



Salt Marsh Vegetation Monitoring at Colonial National Historical Park

2008 Summary Report

Natural Resource Report NPS/NCBN/NRDS—2010/066



ON THE COVER

Marshland off of Island Drive on Jamestown Island, Colonial National Historical Park
Photograph by: Robin Baranowski

Salt Marsh Vegetation Monitoring at Colonial National Historical Park

2008 Summary Report

Natural Resource Report NPS/NCBN/NRDS—2010/066

Erika L. Patenaude

Penelope S. Pooler

National Park Service
Northeast Coastal and Barrier Network
University of Rhode Island
1 Greenhouse Rd
Kingston, RI 02881

August 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from (<http://www.nps.gov/nero/science/>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/NRPM>).

Please cite this publication as:

Patenaude, E. L., and P. S. Pooler. 2010. Salt marsh vegetation monitoring at Colonial National Historical Park: 2008 summary report. Natural Resource Data Series NPS/NCBN/NRDS—2010/066. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	v
Tables.....	v
Executive Summary	vii
Acknowledgments.....	ix
Introduction.....	1
Methods.....	3
Permanent Site Selection	3
Vegetation Plot Selection and Data Collection	4
Data Summary	5
Results.....	7
Discussion.....	9
Literature Cited	11
Appendix 1. Coordinates for vegetation plot locations at COLO in 2008.....	13

Figures

Page

Figure 1. Locations of permanent nekton and vegetation monitoring sites established by NCBN at Colonial National Historical Park (COLO).....	3
---	---

Tables

Page

Table 1. Sampling dates and total number of vegetation plots sampled at four marsh sites at COLO in 2008.....	4
Table 2. Definition of standard cover type categories used in the Northeast Coastal and Barrier Network salt marsh vegetation monitoring program.	4
Table 3. Modified Braun-Blanquet scale and corresponding midpoint values for determining percent cover of salt marsh vegetation.	5
Table 4. Average cover percent (Average Cover % $\pm$ SD) and relative prevalence percent of each plant species and non-vegetation cover type at COLO in 2008.	8

Executive Summary

The Northeast Coastal and Barrier Network (NCBN) is one of 32 networks of parks created by the Inventory and Monitoring Program (I&M Program) of the National Park Service. 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 Network parks. 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 Vital Signs 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 In Development).

This annual report summarizes the first year of data collected at Colonial National Historical Park (COLO) Virginia. Fifty vegetation plots were sampled for vegetation at four marshes in August of 2008. Monitoring data is to be collected at these same marsh sites biennially. Vegetation was monitored using 1m² plots and a revised Braun-Blanquet method (Kent and Coker 1992) to estimate percent cover of each vegetation species and non-vegetation cover type within each plot.

At the four COLO sites, 25 vegetation species along with 3 non-vegetation cover types were recorded during vegetation sampling in 2008. Non-vegetation cover types recorded included wrack and litter, bare ground, and water. One of the identified vegetation species, *Phragmites australis*, is listed as a highly invasive species in the state of Virginia (Virginia Department of Conservation and Recreation 2009).

The information collected through this long-term monitoring program will equip park managers with scientific data to make informed decisions on both the aquatic and terrestrial resources they manage. This report summarizes the 2008 baseline data for COLO salt marshes. Changes in salt marsh condition will be examined following data collection in 2010. By understanding the changes or trends occurring in salt marsh vegetation, managers will be able to better adapt and respond to these changes through their management practices.

Acknowledgments

We would like to thank Charles T. Roman and Mary-Jane James-Pirri for the development of the salt marsh vegetation monitoring protocol and Dennis Skidds for his work on the salt marsh monitoring database and data management support. We would also like to thank the 2008 salt marsh field crew members, Casey Nolan and Rachel Lux for their hard work and, of course, the Colonial National Historical Park staff for providing support to the NCBN field crew.

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 2008 according to the protocol developed by Pirri et al., *Monitoring Salt Marsh Vegetation: A Protocol for the National Park Service’s Long-Term Monitoring Program, Northeast Coastal and Barrier Network* (In Development).

The objective of salt marsh vegetation monitoring is to identify long-term trends in the structure of these communities, which in turn should provide a better understanding of the current status and condition of salt marsh within the parks. These data will assist park managers in making 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 the Salt Marsh Vegetation Protocol (James-Pirri et al. In Development).

