



Monitoring Salt Marsh Vegetation at Colonial National Historical Park

2010 Summary Report

Natural Resource Data Series NPS/NCBN/NRDS—2010/120



ON THE COVER

Prevalence of *Peltandra virginica* and *Zizania aquatic* in a salt marsh (marsh 8) on Jamestown Island, Colonial National Historical Park.

Photograph by: Robin Baranowski

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Executive Summary

The Northeast Coastal and Barrier Network (NCBN) is one of 32 networks of parks created by the National Park Service (NPS) Inventory and Monitoring Program (I&M Program). The I&M Program has two components, 1) to collect baseline ecological inventory datasets and 2) to implement *Vital Signs* monitoring, a long-term ecological monitoring program, in each of the 32 networks. The Northeast Coastal and Barrier Network consists of eight parks linked by geography and shared ecological characteristics along the Northeastern Atlantic Coast. As part of the I&M Program, each network has developed detailed protocols for monitoring a select number of Vital Signs, or ecological indicators. Because the majority of parks in the NCBN are coastal parks, salt marsh monitoring was chosen as a high priority and a protocol was developed for collecting long-term data on salt marsh vegetation (James-Pirri and Roman in Review). The objective of monitoring salt marsh vegetation is to identify long-term trends in community structure, and to provide resource managers with a better understanding of the current status and condition of the salt marsh resources they manage.

The NCBN protocol for monitoring salt marsh vegetation was first implemented at Colonial National Historical Park (COLO) in Virginia during the summer of 2008. This report summarizes the vegetation data collected at COLO in 2010, and includes a brief discussion of observed differences in species composition between 2008 and 2010. Changes in vegetation data between sampling years should not be considered indicative of a significant change in the salt marsh plant community at COLO. Because new plot locations are randomly selected each sampling year, substantial inter-annual variability is to be expected. Long-term monitoring of salt marsh vegetation is necessary in order to distinguish between inter-annual variability and significant changes in the vegetation community.

The percent cover of each vegetation species and non-vegetation cover type within each 1m² plot was visually estimated using a revised Braun-Blanquet method (Kent and Coker 1992). Fifty or more vegetation plots were sampled for vegetation at three marshes in July of 2010. Sampling at a fourth site was attempted (only four vegetation plots were sampled); however, extreme heat and difficulties accessing this site prevented the crew from completing the data collection. A total of 29 vegetation species and 3 non-vegetation cover types were recorded in 2010. Non-vegetation cover types recorded included wrack and litter, bare ground, and water. One of the observed species, *Phragmites australis*, is listed as a highly invasive species in the state of Virginia (Virginia Department of Conservation and Recreation 2009).

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Introduction

National Park Service (NPS) managers need accurate information about how, when and why natural systems change over time in order to make sound management decisions. To address this need, the NPS initiated natural resource monitoring through the Natural Resource Challenge funded by Congress in 2000. The Inventory and Monitoring Program (I&M), the key component of this effort, organizes 270 park units into 32 networks tasked with conducting long-term ecological monitoring. Networks were required to develop a monitoring plan addressing the implementation of long-term monitoring of key ecological indicators or “vital signs.” Vital signs are defined as measurable, early warning signals that may indicate change in the long-term health of natural systems. Early detection of potential problems allows park managers to take steps in restoring or maintaining ecological health of park resources.

The Northeast Coastal and Barrier Network (NCBN) is made up of eight parks: Assateague Island National Seashore (ASIS, coastal Maryland and Virginia), Thomas Stone National Historic Site (THST, Charles County, MD), Cape Cod National Seashore (CACO, Cape Cod, MA), Gateway National Recreation Area (GATE, New York, NY and Sandy Hook, NJ), Fire Island National Seashore (FIIS, Long Island, NY), Sagamore Hill National Historic Site (SAHI, Oyster Bay, NY), Colonial National Historical Park (COLO, Virginia Peninsula), and George Washington Birthplace National Monument (GEWA, Westmoreland County, VA). Vital Signs chosen as part of the Network’s monitoring plan include salt marsh vegetation communities, nekton communities, essential estuarine water quality parameters and specific coastal geomorphologic features (Stevens et al. 2005). Detailed monitoring protocols have been developed and implemented in the eight parks. This annual report summarizes salt marsh vegetation data collected at Colonial National Historical Park (COLO) in 2010 according to the protocol developed by James-Pirri and Roman (In Review), *Monitoring Vegetation in Salt Marshes: A Protocol for the National Park Service’s Long-Term Monitoring Program, Northeast Coastal and Barrier Network*.

