



Dune Slack Wetland Vegetation Monitoring Protocol, Cape Cod National Seashore

Natural Resource Report NPS/NER/NRR—2013/732



ON THE COVER

Photo of Dune slack wetland in the Province Lands.

Photograph by: Stephen Smith, 2004.

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Stephen M. Smith (Plant Ecologist)

Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667

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Revision History

The Dune Slack Wetland Vegetation Monitoring Protocol consists of a narrative (this report) and Standard Operating Procedures (SOPs) that outline specific aspects of the monitoring protocol. The latest versions of the SOPs and additional supporting information can be accessed online at the National Park Service's Northeast Region website (<http://www.nps.gov/nero/science/>).

The narrative and each SOP have respective revision history logs to document changes in the protocol. The following revision history log is for the narrative.

Version numbers will be incremented by a whole number (e.g., Version 1.0 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.3 to Version 1.4) when there are minor modifications that do not affect requirements or procedures included in the protocol. Rows are added to the log as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Description / Justification

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Background and Objectives

Background and History

Across the northern tip of Cape Cod, spanning approximately 4,448 ac (1,800 ha) within Cape Cod National Seashore (CACO) in northern Truro and Provincetown, lies a vast system of sand dunes known as the Province Lands. This post-glacial extension of the Cape Cod peninsula began forming ~6,000 years ago as eroding sediments from the Atlantic-facing coastal bluffs were transported north and re-deposited by long-shore currents. Sand from the elongating spit was then blown inland to form a wide expanse of interior dunes. Although mature forests eventually became established on this landscape, most of the vegetation was removed by European settlers for agriculture and livestock grazing. This resulted in a rapid destabilization of the ground surface, and by the mid 1800's the area had been converted to a sparsely vegetated system of shifting dunes.

Aeolian-driven changes in topography since the Province Lands developed into dunes have resulted in the formation of freshwater interdunal wetlands, otherwise known as dune slack wetlands. They occur where wind-scour has lowered ground surface elevations to the point that they intersect seasonally with the groundwater table. The wetlands tend to become “permanent” (i.e., lasting for at least 60 years) landscape features after they are formed (Smith et al. 2008). Water levels in dune slack wetlands fluctuate rapidly in response to precipitation and evapotranspiration. Hydroperiods are generally short, and there is often no surface water remaining by the end of June. In fact, water levels can fall to as much as 31.5 in (80 cm) below ground by August (Smith 2005).

Rationale for Monitoring Dune Slack Wetland Habitat at CACO

Dune slack wetlands are one of the last refuges on the outer Cape for plant species such as the insectivorous sundews (*Drosera* spp.) and orchids (*Calapogon tuberosus*, *Pogonia ophioglossoides*), which thrive in open, early successional communities. In fact, the process of plant succession (i.e., the “aging” of dune slacks) is a major driving force that determines vegetation dynamics (Smith et al. 2008). From a wildlife perspective, dune slack wetlands are critical habitat for the reproduction and survival of numerous invertebrates and amphibians, such as the spadefoot toad (*Scaphiopus holbrookii*) and Fowler's toad (*Bufo fowleri*). For larger mammals and birds, dune slack wetlands are an important source of drinking water, succulent forage, and prey. Dune slack wetlands also create soil layers on top of the sand on which they develop, thereby helping to stabilize this landscape. Finally, these areas stand out against the stark, barren vista of the dunes. As such, they are very popular with visitors, possessing aesthetic qualities that are a valued component of the Province Lands scenery.

Hydrology and water quality are of critical importance to the structure and function of dune slack wetlands (van der Laan 1979, Seliskar 1988, 1990, Mitsch and Gosselink 1993, Chadde et al. 1998, Rheinhardt and Faser 2001). Hence, CACO's dune slack wetlands may be at risk since the rapid growth of towns adjacent to CACO has been accompanied by increased demands for fresh water, which can lower the groundwater table (Martin 1993). Urban development also carries with it the potential for groundwater contamination from a wide variety of pollutants (Winkler 1994). Other threats include infestations of exotic plants such as *Phragmites australis* (common reed) and *Lythrum*

salicaria (purple loosestrife). On a broader scale, various aspects of climate change could affect the condition of these wetlands. For example, hotter, dryer summers and/or wetter winters would greatly influence hydrology and, therefore, the character of vegetation. In addition, sea level rise will result in a raised groundwater table and increased saltwater intrusion near the coastline. A longer growing season and increased CO₂ levels may enhance plant growth and accelerate rates of succession. Unfortunately, relatively little is known about dune slack wetlands within CACO and, more importantly, how they are influenced by changes in the environment. A rigorous assessment of CACO's dune slack habitat is needed to provide a basis for understanding, evaluating, and, if need be, effectively managing this resource.