Vegetation sampling will be conducted at these four marshes every 2 years. In future years, more permanent marsh sites may be added to the vegetation sampling protocol, as time permits. 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 permanent nekton and vegetation monitoring sites established by NCBN at Colonial National Historical Park (COLO). These four sites will be monitored biennially.

Vegetation Plot Selection and Data Collection

Vegetation sampling was conducted at each of the four permanent marsh sites during August. Ten transects, extending from creek bank to upland, were randomly located within each marsh and 50 1m² plots were randomly placed along these transects. Each plot was visited once during the summer sampling season (Table 1).

For each plot, all vegetation species and non-vegetation cover types were recorded (Table 2), and the estimated percent cover was determined 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 2008.

Site	Dates	Total
1	8/26-28/2008	50
5	8/19-21/2008	51
6	8/25/2008	50
8	8/22-23/2008	50

Table 2. Definition of standard cover type categories used in the Northeast Coastal and Barrier Network salt marsh vegetation monitoring program. (James-Pirri et al. In Development)

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 in the data 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 salt marsh vegetation.

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 which is the average of the relative percent cover and the relative percent frequency.

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

Taking the average of the relative percent cover and the relative percent frequency gives the relative percent prevalence for each species, or non-vegetation cover type present. 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. We also report the average percent cover of each species for all plots combined.

Lastly, if any identified vegetation species in the sample 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. 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).

If any species found in the sample plots are noted as being from one of these categories, plots with those categories of vegetation present will be noted in Appendix 4, the list of all vegetation sample plots and their respective Universal Transverse Mercator (UTM) coordinates.

Results

Twenty-five vegetation species along with five non-vegetation cover types were recorded at four salt marsh sites during vegetation sampling at COLO in 2008 (Table 4). Non-vegetation cover types recorded included bare ground, water, and wrack and litter. The average percent cover and the relative percent prevalence of each species or non-vegetation cover type are also shown.

None of the identified vegetation species in the sample plots are listed by the USDA as exotic, invasive, threatened, endangered, or rare (USDA 2010). One of the identified vegetation species in the sample plots, *Phragmites australis*, is listed by the state of Virginia as highly invasive (Virginia Department of Conservation and Recreation 2009). None of the identified plants in the 2008 sampled plots at COLO are listed as threatened, endangered, or rare in Virginia (Townsend 2009).

Data are sorted by average percent cover of living vegetation species. Average percent cover of non-living vegetation is also shown by species. As explained in the Data Summary section, the relative percent prevalence combines information about how much of each site each species or cover type covers relative to all other cover types present and how frequently it appears throughout the site relative to all other cover types present. The species with the highest living percent cover, *S. cynosuroides*, dwarfs the percent cover of all other species at 60.3 ± 32.5 , but its relative percent prevalence, 35.4, 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 the site. In contrast, *P. virginica* has a substantially higher relative percent prevalence, 6.7, than its average percent cover, 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).

Table 4. Average cover percent (Average Cover % $\pm$ SD) and relative prevalence percent of each plant species and non-vegetation cover type at COLO in 2008. Data were summarized over all 201 plots. 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.

