33	2	33	--	--	--	--
Spartina cynosuroides	4	100	--	--	--	--	--	--	--	--
Spartina patens	--	--	--	--	7	100	--	--	--	--
Symphyotrichum elliottii	--	--	--	--	--	--	--	--	3	100
Symphyotrichum tenuifolium	5	100	--	--	--	--	--	--	--	--
Thelypteris palustris var. pubescens	--	--	--	--	2	33	--	--	--	--
Triadenum walteri	--	--	--	--	--	--	--	--	2	33
Typha angustifolia	2	67	2	33	2	100	--	--	--	--
Typha domingensis	--	--	--	--	--	--	--	--	3	100
Typha latifolia	--	--	--	--	--	--	7	100	--	--
Zizania aquatica	--	--	--	--	--	--	--	--	6	100
Zizaniopsis miliacea	9	100	--	--	--	--	7	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		Cedar Island NWR - West Marsh		Harris Neck NWR - Harris Neck Creek		Lower Suwannee NWR - Dan May 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
Borrichia frutescens	--	--	--	--	--	--	--	--	--	--	--	--	3	100	--	--	--	--	--	--	--	--	--	--
Cladium jamaicense	--	--	--	--	--	--	--	--	8	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Distichlis spicata	--	--	--	--	2	100	--	--	--	--	--	--	--	--	--	--	2	33	--	--	--	--	--	--
Eupatorium mikanioides	--	--	--	--	--	--	--	--	2	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Juncus roemerianus	9	100	--	--	9	100	2	67	--	--	9	100	9	100	--	--	9	100	9	100	--	--	--	--
Ludwigia repens	--	--	--	--	--	--	--	--	2	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lythrum lineare	--	--	--	--	--	--	--	--	2	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Persicaria hydropiperoides	--	--	--	--	--	--	--	--	2	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Phragmites australis ssp. australis	5	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pluchea camphorata	--	--	--	--	--	--	--	--	2	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sagittaria graminea	--	--	--	--	--	--	--	--	2	67	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sagittaria lancifolia var. lancifolia	--	--	--	--	--	--	--	--	4	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Salicornia bigelovii	6	33	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Schoenoplectus tabernaemontani	--	--	--	--	--	--	--	--	4	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Solidago sempervirens var. mexicana	--	--	--	--	2	67	2	33	--	--	--	--	--	--	--	--	2	100	--	--	--	--	--	--
Spartina alterniflora	6	67	7	100	2	67	7	100	--	--	5	67	--	--	7	100	--	--	--	--	7	100	7	100
Spartina patens	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	100	--	--	--	--