History of Protocol Development

Potential dune slack wetlands were identified in 2002 on August 2000 (available at CACO) and December 2001 (available from Massachusetts Department of Environmental Protection) digital, georeferenced images of Provincetown and Truro. In addition, coordinates and general information for 66 previously known dune slack wetlands were provided by Dr. Robert Cook (Wildlife Biologist, CACO). Excluded from the search area were about 815 ac (330 ha) of dense beech and pine-oak forest where seasonally flooded wetlands are properly referred to as forested vernal wetlands. Using Arcview™ version 3.2, each potential wetland was identified with a point symbol. The coordinates of these points (the approximate center of each wetland) were then exported and uploaded into a Garmin 76S GPS unit. During the summers of 2003–2004, field crews ground-truthed every site (excluding the 66 known sites). Wetlands were then characterized based on the presence of hydrophytic taxa with wetland indicator designations (USACOE 1987) of facultative (FAC), facultative-wet (FACW), or obligate (OBL). This is stated in the text of the document as “The boundaries of the wetlands were determined by where hydrophytic vegetation was absent; i.e., where it gives way to upland dune species. Within each wetland, percent canopy cover of trees and shrubs was estimated to the nearest 5% (a commonly used method of vegetation analysis; e.g., Wang et al. 2000). In addition, the cover of each species found within the wetland was estimated visually and assigned a modified Braun-Blanquet cover class value (0=0%, 1=<1%, 2=1–5%, 3=6–25%, 4=26–50%, 5=51–75%, 6=76–100%) indicating its relative abundance. While visual estimates of cover inherently have some observer bias, good training of field crews on this method should minimize this problem. In addition, the percentage bounds are relatively broad, so estimates can vary quite substantially without translating to different cover ranks. The boundary of each wetland was determined by the extent of hydrophytic vegetation belonging to OBL, FACW, or FAC categories. A total of 336 wetlands were identified and characterized in this manner (Smith 2005).

In 2004, a subset of 15 wetlands was randomly selected from the entire known inventory of 336 sites (using Arcview 3.2 randomization tools) for more intensive, transect-based sampling. The vegetation survey techniques, consisting of visual assessments and line point intercept (which are described in detail below), are commonly used for vegetation assessments in many different environments (Kent and Coker 1992). This effort allowed for an initial analysis of dune slack wetland vegetation character and the relationship of vegetation communities with successional stage/age and certain environmental parameters—providing a basic conceptual model for the development of a long-term protocol (Smith et al. 2008).

Another 11 intensively monitored sites were added (random selection using ARCGIS™ version 8.1) in 2009 (for a total of 26), and vegetation surveys were conducted at all 26 sites using the same methods used in 2004. To date, dune slack vegetation monitoring has provided valuable information on plant community composition, character, and rates of change over time (e.g., Smith et al. 2008, 2010). This document describes the techniques to be used to collect this information in the future and discusses how the data fit into the context of the larger I&M programmatic framework for long-term protocol development at CACO.

Objectives

Management Objectives

Although CACO has not yet developed any specific management objectives for dune slack wetlands, the preservation of natural hydrology, natural rates of plant succession, control of invasive taxa, and maintenance of unique wetland plant assemblages are some of the more important management issues for this resource. More broadly, it is the responsibility of CACO to use scientific information to better understand, preserve, and protect natural ecosystems.

Monitoring Objectives

The principal monitoring objective is to document spatial and temporal change within dune slack wetland plant communities with the highest degree of accuracy possible. The sampling design seeks to provide high-quality quantitative data on dune slack vegetation structure and composition and temporal changes in these variables. This protocol also seeks to maximize statistical power to detect such changes. Understanding the ways in which dune slack vegetation and pertinent environmental factors are shifting through time provides a basis for predicting changes in these ecosystems, and, vice versa, the frequency with which various management actions (cutting, herbiciding, and/or prescribed fire) may be warranted.