Species/Cover Type	Common Name	Average Cover % $\pm$ SD	Relative Prevalence %
<i>Spartina cynosuroides</i>	Big Cordgrass	60.3 $\pm$ 32.5	35.4
<i>S. cynosuroides</i> (NL)	Big Cordgrass (NL)	8.1 $\pm$ 11.1	11.0
<i>Schoenoplectus robustus</i>	Saltmarsh Bulrush	7.8 $\pm$ 13.9	8.4
<i>S. robustus</i> (NL)	Saltmarsh Bulrush (NL)	3.4 $\pm$ 10.2	4.9
<i>Spartina alterniflora</i>	Saltmarsh Cordgrass	6.1 $\pm$ 20.8	3.6
<i>S. alterniflora</i> (NL)	Saltmarsh Cordgrass (NL)	0.1 $\pm$ 1.2	0.4
Water		4.9 $\pm$ 14.5	3.8
<i>Peltandra virginica</i>	Green Arrow Arum	4.8 $\pm$ 7.7	6.7
<i>P. virginica</i> (NL)	Green Arrow Arum	2.6 $\pm$ 4.5	5.4
Bare Ground		3.4 $\pm$ 8.1	4.5
<i>Polygonum species</i>	Knotweed Species	2.8 $\pm$ 5.8	4.4
<i>Scirpus pungens</i>	Common Three-square	1.6 $\pm$ 5.6	2.3
<i>S. pungens</i> (NL)	Common Three-square	0.6 $\pm$ 5.3	0.7
* <i>Phragmites australis</i>	Common Reed	0.8 $\pm$ 7.7	0.5
* <i>P. australis</i> (NL)	Common Reed (NL)	0.1 $\pm$ 1.1	0.1
<i>Schoenoplectus tabernaemontani</i>	Softstem Bulrush	0.7 $\pm$ 3.5	1.3
<i>S. tabernaemontani</i> (NL)	Softstem Bulrush (NL)	0.4 $\pm$ 2.8	0.8
<i>Lythrum lineare</i>	Saltmarsh Loosestrife	0.7 $\pm$ 4.2	0.7
Unidentified Plant	Unidentified Plant	0.5 $\pm$ 3.3	0.7
Wrack/Litter		0.5 $\pm$ 2.2	0.8
<i>Mikania scandens</i>	Climbing Hempvine	0.5 $\pm$ 3.3	0.5
<i>Distichlis spicata</i>	Spikegrass	0.2 $\pm$ 2.7	0.3
<i>Leersia oryzoides</i>	Rice Cutgrass	0.2 $\pm$ 1.3	0.7
<i>L. oryzoides</i> (NL)	Rice Cutgrass (NL)	< 0.05	0.1
<i>Typha angustifolia</i>	Narrowleaf Cattail	0.2 $\pm$ 1.3	0.6
<i>T. angustifolia</i> (NL)	Narrowleaf Cattail (NL)	< 0.05	0.2
<i>Zizania aquatica</i>	Annual Wildrice	0.2 $\pm$ 2.7	0.2
<i>Lilaeopsis chinensis</i>	Eastern Grasswort	0.2 $\pm$ 2.7	0.1
<i>Myrica cerifera</i>	Southern Wax Myrtle	0.2 $\pm$ 2.7	0.1
<i>Carex lurida</i>	Shallow Sedge	0.1 $\pm$ 0.6	0.4
<i>C. lurida</i> (NL)	Shallow Sedge (NL)	0.1 $\pm$ 1.1	0.1
<i>Iva frutescens</i>	Marsh Elder	0.1 $\pm$ 1.1	0.1
<i>Lonicera species</i>	Honeysuckle Species	0.1 $\pm$ 1.1	0.1
<i>Brasenia schreberi</i>	Watershield	< 0.05	0.1
<i>Amaranthus cannabinus</i>	Tidalmarsh Amaranth	< 0.05	0.1
<i>Malvaceae species</i>	Mallow Family	< 0.05	0.1
<i>Pluchea odorata</i>	Marsh Fleabane	< 0.05	0.1
<i>Poaceae species</i>	Grass Species	< 0.05	0.1
<i>Rumex verticillatus</i>	Swamp Dock	< 0.05	0.1

Discussion

This first year of vegetation monitoring at COLO provides essential information about the species present and how prevalent they are. These data also include information about non-vegetation cover types such as bare ground and standing water which will be important to monitor over time. 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 spatial distribution of some species will be important primary indicators of change in salt marsh condition. Trends in the spatial distribution of vegetation species 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 sea-level rise and climate change.

This first year of data at COLO establishes a baseline for monitoring trends in vegetation community structure and spatial distribution of both vegetation species and non-vegetation cover types. Long-term monitoring of salt marsh vegetation will allow us to test hypotheses about whether apparent changes are due to year to year variability or represent significant trends.

Literature Cited

- James-Pirri, M.J., and C.T. Roman. In Review. Monitoring vegetation in salt marshes: a protocol for National Park Service's Long-Term Monitoring Program, Northeast Coastal Barrier Network. Natural Resource Technical Report NPS/NCBN/NRTR—2010/XXX. National Park Service, Fort Collins, Colorado.
- Kent, M., and P. Coker. 1992. Vegetation description and analysis: a practical approach. J. Wiley and Sons, Ltd., Chichester, England.
- Stevens, S., B. Milstead, M. Albert, G. Entsminger. 2005. Northeast Coastal and Barrier Network Vital Signs Monitoring Plan. Technical Report NPS/NER/NRTR--2005/025. National Park Service. Boston, Massachusetts.
- Townsend, J.F. 2009. Natural Heritage Resources of Virginia: Rare Plants. Natural Heritage Technical Report 09-07. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia. Unpublished report.
- United States Department of Agriculture. 2010. Natural Resources Conservation Service. Plants Database. <http://plants.usda.gov/>
- Virginia Department of Conservation and Recreation. 2009. Division of Natural Heritage. Invasive Alien Plant Species of Virginia. http://www.dcr.virginia.gov/natural_heritage/documents/invlist.pdf
- Wikum, D.A., G.F. Shanholtzer. 1978. Application of the Braun-Blanquet Cover-Abundance Scale for Vegetation Analysis in Land Development Studies. 2: 323-329.