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				Pocosin Lakes NWR - Harvester Road Tall Pocosin				Roanoke River NWR - Goodman 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)	Count (mean)	Count (St Dev)	BA (mean)	BA (St Dev)
Acer rubrum var. rubrum	--	--	--	--	--	--	--	--	9.7	10.3	2.12	1.33	--	--	--	--
Alnus serrulata	--	--	--	--	--	--	--	--	--	--	--	--	5.0	8.7	0.58	1.00
Aralia spinosa	19.7	17.0	0.55	0.49	--	--	--	--	--	--	--	--	--	--	--	--
Aronia arbutifolia	--	--	--	--	1.7	2.9	0.00	0.01	--	--	--	--	--	--	--	--
Baccharis halimifolia	--	--	--	--	--	--	--	--	--	--	--	--	1.0	1.7	0.02	0.04
Berchemia scandens	--	--	--	--	--	--	--	--	0.7	1.2	0.01	0.02	--	--	--	--
Carpinus caroliniana	--	--	--	--	--	--	--	--	38.7	52.0	3.03	4.61	--	--	--	--
Cephalanthus occidentalis	--	--	--	--	--	--	--	--	2.0	3.5	0.06	0.11	--	--	--	--
Clethra alnifolia	--	--	--	--	--	--	--	--	3.7	4.7	0.04	0.06	--	--	--	--
Crataegus	--	--	--	--	--	--	--	--	1.0	1.7	0.05	0.08	--	--	--	--
Eubotrys racemosa	--	--	--	--	--	--	--	--	1.3	2.3	0.00	0.00	--	--	--	--
Fraxinus caroliniana	--	--	--	--	--	--	--	--	3.7	4.6	0.53	0.61	--	--	--	--
Fraxinus pennsylvanica	--	--	--	--	--	--	--	--	12.3	9.7	16.88	6.82	0.3	0.6	0.01	0.01
Gelsemium sempervirens	11.7	2.9	0.02	0.01	--	--	--	--	--	--	--	--	--	--	--	--
Gordonia lasianthus	--	--	--	--	30.7	28.7	1.35	1.47	--	--	--	--	--	--	--	--
Ilex [coriacea + glabra]	635.0	181.7	10.86	2.37	156.0	124.7	0.46	0.15	--	--	--	--	--	--	--	--
Ilex opaca var. opaca	--	--	--	--	--	--	--	--	0.3	0.6	0.00	0.00	--	--	--	--
Ilex verticillata	--	--	--	--	--	--	--	--	10.3	9.3	0.36	0.48	--	--	--	--
Itea virginica	--	--	--	--	--	--	--	--	10.0	11.8	0.10	0.11	--	--	--	--
Liquidambar styraciflua	--	--	--	--	--	--	--	--	2.0	1.0	2.32	0.95	--	--	--	--
Lyonia lucida	13.3	23.1	0.03	0.05	37.7	49.8	0.07	0.10	--	--	--	--	--	--	--	--
Morella cerifera	--	--	--	--	--	--	--	--	1.3	2.3	0.05	0.08	--	--	--	--
Nyssa biflora	--	--	--	--	--	--	--	--	1.3	1.5	12.89	12.89	--	--	--	--
Parthenocissus quinquefolia	1.7	2.9	0.00	0.01	--	--	--	--	0.7	1.2	0.00	0.00	--	--	--	--
Persea palustris	22.0	28.2	1.04	0.72	3.7	5.5	0.01	0.01	4.3	6.7	0.19	0.31	--	--	--	--
Pinus serotina	2.3	1.2	21.91	12.39	16.3	24.9	1.21	1.22	--	--	--	--	--	--	--	--
Quercus laurifolia	--	--	--	--	--	--	--	--	3.3	3.5	3.56	3.08	--	--	--	--
Rhus copallinum var. copallinum	1.7	2.9	0.04	0.07	0.7	1.2	0.00	0.00	--	--	--	--	--	--	--	--
Salix caroliniana	--	--	--	--	--	--	--	--	--	--	--	--	1.0	1.7	0.08	0.14
Sassafras albidum	4.0	2.0	0.41	0.32	--	--	--	--	--	--	--	--	--	--	--	--
Smilax glauca	3.3	5.8	0.01	0.01	--	--	--	--	--	--	--	--	--	--	--	--
Smilax laurifolia	125.0	54.1	0.69	0.42	30.0	43.6	0.10	0.15	2.0	2.0	0.00	0.00	--	--	--	--
Smilax walteri	--	--	--	--	--	--	--	--	24.7	15.0	0.05	0.03	--	--	--	--
Toxicodendron radicans var. radicans	1.7	2.9	0.00	0.01	--	--	--	--	4.3	3.8	0.02	0.03	--	--	--	--
Ulmus americana var. americana	--	--	--	--	--	--	--	--	1.0	1.0	2.01	1.85	--	--	--	--
Vaccinium formosum	--	--	--	--	23.3	36.2	0.05	0.07	--	--	--	--	--	--	--	--
Vaccinium fuscatum	8.3	14.4	0.20	0.35	--	--	--	--	1.3	2.3	0.01	0.02	--	--	--	--
Vitis rotundifolia var. rotundifolia	10.0	0.0	0.06	0.06	--	--	--	--	--	--	--	--	--	--	--	--

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*
Cladium mariscus ssp. *jamaicense* Tidal Herbaceous Vegetation	0.4 (0.25 -0.75)	1.3 (1.25 -1.5)	2.2 (2 -2.5)	3.5 (3 -4.25)	6.3 (5 -8)
Ilex glabra - Lyonia lucida - Zenobia pulverulenta Shrubland	0.5 (0.25 -0.75)	1.3 (1.25 -1.25)	2.2 (1.5 -3)	4.9 (4.25 -5.75)	9.0 (7 -12)
Juncus roemerianus - Pontederia cordata Herbaceous Vegetation	1.2 (1 -1.5)	1.3 (1 -1.5)	2.1 (1 -3.25)	2.7 (1.5 -3.75)	6.0 (3 -10)
Juncus roemerianus Herbaceous Vegetation	1.0 (0.25 -2)	1.3 (1 -2)	1.6 (1 -2.5)	1.7 (1 -2.5)	2.3 (1 -4)
Pinus serotina / Ilex glabra / Woodwardia virginica Woodland	0.1 (0 -0.25)	1.2 (0.75 -1.75)	3.1 (2 -3.75)	9.1 (7 -10.5)	16.3 (13 -21)
Schoenoplectus pungens - (*Osmunda regalis* var. *spectabilis)* Herbaceous Vegetation	1.6 (1 -2)	2.6 (2 -3)	4 (3.5 -5)	6.9 (5.75 -8.25)	12.7 (11 -16)
Spartina alterniflora Carolinian Zone Herbaceous Vegetation	0.8 (0.25 -1)	0.99 (0.75 -1)	1.0 (1 -1.25)	1.1 (1 -1.5)	1.2 (1 -3)
Taxodium distichum - Nyssa aquatica - Nyssa biflora / Fraxinus caroliniana / Itea virginica Forest	0.5 (0.25 -0.75)	2 (1.75 -2.25)	4.2 (3.25 -5.5)	13.7 (11 -17.75)	**34.3 (27 -47)**
Zizania aquatica Tidal Herbaceous Vegetation	**1.5 (0.75 -2)**	**3.3 (2 -4.5)**	**9.1 (8.25 -10.25)**	**17.0 (15.75 -18.75)**	31.0 (29 -34)
Zizaniopsis miliacea Tidal Herbaceous Vegetation	1.1 (0.5 -1.5)	3.1 (2.5 -4)	5.3 (4.25 -6.25)	6.8 (5 -7.75)	8.7 (6 -10)