Sampling Design

Vegetation

The vegetation sampling design is based on standard methods of vegetation monitoring as well as the knowledge and experience gained from conducting surveys in dune slack wetlands in 2003, 2004, and 2009. It is important to note that the methodology used in all years has already resulted in the detection of various changes in the vegetation. For example, analyses based on 2004 and 2009 data from the 15 original intensively studies (IS) sites (contained in Smith et al. 2010) revealed clear evidence of succession, with woody species increasing in cover and herbaceous species diminishing. The exotic *Phragmites australis* (common reed) also increased, particularly at one site that experiences occasional flooding by salt water.

There are currently 26 IS dune slack wetland sites included in this protocol (Figure 1); these chosen randomly from the set of known wetlands using ARCGIS™ randomization tools. The group includes a large range in size, complexity, species composition, and hydrology. At each IS site, five randomly placed transects run through the wetland from a few meters upland of the wetland edge (defined as the point where non-wetland vegetation started) to the opposite edge perpendicular to the long axis of the wetland (thus the length of each transect varies with the width of the wetland; Figure 2). In this way, transects capture the “edge” species. These species represent a very small proportion of the overall community. They exist as a very thin ring around the periphery of the wetlands in most cases. As such, it is thought that they are adequately represented. PVC pipes (0.5-in diameter) demarcate the end points of each transect (a few meters beyond the edge of the wetland) and are GPSed with a Garmin 76S. The end points were chosen subjectively, but with the stipulation that they be at least 1-m distant from the wetland edge (where hydrophytic vegetation dominates).

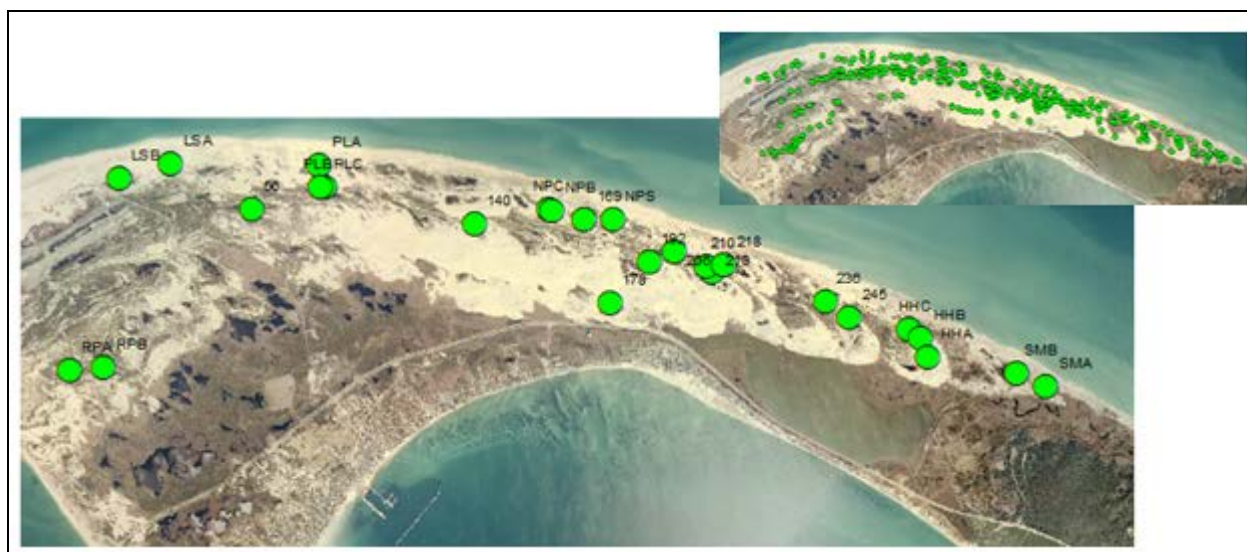


Figure 1. Air photo of the 26 IS (main photo) and the 520 mapped (top-right insert) dune slack wetland sites.