The objective of salt marsh vegetation monitoring is to identify long-term trends in the vegetation community structure, which will provide a better understanding of the current status and condition of salt marsh within the parks. Because salt marshes are located in coastal areas and many of the plant species are sensitive to subtle changes in soil salinity and saturation, changes in the percent cover and prevalence of some species will be important primary indicators of change in salt marsh condition. Trends in the percent cover and prevalence of bare ground and water will also provide information about changes in the overall condition of the salt marsh and whether or not it may transition to mud flat due to climate change (*e.g.*, sea level rise, changes in temperature). Long-term monitoring data will provide park managers with the scientific data they need to make informed decisions regarding the management and continued protection of this rare and valuable coastal resource.

Methods

Permanent Site Selection

Four permanent 5-8 hectare salt marsh sites were selected for monitoring at COLO (Figure 1). The number of sites chosen within the park was based on available habitat and the logistics and feasibility of sampling. Marsh sites were chosen randomly from all salt marsh within a park, so that statistical inference could be extended to the entire park. Detailed information about the site selection process and sampling design can be found in *Monitoring Vegetation in Salt Marshes: A Protocol for the National Park Service's Long-Term Monitoring Program, Northeast Coastal and Barrier Network* (James-Pirri and Roman in Review). Due to difficulties accessing these four locations, it is likely that new monitoring sites will be selected for 2012.

Vegetation sampling is conducted biennially. At this time, nekton monitoring is not being implemented at COLO marsh sites. We hope to expand the COLO monitoring plan to include nekton monitoring in the future.



Figure 1. Locations of vegetation monitoring sites established by NCBN at Colonial National Historical Park (COLO). These four sites were sampled in 2008 and 2010. Due to difficulties accessing these locations, it is likely that new monitoring sites will be selected for 2012.

Vegetation Plot Selection and Data Collection

Vegetation was sampled in 1 m² plots randomly located within each marsh. Transects—extending from creek bank to upland—were systematically placed throughout the site based on a single random start. Plots were then randomly located by treating all transects as a single transect and randomly selecting approximately 50 points along this total length. This combination of systematic transects and replicate plots is necessary to ensure interspersed plots throughout the marsh study area, thus providing a representative sample of all salt marsh communities (*e.g.*, low marsh, high marsh).

Vegetation sampling was conducted at COLO in July of 2010. At three of the sites, 50-52 randomly located 1 m² plots were sampled. At a fourth marsh, only four plots were sampled due to difficulties accessing the area. Each plot was visited once during the summer (Table 1). For each plot, all vegetation species and non-vegetation cover types were recorded (Table 2), and the estimated percent cover was visually estimated using a modified Braun-Blanquet cover scale (0: 0%; 1: <1%; 2: 1-5%; 3: 6-25%; 4: 26-50%; 5: 51-75%; 6: 76-100%), (Kent and Coker 1992).

Table 1. Sampling dates and total number of vegetation plots sampled at four marsh sites at COLO in 2010. Due to extremely difficult conditions it was not possible to complete sampling of site 6. Sampling was discontinued after four plots were sampled.

Site	Dates	Total
1	July 21, July 23	52
5	July 20	52
6	July 28	4
8	July 21, July 23	50

Table 2. Definition of standard cover type categories used in the Northeast Coastal and Barrier Network salt marsh vegetation monitoring protocol (James-Pirri and Roman in Review).

Live vascular plants	(herbaceous and shrubs) identified by species.
Standing non-living vascular plants	Identified by species (e.g., <i>S. alterniflora</i> Not Living). This category only includes standing dead (attached) plants that are from a previous year's growth. There may be some dead leaves from this year's growth (e.g., the ends of leaves or leaves that are being replaced by new growth, etc.). In cases where dead leaves are from the current growing season, plant cover is recorded as live.
Macroalgae	Identified by species. This category generally includes the rockweeds (e.g., <i>Fucus</i> , <i>Ascophyllum</i>). Microalgae (e.g., diatom mats) and fine filamentous algae are not included in this category.
Bare ground	Includes mud, sand, microalgae cover, etc. These are areas that are not flooded with water and are devoid of standing live, standing dead, or macroalgae. There can be a thin film of surface water within the bare ground category.
Water	Permanent standing water is identified in plots that are partly within a creek, ditch, marsh pool, or flooded panne.
Wrack/litter	Wrack is material that has floated into the plot. This is generally dead (not attached) plant material, but could also be trash. Litter is dead plant material that is highly decomposed and is no longer attached.
Trash	Items such as logs, old piers, tires, etc.
Rock	Boulders or rocks can be found on the surface of northern New England marshes.