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 (pocosins and pond pine woodlands), 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.

This dataset currently serves as a "baseline at year 2013" inventory 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.

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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: 7 August 2013

Alligator River NWR – Koehring Road Pocosin

Sample Date: 1 May 2013

Alligator River NWR – Long Shoal River

Sample Date: 17 July 2013

Blackbeard Island NWR – Blackbeard Creek

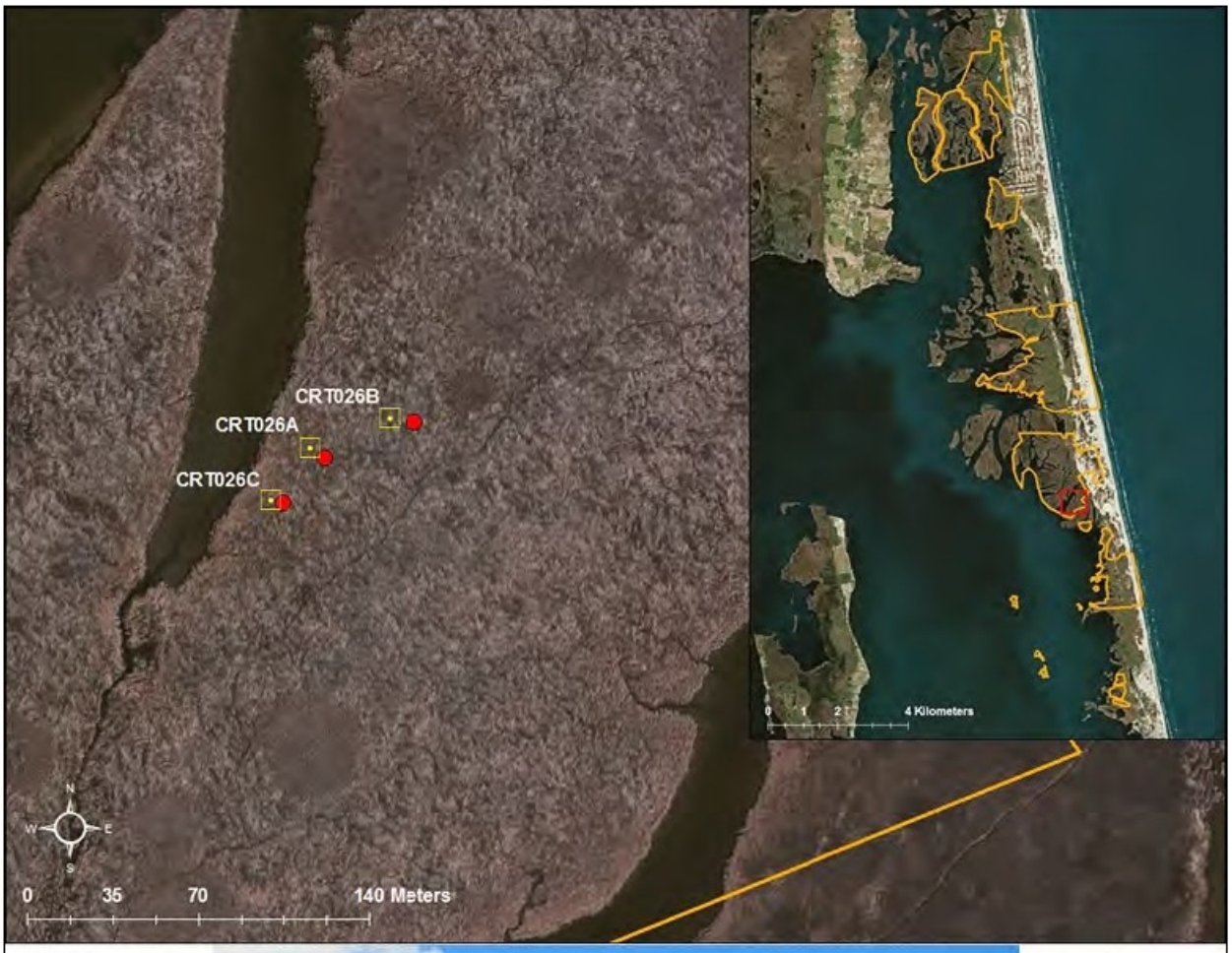
Sample Date: 27 June 2013

Cedar Island NWR – West Marsh

Sample Date: 3 May 2013

Currituck NWR – Swan Island

Sample Date: 8 May 2013



Harris Neck NWR – Harris Neck Creek

Sample Date: 18 June 2013

Lower Suwannee NWR – Dan May Creek

Sample Date: 26 August 2013

Lower Suwannee NWR – Shired Creek

Sample Date: 27 August 2013

Mackay Island NWR – Great Marsh

Sample Date: 9 May 2013

Pea Island NWR – South Pea Island Marsh