Appendix 1. Coordinates for vegetation plot locations at COLO in 2008

Table 1. Coordinates for vegetation plot locations sampled at COLO site 1 in 2008, UTM, Zone 18, NAD 83, meters. ‘*’ indicates that invasive or exotic species is present at that sample plot location.

Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
COLO_C1_C1V108_2008	344822	4117815	COLO_C1_C1V2608_2008	344770	4117790
COLO_C1_C1V208_2008	344811	4117833	COLO_C1_C1V2708_2008	344743	4117831
COLO_C1_C1V308_2008	344794	4117862	COLO_C1_C1V2808_2008	344742	4117835
COLO_C1_C1V408_2008	344785	4117875	COLO_C1_C1V2908_2008	344752	4117722
COLO_C1_C1V508_2008	344695	4117729	COLO_C1_C1V3008_2008	344747	4117734
COLO_C1_C1V608_2008	344680	4117756	COLO_C1_C1V3108_2008	344704	4117802
COLO_C1_C1V708_2008	344675	4117761	COLO_C1_C1V3208_2008	344704	4117808
COLO_C1_C1V808_2008	344647	4117812	COLO_C1_C1V3308_2008	344670	4117858
COLO_C1_C1V908_2008	344641	4117820	COLO_C1_C1V3408_2008	344703	4117689
COLO_C1_C1V1008_2008	344708	4117776	COLO_C1_C1V3508_2008	344701	4117688
COLO_C1_C1V1108_2008	344697	4117795	COLO_C1_C1V3608_2008	344657	4117768
COLO_C1_C1V1208_2008	344675	4117828	COLO_C1_C1V3708_2008	344653	4117772
COLO_C1_C1V1308_2008	344671	4117835	COLO_C1_C1V3808_2008	344645	4117785
COLO_C1_C1V1408_2008	344659	4117856	COLO_C1_C1V3908_2008	344721	4117748
COLO_C1_C1V1508_2008	344657	4117860	COLO_C1_C1V4008_2008	344718	4117749
COLO_C1_C1V1608_2008	344927	4117857	COLO_C1_C1V4108_2008	344706	4117774
* COLO_C1_C1V1708_2008	344920	4117871	COLO_C1_C1V4208_2008	344704	4117775
* COLO_C1_C1V1808_2008	344914	4117880	COLO_C1_C1V4308_2008	344698	4117787
COLO_C1_C1V1908_2008	344898	4117902	COLO_C1_C1V4408_2008	344693	4117795
COLO_C1_C1V2008_2008	344880	4117937	COLO_C1_C1V4508_2008	344719	4117763
COLO_C1_C1V2108_2008	344741	4117755	COLO_C1_C1V4608_2008	344708	4117783
COLO_C1_C1V2208_2008	344732	4117772	COLO_C1_C1V4708_2008	344692	4117811
COLO_C1_C1V2308_2008	344720	4117789	COLO_C1_C1V4808_2008	344680	4117825
COLO_C1_C1V2408_2008	344710	4117807	COLO_C1_C1V4908_2008	344673	4117839
COLO_C1_C1V2508_2008	344684	4117849	COLO_C1_C1V5008_2008	344669	4117847

Table 2. Coordinates for vegetation plot locations sampled at COLO site 5 in 2008, UTM, Zone 18, NAD 83, meters.