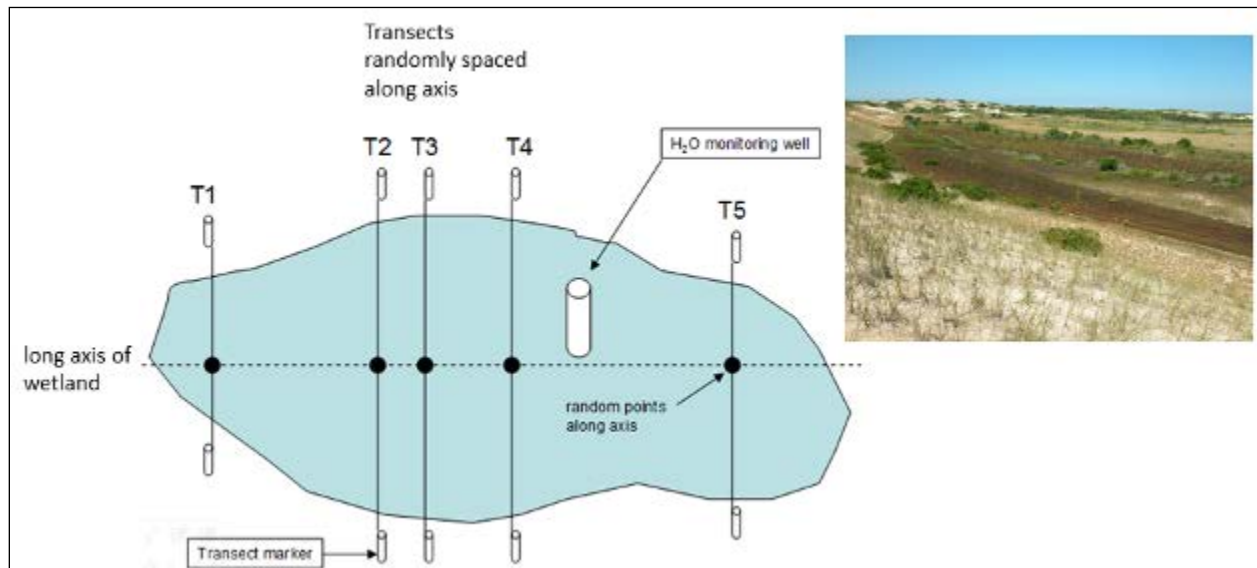


Figure 2. Diagram of an Intensively-monitored Subset site with transect layout (left) and an example of a dune slack wetland (right)

To assess vegetation cover within a wetland (SOP#5), a field tape is stretched out between the end points (the PVC pipes) of five transects within each wetland (Figure 2). Vegetation is recorded at 0.5-m intervals along the line by point intercept, which is a standard method for collecting vegetation data (Kent and Coker 1996). Point intercept was chosen over plot sampling as it would be extremely difficult, if not impossible, to set up two-dimensional plots in dense shrubby vegetation with many layers of vegetation at different heights. All species making contact with a vertical rod placed at each point are recorded and percent abundances are then calculated from counts of species “hits” (sample worksheets: Y:\I&M_Projects\Dune_Slack_Wetlands\Methods&Metadata\Worksheets). This is done along the entire length of the transect (note: the distance between the 2nd to last point and the transect end point are usually not 1 m, but this is okay). Transects are surveyed in July–August every five years. The field crew should be able to still identify species that bloom in late August or September because they will still be present at this time—even though they haven’t flowered. Species abundances across the entire wetland (the extent of which is based upon the presence of hydrophytic vegetation) are converted to cover class ranks based on the modified Braun-Blanquet scale (0=0%, 1=<1%, 2=1–5%, 3=6–25%, 4=26–50%, 5=51–75%, 6=76–100%). The data generated by these two methods provide a means with which to quantify temporal changes in plant communities in these systems. Because Braun-Blanquet data is based on rankings, only non-parametric analyses should be used for analysis such as Analysis of Similarities (ANOSIM) and Similarities Percentages (SIMPER), etc. (Clarke and Warwick 2001).

Environmental Variables

Several abiotic variables important for describing structure and functioning of dune slack wetlands are characterized in this protocol. These are porewater quality, soil properties, and hydrology.

Porewater Quality

Porewater is collected by syringe from each wetland (see SOP#5) in July and tested for pH and conductivity using a multi-parameter water quality analyzer (Oakton Multi-Parameter PCSTestrTM35) (SOP#5). Porewater collection locations are the mid-points of the middle three transects. Elevated conductivity is an indication of salt spray influence. Salt spray has been shown to directly inhibit plant growth in many different kinds of coastal communities (Griffiths and Orians 2003) and may be similarly influencing CACO's dune slack wetlands. Inputs of base-forming cations from sea salts (Ca, Mg, K, Na) can produce changes in water chemistry that enhance organic matter decomposition (Duckworth and Kresser 1991, Sival and Grootjans 1996). Acidity (pH) has been cited as a primary factor regulating dune slack successional processes (Sival 1996, Sival and Grootjans 1996, Adema et al. 2002). Groundwater is generally less acidic (higher pH) than precipitation; similarly, conductivity values in groundwater are generally higher than those of rainwater. Decreasing groundwater influence, which could occur as a consequence of groundwater extraction and water table depression, would theoretically result in more rapid acidification of dune slack wetlands as rainwater becomes less diluted with the more alkaline groundwater, thereby hastening the acidification of wetlands as precipitation begins to contribute more to the water budget of these wetlands. This, in turn, may result in increasing abundance of more acid-tolerant vegetation.