Sample Date: 2 May 2013

Pinckney Island NWR – Mackay Creek

Sample Date: 21 May 2013

Pocosin Lakes NWR – Harvester Road Tall Pocosin

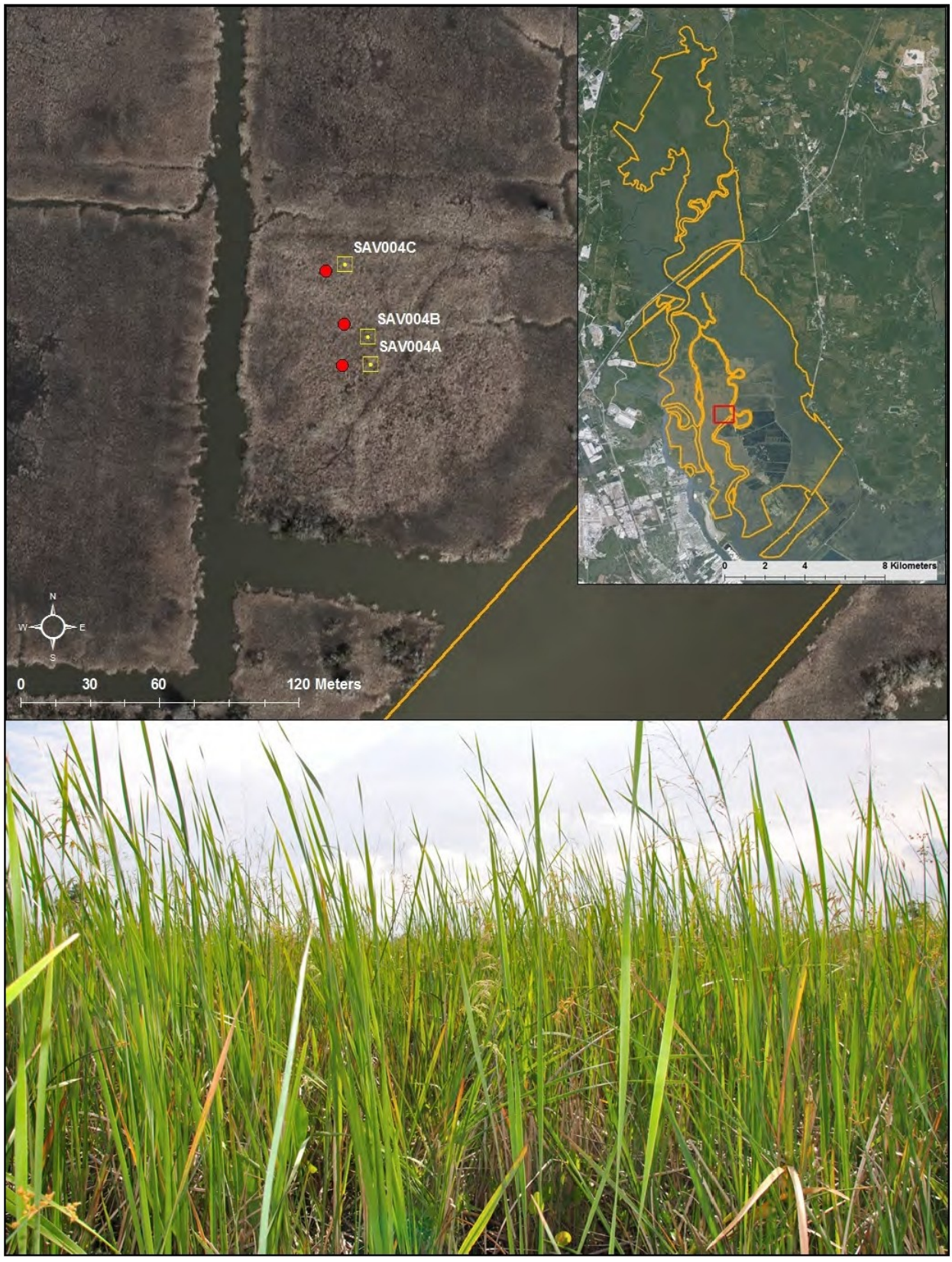
Sample Date: 30 April 2013

Roanoke River NWR –Goodman Island

Sample Date: 29 April 2013

Savannah NWR – Little Back River

Sample Date: 21 May 2013



St.Marks NWR – Goose Creek Bay

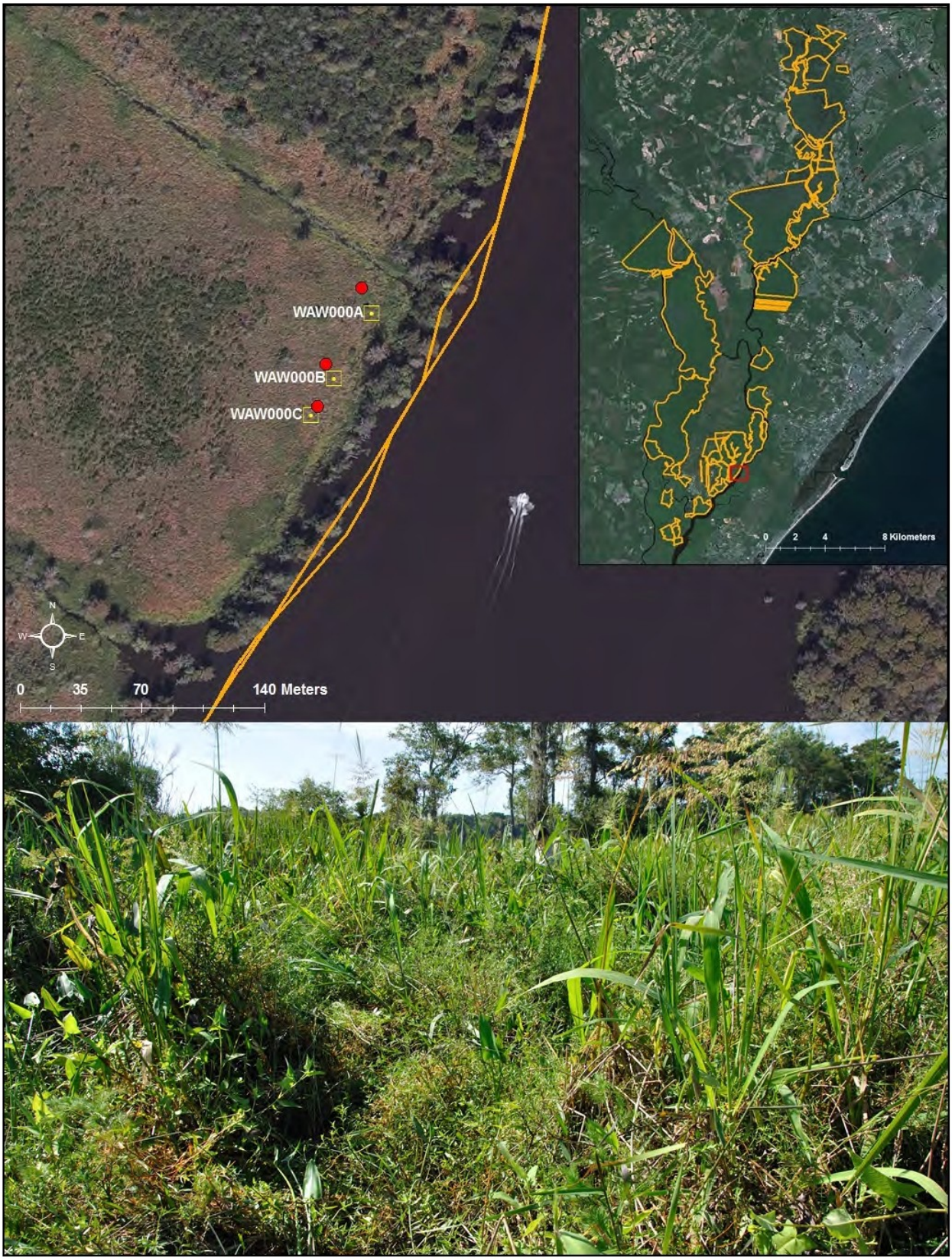
Sample Date: 12 August 2013

Swanquarter NWR – Juniper Bay Marsh

Sample Date: 16 May 2013