Data Summary

Vegetation data were recorded using the modified Braun-Blanquet scale as described above (Kent and Coker 1992). For summary purposes, each Braun-Blanquet value was converted to the midpoint of the percent range it represented (Table 3) as described in Wikum and Shanholtzer (1978).

Table 3. Modified Braun-Blanquet scale and corresponding midpoint values for determining percent cover of each vegetation species and non-vegetation cover type.

BB Value	Percent Cover	Midpoint
0	0%	0%
1	< 1%	0.5%
2	1 - 5%	3%
3	6 - 25%	15.5%
4	26 - 50%	38%
5	51 - 75%	63%
6	76 - 100%	88%

Wikum and Shanholtzer (1978) outline a method for calculating an importance value for each species. So as not to confuse this value with ecological importance, we rename it a ‘relative prevalence’ value. The calculation is essentially identical to that described in Wikum and Shanholtzer’s publication. Although Wikum and Shanholtzer (1978) present their importance value as a sum of the percent frequency and percent cover values, this report takes the average of these values so that relative prevalence is on a more readily interpretable percent scale. We estimated the relative percent prevalence for each species and non-vegetation cover type present, which is equal to the average of the relative percent cover and the relative percent frequency.

Relative percent cover is the percentage of all plots that each species covers relative to all other species present in the plots. The sum of all relative percent cover values for all species and non-vegetation cover types equals 100%. Relative percent frequency is the number of plots where each species is present, relative to all other species observed in the plots. The sum of the relative percent frequency values for all species and non-vegetation cover type equals 100%.

Taking the average of the relative percent cover and the relative percent frequency gives the *relative percent prevalence* for each species and non-vegetation cover type. Because the relative percent prevalence incorporates both percent frequency and percent cover, it is likely to differ substantially from the average percent cover for a given species or non-vegetation cover type. The relative percent prevalence of a species provides information about how a species is distributed (*i.e.*, its ‘patchiness’) throughout the salt marsh. We also report the average percent cover of each species for all plots combined.

Lastly, if any vegetation species observed in the plots are listed by the United States Department of Agriculture (USDA), or the commonwealth of Virginia as exotic, invasive, threatened, endangered, or rare, these species are noted in the vegetation table. Individual plots that were found to contain a species listed as exotic, invasive, threatened, endangered, or rare, will be noted in Appendix A, which includes a table of all vegetation plots and their respective Universal Transverse Mercator (UTM) coordinates. Information about plants listed by each state as exotic, invasive, threatened, endangered, or rare is available online (USDA 2010). In some cases, more specific information may be available on state websites. Information about plants listed by the commonwealth of Virginia as exotic or invasive is available online (Virginia Department of Conservation and Recreation 2009). Information about plants listed by the commonwealth of Virginia as threatened, endangered, or rare can be obtained from an online report produced by the Virginia Department of Conservation and Recreation (Townsend 2009).

Vegetation sampling was first conducted at COLO in 2008, and then again in 2010. Given the inherent inter-annual variability in the sampling design, it is not informative to make quantitative comparisons between two years of data. We do, however, make qualitative comparisons between the two monitoring visits that discuss changes in species composition and changes in prevalence of the most common species.

Results

Twenty-nine vegetation species and three non-vegetation cover types (bare ground, water, and wrack and litter) were recorded at four salt marsh sites at COLO in 2010 (Table 4). The average percent cover and the relative percent prevalence of each species or non-vegetation cover type are also shown in Table 4.

Data are sorted by average percent cover of living vegetation species. Average percent cover of non-living vegetation (if present) is also shown for each species. As explained in the Data Summary section, the relative percent prevalence combines information about how much area each species covers relative to all other species present, and how frequently it appears throughout the sites relative to all others present. The species with the highest living percent cover, *S. cynosuroides*, dwarfs the percent cover of all other species at 39.6 ± 34.8 , but its relative percent prevalence of 22.1, while still high, is substantially lower. This is an indication that *S. cynosuroides* is present in large patches as opposed to being well dispersed throughout all of the sites. In contrast, *P. virginica* has a substantially higher relative percent prevalence of 6.7, compared to its average percent cover of 4.8 ± 7.7 , indicating that although it does not cover a large proportion of the sites sampled at COLO, it is well dispersed throughout the sites where it is found (Table 4).

None of the vegetation species observed in the 2010 plots are federally listed by the USDA as exotic, invasive, threatened, endangered, or rare (USDA 2010). One of the species, *Phragmites australis*, is listed by the state of Virginia as highly invasive (Virginia Department of Conservation and Recreation 2009). All of the *Phragmites australis* specimens present in vegetation plots at COLO in 2010 were dead. None of the species observed are listed as threatened, endangered, or rare in Virginia (Townsend 2009).