14						
	Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
	COLO_C5_C5V108_2008	345279	4118523	COLO_C5_C5V2708_2008	345666	4118524
	COLO_C5_C5V208_2008	345279	4118483	COLO_C5_C5V2808_2008	345666	4118492
	COLO_C5_C5V308_2008	345279	4118476	COLO_C5_C5V2908_2008	345666	4118488
	COLO_C5_C5V408_2008	345279	4118469	COLO_C5_C5V3008_2008	345446	4118535
	COLO_C5_C5V508_2008	345279	4118414	COLO_C5_C5V3108_2008	345446	4118528
	COLO_C5_C5V608_2008	345332	4118514	COLO_C5_C5V3208_2008	345446	4118527
	COLO_C5_C5V708_2008	345332	4118511	COLO_C5_C5V3308_2008	345446	4118452
	COLO_C5_C5V808_2008	345332	4118476	COLO_C5_C5V3408_2008	345446	4118451
	COLO_C5_C5V908_2008	345331	4118401	COLO_C5_C5V3508_2008	345446	4118434
	COLO_C5_C5V1008_2008	345331	4118389	COLO_C5_C5V3608_2008	345445	4118389
	COLO_C5_C5V1108_2008	345331	4118379	COLO_C5_C5V3708_2008	345292	4118510
	COLO_C5_C5V1208_2008	345353	4118519	COLO_C5_C5V3808_2008	345292	4118486
	COLO_C5_C5V1308_2008	345353	4118510	COLO_C5_C5V3908_2008	345292	4118479
	COLO_C5_C5V1408_2008	345353	4118486	COLO_C5_C5V4008_2008	345292	4118427
	COLO_C5_C5V1508_2008	345353	4118457	COLO_C5_C5V4108_2008	345292	4118426
	COLO_C5_C5V1608_2008	345353	4118443	COLO_C5_C5V4208_2008	345292	4118393
	COLO_C5_C5V1708_2008	345353	4118422	COLO_C5_C5V4308_2008	345431	4118533
	COLO_C5_C5V1808_2008	345482	4118539	COLO_C5_C5V4408_2008	345431	4118485
	COLO_C5_C5V1908_2008	345482	4118538	COLO_C5_C5V4508_2008	345430	4118448
	COLO_C5_C5V2008_2008	345482	4118510	COLO_C5_C5V4608_2008	345430	4118426
	COLO_C5_C5V2108_2008	345482	4118509	COLO_C5_C5V4708_2008	345430	4118418
	COLO_C5_C5V2208_2008	345482	4118467	COLO_C5_C5V4808_2008	345430	4118404
	COLO_C5_C5V2308_2008	345482	4118444	COLO_C5_C5V4908_2008	345430	4118373
	COLO_C5_C5V2408_2008	345482	4118421	COLO_C5_C5V5008_2008	345725	4118539
	COLO_C5_C5V2508_2008	345482	4118415	COLO_C5_C5V5108_2008	345705	4118544
	COLO_C5_C5V2608_2008	345482	4118317			

Table 3. Coordinates for vegetation plot locations sampled at COLO site 6 in 2008, UTM, Zone 18, NAD 83, meters. ‘*’ indicates that invasive or exotic species were present in that sample plot.

15

Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
COLO_C6_C6V108_2008	348839	4121442	COLO_C6_C6V2608_2008	348730	4121376
COLO_C6_C6V208_2008	348835	4121438	COLO_C6_C6V2708_2008	348725	4121371
COLO_C6_C6V308_2008	348825	4121430	COLO_C6_C6V2808_2008	348694	4121344
COLO_C6_C6V408_2008	348817	4121421	COLO_C6_C6V2908_2008	348680	4121327
COLO_C6_C6V508_2008	348813	4121419	COLO_C6_C6V3008_2008	348662	4121309
COLO_C6_C6V608_2008	348799	4121456	COLO_C6_C6V3108_2008	348966	4121438
COLO_C6_C6V708_2008	348770	4121427	COLO_C6_C6V3208_2008	348955	4121427
COLO_C6_C6V808_2008	348763	4121417	COLO_C6_C6V3308_2008	348672	4121489
COLO_C6_C6V908_2008	348750	4121404	COLO_C6_C6V3408_2008	348659	4121476
COLO_C6_C6V1008_2008	348739	4121393	COLO_C6_C6V3508_2008	348642	4121458
COLO_C6_C6V1108_2008	348711	4121368	COLO_C6_C6V3608_2008	348635	4121454
COLO_C6_C6V1208_2008	348701	4121358	COLO_C6_C6V3708_2008	348850	4121446
COLO_C6_C6V1308_2008	348684	4121337	COLO_C6_C6V3808_2008	348849	4121442
COLO_C6_C6V1408_2008	348675	4121332	COLO_C6_C6V3908_2008	348848	4121442
COLO_C6_C6V1508_2008	348660	4121315	COLO_C6_C6V4008_2008	348829	4121423
COLO_C6_C6V1608_2008	348968	4121469	COLO_C6_C6V4108_2008	348670	4121459
COLO_C6_C6V1708_2008	348952	4121451	COLO_C6_C6V4208_2008	348669	4121458
COLO_C6_C6V1808_2008	348939	4121438	COLO_C6_C6V4308_2008	348644	4121435
COLO_C6_C6V1908_2008	348926	4121424	COLO_C6_C6V4408_2008	348621	4121409
COLO_C6_C6V2008_2008	348913	4121415	*COLO_C6_C6V4508_2008	348849	4121423
COLO_C6_C6V2108_2008	348795	4121442	COLO_C6_C6V4608_2008	348843	4121417
COLO_C6_C6V2208_2008	348776	4121423	COLO_C6_C6V4708_2008	348981	4121468
COLO_C6_C6V2308_2008	348769	4121418	COLO_C6_C6V4808_2008	348961	4121446
COLO_C6_C6V2408_2008	348766	4121415	COLO_C6_C6V4908_2008	348956	4121438
COLO_C6_C6V2508_2008	348755	4121402	COLO_C6_C6V5008_2008	348936	4121422