Waccamaw NWR – Sandy Island Marsh

Sample Date: 6 September 2013

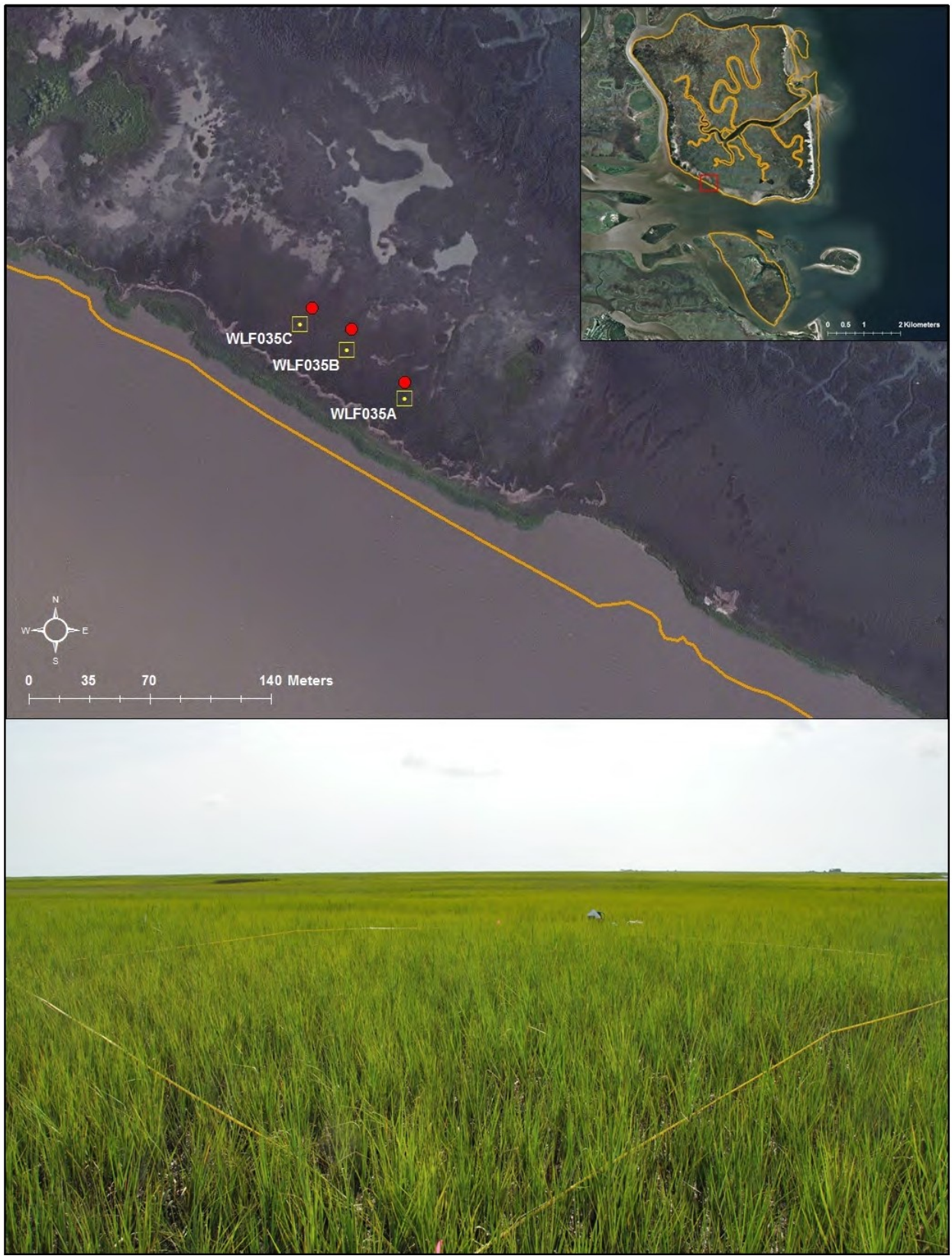


Wassaw NWR – Wassaw Creek

Sample Date: 26 June 2013

Wolf Island NWR – Altamaha Sound

Sample Date: 6 August 2013



Appendix 2. List of vascular plants detected and frequency of occurrence within the 60 CWEM Site vegetation plots in the SALCC Geography in the spring and summer 2013. Scientific names follow Weakley's (2012) Flora of the Southern and Mid-Atlantic States. Alien species are marked with an asterisk.