Results of a qualitative comparison between the 2008 and 2010 data indicate several differences between the two years, particularly in the species observed. Thirteen of the 29 species recorded in 2010 were not observed in 2008 (Appendix B). In addition, 10 of the 27 species recorded during 2008 were not observed in 2010 (Appendix B). These differences appear to be due to species that are only present in a few plots. The most frequently observed species (*e.g.*, *S. cynosuroides*, *P. virginica*, and *Schoenoplectus robustus*) were similar in both years. Differences between sampling years are important to note, but should not be considered indicative of a significant change in the plant community at COLO. Because vegetation plots are re-randomized each year, and therefore distributed differently across each site, substantial inter-annual variability is to be expected.

Table 4. Average percent cover (Average % Cover $\pm$ SD) and relative percent prevalence of each plant species and non-vegetation cover type at COLO in 2010. Data are summarized over all 158 plots. Average percent cover was estimated using the midpoint values of Braun-Blanquet percent ranges (Table 3). 'NL' indicates standing non-living vegetation. '*' indicates an invasive or exotic species. '+' indicates an invalid synonym was used on the data sheet (Appendix C); accepted synonyms (www.itis.gov) are presented here.

Species/Cover Type	Common Name	Average % Cover $\pm$ SD	Relative % Prevalence
<i>Spartina cynosuroides</i>	Big cordgrass	39.6 $\pm$ 34.8	22.1
<i>S. cynosuroides</i> (NL)	Big cordgrass (NL)	9.1 $\pm$ 15.3	9.5
Water		22.1 $\pm$ 35.7	11.6
Wrack/litter		15.4 $\pm$ 23.7	11.0
<i>Peltandra virginica</i>	Green arrow arum	12.8 $\pm$ 17.3	10.8
<i>P. virginica</i> (NL)	Green arrow arum (NL)	0.9 $\pm$ 2.8	2.1
+ <i>Schoenoplectus robustus</i>	Saltmarsh bulrush	10.4 $\pm$ 17.6	8.6
<i>S. robustus</i> (NL)	Saltmarsh bulrush (NL)	2.0 $\pm$ 9.8	1.8
Bare ground		7.0 $\pm$ 15.9	5.6
<i>Spartina alterniflora</i>	Saltmarsh cordgrass	3.2 $\pm$ 14.7	1.8
<i>S. alterniflora</i> (NL)	Saltmarsh cordgrass (NL)	0.1 $\pm$ 1.3	0.2
+ <i>Schoenoplectus pungens</i> var. <i>pungens</i>	Common threesquare	2.8 $\pm$ 10	3.0
<i>S. pungens</i> (NL)	Common threesquare (NL)	0.8 $\pm$ 7.6	0.5
* <i>Phragmites australis</i> (NL)	Common reed (NL)	2.5 $\pm$ 14.1	1.9
<i>Polygonum punctatum</i>	Dotted smartweed	1.4 $\pm$ 5.4	2.0
+ <i>Morella cerifera</i>	Wax myrtle	0.8 $\pm$ 7.6	0.4
<i>Teucrium canadense</i>	American germander	0.7 $\pm$ 7.1	0.4
<i>Typha angustifolia</i>	Narrowleaf cattail	0.6 $\pm$ 3.5	1.2
<i>T. angustifolia</i> (NL)	Narrowleaf cattail (NL)	0.4 $\pm$ 3.3	0.3
<i>Carex hyalinolepis</i>	Shoreline sedge	0.5 $\pm$ 3.3	0.9
<i>C. hyalinolepis</i> (NL)	Shoreline sedge (NL)	0.2 $\pm$ 1.3	0.4
<i>Juncus effusus</i>	Soft rush	0.3 $\pm$ 3.1	0.4
<i>J. effusus</i> (NL)	Soft rush (NL)	0.1 $\pm$ 1.3	0.2
<i>Zizania aquatic</i>	Annual wildrice	0.3 $\pm$ 1.8	0.5
+ <i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	0.3 $\pm$ 1.4	0.8
<i>Carex</i> species	Sedge species	0.2 $\pm$ 3.0	0.2
<i>Carex</i> species (NL)	Sedge species (NL)	0.6 $\pm$ 7.0	0.3
<i>Sagittaria lancifolia</i>	Bulltongue arrowhead	0.2 $\pm$ 1.8	0.3
<i>Iva frutescens</i>	Marsh elder	0.1 $\pm$ 1.2	0.1
<i>Persea borbonia</i>	Redbay	0.1 $\pm$ 1.2	0.1
+ <i>Schoenoplectus americanus</i>	American bulrush	0.1 $\pm$ 0.4	0.2
<i>Hibiscus moscheutos</i>	Crimson-eyed rosemallow	< 0.05	0.1
<i>Lilaeopsis chinensis</i>	Eastern grasswort	< 0.05	0.1
<i>Lythrum lineare</i>	Saltmarsh loosestrife	< 0.05	0.1