Table 4. Coordinates for vegetation plot locations sampled at COLO site 8 in 2008, UTM, Zone 18, NAD 83, meters.

Plot ID	UTM X (east)	UTM Y (north)	Plot ID	UTM X (east)	UTM Y (north)
COLO_C8_C8V108_2008	343602	4119798	COLO_C8_C8V2608_2008	343678	4119937
COLO_C8_C8V208_2008	343596	4119870	COLO_C8_C8V2708_2008	343675	4119951
COLO_C8_C8V308_2008	343592	4119902	COLO_C8_C8V2808_2008	343674	4119969
COLO_C8_C8V408_2008	343586	4119955	COLO_C8_C8V2908_2008	343677	4119821
COLO_C8_C8V508_2008	343584	4119977	COLO_C8_C8V3008_2008	343677	4119826
COLO_C8_C8V608_2008	343580	4120006	COLO_C8_C8V3108_2008	343676	4119853
COLO_C8_C8V708_2008	343516	4119824	COLO_C8_C8V3208_2008	343673	4119870
COLO_C8_C8V808_2008	343515	4119835	COLO_C8_C8V3308_2008	343668	4119911
COLO_C8_C8V908_2008	343512	4119868	COLO_C8_C8V3408_2008	343628	4119768
COLO_C8_C8V1008_2008	343498	4120000	COLO_C8_C8V3508_2008	343625	4119807
COLO_C8_C8V1108_2008	343497	4120007	COLO_C8_C8V3608_2008	343624	4119814
COLO_C8_C8V1208_2008	343517	4119852	COLO_C8_C8V3708_2008	343619	4119858
COLO_C8_C8V1308_2008	343515	4119868	COLO_C8_C8V3808_2008	343610	4119954
COLO_C8_C8V1408_2008	343514	4119877	COLO_C8_C8V3908_2008	343608	4119966
COLO_C8_C8V1508_2008	343515	4119880	COLO_C8_C8V4008_2008	343674	4119764
COLO_C8_C8V1608_2008	343502	4120017	COLO_C8_C8V4108_2008	343663	4119883
COLO_C8_C8V1708_2008	343592	4119852	COLO_C8_C8V4208_2008	343661	4119906
COLO_C8_C8V1808_2008	343594	4119868	COLO_C8_C8V4308_2008	343656	4119936
COLO_C8_C8V1908_2008	343590	4119901	COLO_C8_C8V4408_2008	343656	4119948
COLO_C8_C8V2008_2008	343588	4119925	COLO_C8_C8V4508_2008	343731	4119711
COLO_C8_C8V2108_2008	343580	4119998	COLO_C8_C8V4608_2008	343524	4119843
COLO_C8_C8V2208_2008	343578	4120019	COLO_C8_C8V4708_2008	343520	4119884
COLO_C8_C8V2308_2008	343698	4119730	COLO_C8_C8V4808_2008	343515	4119908
COLO_C8_C8V2408_2008	343699	4119733	COLO_C8_C8V4908_2008	343503	4120029
COLO_C8_C8V2508_2008	343686	4119852	COLO_C8_C8V5008_2008	343503	4120031