Family	Scientific Name	Common Name	Frequency
Adoxaceae	*Viburnum recognitum*	Smooth arrow-wood	1
Alismataceae	*Sagittaria [graminea + weatherbiana]*	Grassy arrowhead + Weatherby's arrowhead	2
Alismataceae	*Sagittaria graminea*	Grassy arrowhead	4
Alismataceae	*Sagittaria lancifolia var. lancifolia*	Bulltongue arrowhead	3
Alismataceae	*Sagittaria lancifolia var. media*	Bulltongue arrowhead	9
Alismataceae	*Sagittaria latifolia var. latifolia*	Broadleaf arrowhead	1
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	3
Anacardiaceae	*Toxicodendron radicans var. radicans*	Eastern poison ivy	6
Apiaceae	*Centella erecta*	Coinleaf	8
Apiaceae	*Cicuta maculata var. maculata*	Water-hemlock	4
Apiaceae	*Ptilimnium capillaceum*	Eastern bishopweed	3
Aquifoliaceae	*Ilex [coriacea + glabra]*	Gallberry	6
Aquifoliaceae	*Ilex opaca var. opaca*	American holly	1
Aquifoliaceae	*Ilex verticillata*	Winterberry	3
Araceae	*Arisaema triphyllum ssp. pusillum*	Small jack-in-the-pulpit	1
Araceae	*Orontium aquaticum*	Golden club	2
Araceae	*Peltandra virginica*	Green arrow-arum	9
Araliaceae	*Aralia spinosa*	Devil's-walking-stick	2
Asteraceae	*Baccharis halimifolia*	Silverling	1
Asteraceae	*Bidens coronata*	Northern tickseed-sunflower	2
Asteraceae	*Borrichia frutescens*	Seaside oxeye	4
Asteraceae	*Erechtites hieracifolia*	Fireweed	3
Asteraceae	*Eupatorium capillifolium*	Common dog-fennel	1
Asteraceae	*Eupatorium mikanioides*	Semaphore thoroughwort	1
Asteraceae	*Mikania scandens*	Climbing hempweed	6
Asteraceae	*Pluchea camphorata*	Camphorweed	4
Asteraceae	*Solidago sempervirens var. mexicana*	Southern seaside goldenrod	6
Asteraceae	*Symphyotrichum elliottii*	Southern swamp aster	3
Asteraceae	*Symphyotrichum tenuifolium*	Perennial salt-marsh aster	3
Balsaminaceae	*Impatiens capensis*	Orange jewelweed	3
Betulaceae	*Alnus serrulata*	Tag alder	2
Betulaceae	*Carpinus caroliniana*	American hornbeam	3
Blechnaceae	*Woodwardia areolata*	Netted chain fern	2
Blechnaceae	*Woodwardia virginica*	Virginia chain fern	4
Bromeliaceae	*Tillandsia usneoides*	Spanish-moss	1
Caprifoliaceae	*Lonicera sempervirens*	Coral honeysuckle	1
Chenopodiaceae	*Salicornia bigelovii*	Dwarf glasswort	1
Clethraceae	*Clethra alnifolia*	Coastal sweet-pepperbush	2
Commelinaceae	*Murdannia keisak**	Murdannia*	4
Convolvulaceae	*Cuscuta compacta*	Compact dodder	3
Convolvulaceae	*Ipomoea*	Morning-glory	1
Cornaceae	*Cornus stricta*	Southern swamp dogwood	1
Cupressaceae	*Taxodium distichum*	Bald-cypress	1

Family	Scientific Name	Common Name	Frequency
Cyperaceae	*Carex grisea*	Inflated narrow-leaf sedge	1
Cyperaceae	*Carex lupulina*	Hop sedge	1
Cyperaceae	*Carex seorsa*	Weak stellate sedge	2
Cyperaceae	*Carex stricta*	Upright sedge	2
Cyperaceae	*Cladium jamaicense*	Sawgrass	3
Cyperaceae	*Cyperaceae*	Sedge	2
Cyperaceae	*Cyperus pseudovegetus*	Marsh flatsedge	2
Cyperaceae	*Eleocharis*	Spikerush	2
Cyperaceae	*Fimbristylis castanea*	Marsh fimbry	1
Cyperaceae	*Schoenoplectus pungens var. pungens*	Common threesquare	4
Cyperaceae	*Schoenoplectus tabernaemontani*	Softstem bulrush	12
Cyrillaceae	*Cyrilla racemiflora*	Ti-ti	1
Dennstaedtiaceae	*Pteridium aquilinum*	Bracken fern	2
Dryopteridaceae	*Onoclea sensibilis var. sensibilis*	Sensitive fern	3
Ericaceae	*Eubotrys racemosa*	Coastal fetterbush	1
Ericaceae	*Lyonia ligustrina var. foliosiflora*	Southern maleberry	1
Ericaceae	*Lyonia lucida*	Shining fetterbush	6
Ericaceae	*Vaccinium formosum*	Southern highbush blueberry	3
Ericaceae	*Vaccinium fuscatum*	Hairy highbush blueberry	3
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	1
Hypericaceae	*Triadenum walteri*	Marsh St.-John's-wort	1
Iridaceae	*Iris virginica var. virginica*	Southern blue flag	1
Iteaceae	*Itea virginica*	Virginia-willow	2
Juncaceae	*Juncus roemerianus*	Black needle rush	25
Lamiaceae	*Lycopus virginicus*	Virginia bugleweed	3
Lauraceae	*Persea palustris*	Swamp bay	8
Lauraceae	*Sassafras albidum*	Sassafras	3
Lythraceae	*Lythrum lineare*	Narrowleaf loosestrife	1
Magnoliaceae	*Magnolia virginiana var. virginiana*	Northern sweet bay	2
Malvaceae	*Hibiscus moscheutos*	Eastern rose-mallow	5
Malvaceae	*Kosteletzkya virginica*	Seashore-mallow	3
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*	Water-primrose	2
Onagraceae	*Ludwigia palustris*	Common water-primrose	3
Onagraceae	*Ludwigia peruviana**	Primrose-willow*	1
Onagraceae	*Ludwigia repens*	Creeping seedbox	4
Orchidaceae	*Habenaria repens*	Water-spider orchid	1
Orchidaceae	*Listera australis*	Southern twayblade	1
Osmundaceae	*Osmunda regalis var. spectabilis*	Royal fern	2
Pinaceae	*Pinus serotina*	Pond pine	6