Table 5. Average percent cover (Average % Cover $\pm$ SD) and relative percent prevalence of each plant species and non-vegetation cover type at COLO in 2010. (continued)

Species/Cover Type	Common Name	Average % Cover $\pm$ SD	Relative % Prevalence
<i>Amaranthus cannabinus</i>	Tidalmarsh amaranth	< 0.05	0.1
<i>Hydrocotyle verticillata</i>	Whorled marsh pennywort	< 0.05	0.1
<i>Leersia oryzoides</i>	Rice cutgrass	< 0.05	0.1
+ <i>Samolus valerandi</i> ssp. <i>parviflorus</i>	Seaside brookweed	< 0.05	0.1
<i>Spartina patens</i>	Saltmeadow cordgrass	< 0.05	0.1
Unidentified plant	Unidentified plant	< 0.05	0.1
Unidentified plant (NL)	Unidentified plant (NL)	< 0.05	0.1
<i>Zizaniopsis miliacea</i>	Giant cutgrass	< 0.05	0.1

Discussion

This report summarized data from the second year of vegetation sampling conducted at COLO in 2010. These data contribute to our knowledge of the vegetation community structure of salt marsh at COLO and provide information about the inter-annual variability associated with our monitoring protocol. Continued monitoring of salt marsh vegetation will allow us to distinguish between inter-annual variability and significant trends in the vegetation community.

Due to the difficulties encountered during sampling in 2008 and 2010, it is necessary to re-evaluate the sampling design at COLO prior to the 2012 sampling season. The four sites have proven to be very difficult to sample due to accessibility and the depth of tidal creeks that need to be crossed during sampling. By selecting sites that are more easily accessible we hope to be able to increase the sampling effort at the park and possibly expand the data collection to include nekton monitoring.

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Appendix A. Coordinates for vegetation plot locations at COLO in 2010.

Table A-1. Coordinates for vegetation plot locations sampled at COLO Site 1 in 2010, UTM, Zone 18, NAD 83, meters. '*' indicates that an invasive or exotic species is present at that plot location.

Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
C1V110_2010	344623	4117777	C1V2710_2010	344188	4117544
C1V210_2010	344809	4117784	C1V2810_2010	344565	4117713
C1V310_2010	344639	4117749	C1V2910_2010	344836	4117895
*C1V410_2010	344534	4117611	C1V3010_2010	344788	4117824
C1V510_2010	344443	4117598	C1V3110_2010	344689	4117822
C1V610_2010	344668	4117858	C1V3210_2010	344769	4117850
C1V710_2010	344507	4117653	C1V3310_2010	344667	4117707
C1V810_2010	344462	4117721	C1V3410_2010	344683	4117680
C1V910_2010	344853	4117869	C1V3510_2010	344653	4117728
C1V1010_2010	344676	4117844	C1V3610_2010	344520	4117628
C1V1110_2010	344184	4117546	C1V3810_2010	344619	4117784
C1V1310_2010	344394	4117676	C1V3910_2010	344604	4117810
C1V1410_2010	344698	4117809	C1V4010_2010	344399	4117517
C1V1510_2010	344619	4117630	C1V4210_2010	344322	4117641
C1V1610_2010	344405	4117505	C1V4310_2010	344856	4117868
C1V1710_2010	344811	4117784	C1V4410_2010	344395	4117677
C1V1810_2010	344532	4117618	C1V4510_2010	344860	4117862
*C1V1910_2010	344549	4117586	C1V4610_2010	344416	4117496
C1V2010_2010	344727	4117765	C1V4710_2010	344702	4117805
C1V2110_2010	344784	4117829	C1V4810_2010	344174	4117567
C1V2210_2010	344662	4117710	C1V4910_2010	344497	4117667
C1V2310_2010	344606	4117799	C1V5010_2010	344791	4117818
C1V2410_2010	344514	4117639	C1V5110_2010	344403	4117659
C1V2510_2010	344651	4117739	C1V5210_2010	344427	4117622
C1V2610_2010	344482	4117688	C1V5310_2010	344406	4117508

Table A-2. Coordinates for vegetation plot locations sampled at COLO Site 5 in 2010, UTM, Zone 18, NAD 83, meters.

Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
C5V110_2010	345520	4118292	C5V2710_2010	345416	4118522
C5V210_2010	345369	4118483	C5V2810_2010	345371	4118393
C5V310_2010	345364	4118483	C5V2910_2010	345469	4118429
C5V410_2010	345614	4118453	C5V3010_2010	345367	4118507
C5V510_2010	345467	4118410	C5V3110_2010	345373	4118400
C5V610_2010	345467	4118486	C5V3210_2010	345269	4118495
C5V710_2010	345318	4118499	C5V3310_2010	345365	4118527
C5V810_2010	345613	4118497	C5V3410_2010	345563	4118511
C5V910_2010	345513	4118531	C5V3510_2010	345522	4118330
C5V1010_2010	345470	4118370	C5V3610_2010	345417	4118491
C5V1110_2010	345472	4118358	C5V3710_2010	345371	4118420
C5V1210_2010	345413	4118545	C5V3810_2010	345520	4118357
C5V1310_2010	345464	4118501	C5V3910_2010	345564	4118483
C5V1410_2010	345514	4118518	C5V4010_2010	345471	4118393
C5V1510_2010	345464	4118482	C5V4110_2010	345523	4118298
C5V1610_2010	345471	4118378	C5V4210_2010	345418	4118499
C5V1710_2010	345318	4118476	C5V4310_2010	345522	4118365
C5V1810_2010	345569	4118413	C5V4410_2010	345613	4118467
C5V1910_2010	345516	4118464	C5V4510_2010	345467	4118479
C5V2010_2010	345569	4118377	C5V4610_2010	345316	4118508
C5V2110_2010	345418	4118486	C5V4710_2010	345421	4118422
C5V2210_2010	345366	4118517	C5V4810_2010	345466	4118488
C5V2310_2010	345365	4118533	C5V4910_2010	345321	4118417
C5V2410_2010	345520	4118356	C5V5010_2010	345417	4118527
C5V2510_2010	345467	4118427	*C5V5110_2010	345610	4118533
C5V2610_2010	345467	4118452	C5V5210_2010	345273	4118450

Table A-3. Coordinates for vegetation plot locations sampled at COLO Site 6 in 2010, UTM, Zone 18, NAD 83, meters.

Plot ID	UTM X (east)	UTM Y (north)
C6V1510_2010	348972	4121450
C6V210_2010	348949	4121416
C6V2510_2010	348901	4121408
C6V710_2010	348953	4121428

Table A-4. Coordinates for vegetation plot locations sampled at COLO Site 8 in 2008, UTM, Zone 18, NAD 83, meters. '**' indicates that invasive or exotic species is present at that plot location.

Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
C8V110_2010	343634	4119822	C8V2710_2010	343450	4119784
C8V210_2010	343448	4119928	*C8V2810_2010	343447	4119967
C8V310_2010	343348	4119839	C8V2910_2010	343631	4119795
C8V410_2010	343352	4119950	*C8V3010_2010	343400	4120013
C8V510_2010	343635	4119937	C8V3110_2010	343351	4119902
C8V610_2010	343540	4119893	C8V3210_2010	343446	4119861
C8V710_2010	343725	4119731	*C8V3310_2010	343448	4120012
C8V810_2010	343349	4119912	C8V3410_2010	343397	4119834
C8V910_2010	343726	4119711	C8V3510_2010	343353	4119997
C8V1010_2010	343683	4119838	C8V3610_2010	343494	4119830
C8V1110_2010	343589	4119974	*C8V3710_2010	343540	4119913
C8V1210_2010	343632	4119796	C8V3810_2010	343632	4119794
C8V1310_2010	343586	4119812	C8V3910_2010	343348	4119829
C8V1410_2010	343630	4119777	C8V4010_2010	343352	4119816
C8V1510_2010	343631	4119757	C8V4110_2010	343353	4120030
C8V1610_2010	343543	4120056	C8V4210_2010	343589	4120010
C8V1710_2010	343588	4120021	C8V4310_2010	343586	4119923
C8V1810_2010	343448	4119919	C8V4410_2010	343681	4119732
C8V1910_2010	343494	4119994	C8V4510_2010	343587	4119900
*C8V2010_2010	343492	4119919	C8V4610_2010	343496	4119869
C8V2110_2010	343353	4120028	C8V4710_2010	343633	4119927
C8V2210_2010	343351	4119820	C8V4810_2010	343588	4120021
C8V2310_2010	343541	4119994	C8V4910_2010	343637	4119902
C8V2410_2010	343352	4119855	C8V5010_2010	343351	4119943
C8V2510_2010	343399	4119883	C8V5210_2010	343542	4120010
C8V2610_2010	343588	4119919	C8V5310_2010	343538	4119826

Appendix B. Vegetation species observed at COLO in 2008 and 2010.