Family	Scientific Name	Common Name	Frequency
Poaceae	*[Glyceria + Leersia]*	Mannagrass + Cutgrass	3
Poaceae	*Andropogon glomeratus var. glomeratus*	Bushy bluestem	1
Poaceae	*Cinna arundinacea*	Common woodreed	2
Poaceae	*Distichlis spicata*	Saltgrass	4
Poaceae	*Phragmites australis ssp. australis**	Common reed*	4
Poaceae	*Poa autumnalis*	Autumn bluegrass	2
Poaceae	*Sacciolepis striata*	American cupscale	2
Poaceae	*Spartina alterniflora*	Saltmarsh cordgrass	23
Poaceae	*Spartina cynosuroides*	Giant cordgrass	3
Poaceae	*Spartina patens*	Saltmeadow cordgrass	6
Poaceae	*Zizania aquatica*	Southern wild-rice	3
Poaceae	*Zizaniopsis miliacea*	Giant cutgrass	9
Polygonaceae	*Persicaria arifolia*	Heart-leaf tearthumb	6
Polygonaceae	*Persicaria hydropiperoides*	Waterpepper	5
Polygonaceae	*Persicaria pensylvanica*	Pinkweed	5
Polygonaceae	*Persicaria punctata*	Dotted smartweed	3
Polygonaceae	*Persicaria sagittata*	Arrowleaf tearthumb	3
Polygonaceae	*Persicaria setacea*	Swamp smartweed	5
Pontederiaceae	*Pontederia cordata*	Pickerelweed	8
Ranunculaceae	*Clematis crispa*	Southern leatherflower	2
Ranunculaceae	*Thalictrum pubescens var. pubescens*	Common tall meadowrue	1
Rhamnaceae	*Berchemia scandens*	Supplejack	2
Rosaceae	*Aronia arbutifolia*	Red chokeberry	1
Rosaceae	*Crataegus*	Hawthorn	1
Rosaceae	*Rubus*	Blackberry	1
Rubiaceae	*Cephalanthus occidentalis*	Buttonbush	1
Rubiaceae	*Galium tinctorium*	Three-lobed bedstraw	9
Salicaceae	*Salix caroliniana*	Carolina willow	1
Samolaceae	*Samolus parviflorus*	Water-pimpernel	1
Sapindaceae	*Acer rubrum var. rubrum*	Eastern red maple	5
Saururaceae	*Saururus cernuus*	Lizard's-tail	4
Smilacaceae	*Smilax glauca*	Whiteleaf greenbrier	2
Smilacaceae	*Smilax laurifolia*	Blaspheme-vine	7
Smilacaceae	*Smilax walteri*	Coral greenbrier	3
Theaceae	*Gordonia lasianthus*	Loblolly bay	4
Thelypteridaceae	*Thelypteris palustris var. pubescens*	Marsh fern	1
Typhaceae	*Typha angustifolia*	Narrowleaf cattail	6
Typhaceae	*Typha domingensis*	Southern cattail	3
Typhaceae	*Typha latifolia*	Common cattail	3
Ulmaceae	*Ulmus americana var. americana*	American elm	3
Urticaceae	*Boehmeria cylindrica*	False-nettle	4
Verbenaceae	*Phyla lanceolata*	Marsh frogfruit	2
Violaceae	*Viola esculenta*	Violet	3
Vitaceae	*Parthenocissus quinquefolia*	Virginia-creeper	4
Vitaceae	*Vitis rotundifolia var. rotundifolia*	Muscadine	3