Table B-1. Species and cover type frequency by site, COLO 2008. 'NL' indicates standing non-living vegetation. '**' indicates an invasive or exotic species. '+' indicates an invalid synonym was used on the data sheet. The accepted synonyms were retrieved from the ITIS database (November 2010) and are presented here. Commonly misused synonyms are shown in Appendix C.

Species	Common Name	Site (no. of plots)				
		1 (50)	5 (51)	6 (50)	8 (50)	All (201)
<i>Spartina cynosuroides</i>	Big cordgrass	48	50	39	49	186
<i>S. cynosuroides</i> (NL)	Big cordgrass (NL)	45	49	29	38	161
+ <i>Schoenoplectus robustus</i>	Saltmarsh bulrush	44	25	26	12	107
<i>S. robustus</i> (NL)	Saltmarsh bulrush (NL)	37	19	14	2	72
<i>Peltandra virginica</i>	Green arrow arum	20	16	17	46	99
<i>P. virginica</i> (NL)	Green arrow arum (NL)	27	12	13	40	92
<i>Polygonum</i> species	Knotweed species	20	2	12	33	67
Bare ground		7	6	27	24	64
Water		4	15	4	12	35
+ <i>Schoenoplectus pungens</i> var. <i>pungens</i>	Common threesquare	15	0	1	18	34
<i>S. pungens</i> var. <i>pungens</i> (NL)	Common threesquare (NL)	6	0	0	2	8
+ <i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	10	5	4	2	21
<i>S. tabernaemontani</i> (NL)	Softstem bulrush (NL)	8	1	3	1	13
<i>Spartina alterniflora</i>	Saltmarsh cordgrass	0	0	19	0	19
<i>S. alterniflora</i> (NL)	Saltmarsh cordgrass (NL)	0	0	7	0	7
Wrack/Litter		1	0	10	3	14
<i>Leersia oryzoides</i>	Rice cutgrass	0	0	0	13	13
<i>L. oryzoides</i> (NL)	Rice cutgrass (NL)	0	0	0	1	1
<i>Typha angustifolia</i>	Narrowleaf cattail	5	4	2	0	11
<i>T. angustifolia</i> (NL)	Narrowleaf cattail (NL)	2	0	1	0	3
Unidentified plant		7	1	1	1	10
<i>Lythrum lineare</i>	Saltmarsh loosestrife	2	0	7	0	9
<i>Carex lurida</i>	Shallow sedge	7	1	0	0	8
<i>C. lurida</i> (NL)	Shallow sedge (NL)	1	0	0	0	1
<i>Mikania scandens</i>	Climbing hempvine	2	4	0	0	6
<i>Distichlis spicata</i>	Spikegrass	0	0	4	0	4
<i>Phragmites australis</i>	Common reed	2	0	1	0	3
* <i>P. australis</i> (NL)	Common reed (NL)	1	0	0	0	1
<i>Brasenia schreberi</i>	Watershield	0	2	0	0	2
<i>Iva frutescens</i>	Marsh elder	0	2	0	0	2
<i>Zizania aquatica</i>	Annual wildrice	0	0	0	2	2
<i>Amaranthus cannabinus</i>	Tidalmarsh amaranth	0	0	0	1	1
<i>Lilaeopsis chinensis</i>	Eastern grasswort	0	0	1	0	1
<i>Lonicera</i> species	Honeysuckle species	0	1	0	0	1
<i>Malvaceae</i> species	Mallow family	1	0	0	0	1
+ <i>Morella cerifera</i>	Wax myrtle	0	1	0	0	1
<i>Pluchea odorata</i>	Marsh fleabane	0	0	1	0	1
<i>Poaceae</i> species	Grass species	0	1	0	0	1
<i>Rumex verticillatus</i>	Swamp dock	0	1	0	0	1

Table B-2. Species and cover type frequency by site, COLO 2010. 'NL' indicates standing non-living vegetation. '*' indicates an invasive or exotic species. '+' indicates an invalid synonym was used on the data sheet. The accepted synonyms were retrieved from the ITIS database (November 2010) and are presented here. Commonly misused synonyms are shown in Appendix C.

Species/Cover Type	Common Name	Site (no. of plots)				
		1 (50)	5 (52)	6 (4)	8 (52)	All (158)
<i>Spartina cynosuroides</i>	Big cordgrass	43	45	2	30	120
<i>S. cynosuroides</i> (NL)	Big cordgrass (NL)	43	34	2	19	98
<i>Peltandra virginica</i>	Green arrow arum	21	24	4	48	97
<i>P. virginica</i> (NL)	Green arrow arum (NL)	6	0	4	18	28
Wrack/litter		37	29	1	19	86
+ <i>Schoenoplectus robustus</i>	Saltmarsh bulrush	36	25	2	14	77
<i>S. robustus</i> (NL)	Saltmarsh bulrush (NL)	11	2	1	3	17
Water		9	5	3	38	55
Bare ground		7	21	3	18	49
+ <i>Schoenoplectus pungens</i> var. <i>pungens</i>	Common threesquare	9	10	1	12	32
<i>S. pungens</i> var. <i>pungens</i> (NL)	Common threesquare (NL)	2	0	1	0	3
<i>Polygonum punctatum</i>	Dotted smartweed	9	0	0	14	23
* <i>Phragmites australis</i> (NL)	Common reed (NL)	4	2	0	10	16
<i>Typha angustifolia</i>	Narrowleaf cattail	9	2	0	4	15
<i>T. angustifolia</i> (NL)	Narrowleaf cattail (NL)	2	0	0	1	3
<i>Carex hyalinolepis</i>	Shoreline sedge	9	2	0	0	11
<i>C. hyalinolepis</i> (NL)	Shoreline sedge (NL)	3	2	0	0	5
+ <i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	0	3	0	8	11
<i>Spartina alterniflora</i>	Saltmarsh cordgrass	0	4	2	4	10
<i>S. alterniflora</i> (NL)	Saltmarsh cordgrass (NL)	0	1	1	1	3
<i>Zizania aquatica</i>	Annual wildrice	0	0	0	7	7
<i>Juncus effusus</i>	Soft rush	4	0	0	1	5
<i>J. effusus</i> (NL)	Soft rush (NL)	1	0	0	1	2
<i>Sagittaria lancifolia</i>	Bulltongue arrowhead	4	0	0	0	4
+ <i>Schoenoplectus americanus</i>	American bulrush	0	3	0	0	3
<i>Hibiscus moscheutos</i>	Crimson-eyed rosemallow	2	0	0	0	2
<i>Lilaeopsis chinensis</i>	Eastern grasswort	0	2	0	0	2
<i>Lythrum lineare</i>	Saltmarsh loosestrife	0	2	0	0	2
+ <i>Morella cerifera</i>	Wax myrtle	1	1	0	0	2
<i>Teucrium canadense</i>	American germander	0	2	0	0	2
<i>Amaranthus cannabinus</i>	Tidalmarsh amaranth	0	0	0	1	1
<i>Carex</i> species	Sedge species	1	0	0	0	1
<i>Carex</i> species (NL)	Sedge species (NL)	1	0	0	0	1
<i>Hydrocotyle verticillata</i>	Whorled marsh pennywort	0	1	0	0	1
<i>Iva frutescens</i>	Marsh elder	0	1	0	0	1
<i>Leersia oryzoides</i>	Rice cutgrass	0	1	0	0	1
<i>Persea borbonia</i>	Redbay	1	0	0	0	1

Table B-2. Species and cover type frequency by site, COLO 2010. (continued)

Species/Cover Type	Common Name	Site (no. of plots)				
		1 (50)	5 (52)	6 (4)	8 (52)	All (158)
+ <i>Samolus valerandi</i> ssp. <i>parviflorus</i>	Seaside brookweed	0	1	0	0	1
<i>Spartina patens</i>	Saltmeadow cordgrass	0	1	0	0	1
Unidentified plant	Unidentified plant	0	0	0	1	1
Unidentified plant (NL)	Unidentified plant (NL)	0	1	0	0	1
<i>Zizaniopsis miliacea</i>	Giant cutgrass	0	0	0	1	1

Appendix C. Accepted species synonyms.

Table C-1. Accepted synonyms for vegetation species from the ITIS database (www.itis.gov) retrieved (November 2010).

Accepted Synonym	Invalid Synonym	Common Name
<i>Morella cerifera</i>	<i>Myrica cerifera</i>	Southern wax myrtle
<i>Samolus valerandi</i> ssp. <i>parviflorus</i>	<i>Samolus floribundus</i>	Seaside brookweed
<i>Schoenoplectus americanus</i>	<i>Scirpus americanus</i>	American bulrush
<i>Schoenoplectus pungens</i> var. <i>pungens</i>	<i>Scirpus pungens</i>	Common threesquare
<i>Schoenoplectus robustus</i>	<i>Scirpus robustus</i>	Saltmarsh bulrush, Sturdy bulrush
<i>Schoenoplectus tabernaemontani</i>	<i>Scirpus validus</i>	Softstem bulrush