Soil Organic Matter

Soil samples (three per wetland taken from the mid points of the middle three transects) are extracted from each IS wetland using a tubular coring device (see SOP#5), brought back to the laboratory, and analyzed for organic matter content. Organic matter content is indicative of both successional stage and hydroperiod in that there tends to be more organic matter accumulation in older, wetter wetlands (Richardson and Vepraskas 2000). Sediment nutrient concentrations are positively correlated with organic matter content (Berendse et al. 1998) and age (Grootjans et al. 2004). It is well-known that accumulation of organic matter facilitates the establishment of later successional species. Finally, just as hydrology can influence the accumulation of soil organic matter, soil organic matter also influences the hydrology of wetlands. Organic matter is much less permeable than inorganic sand. As such, more rainwater would also be trapped and retained by wetlands with thicker organic layers that do not allow percolation to the groundwater. Similarly, groundwater has more difficulty penetrating wetlands through the subsurface peat. Thus, the water surface of wetlands with thicker peat layers can be lower than the surrounding groundwater at times. Where organic matter layers are thin and not well developed, there is greater connectivity between groundwater and wetland hydrology. All these factors have the potential to significantly influence the structure of dune slack vegetation communities.

Hydrology

As in all wetland systems, hydrology is of critical importance to the structure and functioning of dune slack wetlands (van der Laan 1979, Seliskar 1988, 1990, Mitsch and Gosselink 1993, Chadde et al. 1998, Rheinhardt and Faser 2001). The first method involves manual recording of water levels in the fixed groundwater wells. The second method is to use HOBO pressure logging devices, which can automatically collect data every 30 minutes. Both methods are described in detail in SOP#5, although the first method (manual readings) is the one that is proposed for this protocol until enough HOBO units are available to put on in each of the 26 wetlands.

Other Environmental Factors for Which Data is Available

CACO has access to a large quantity of air quality data from a site within the park that is part of the National Atmospheric Deposition Program (NADP). In particular, precipitation and the dry and wet deposition of nitrogen are of interest in analyzing changes in dune slack plant communities. Similarly, information on the deposition of acid (SO_4) vs. basic (e.g., Ca) constituents is important for understanding pH dynamics in these systems.

Number and Location of Sampling Units

The complete inventory of dune slack wetlands includes 524 sites (since 188 new sites were discovered in 2009; Smith et al. 2010). Because it is logistically impossible to survey all 524 in a single growing season, twenty-six of these sites were randomly selected for more intensive analysis. This subset of wetlands is the focus of this long-term monitoring protocol. The location of these sites ranges throughout the extent of the Province Lands, from north Truro (near High Head) to the west end of Provincetown (near Race Point) (see SOP#4 and Figure 1).

Frequency and Timing of Sampling

This protocol proposes conducting the monitoring every five years. This time period will be further evaluated as more data are collected over the next few decades. A revision to sampling frequency may be made depending on future analyses of vegetation change over this time period. The vegetation is surveyed during the peak of the growing season in July–August when plant biomass is at a maximum.

Power Analysis

Dune slack wetland plant communities and the changes they have undergone are described in detail in Smith et al. (2008) and Smith et al. (2010). For this protocol, the 2004 and 2009 data were subjected to power analyses to assess the adequacy of the sampling design for detecting change. Power and Sample Size version 3.043 and XLSTAT version 5.01 were the programs used for these calculations. Although there are no formal standards for power, most researchers assess the power of their tests using $P=0.80$ as a standard for adequacy, which has been adopted for this protocol. A power of 0.80 means that there is an 80% chance that if there was an effect we would detect it (or a 20% chance that we'd miss the effect). The main power objective of this protocol is to achieve at least an 80% power to detect significant changes in the various parameters surveyed. This document is the first report on power values for dune slack wetlands that are monitored at CACO and makes some recommendations as to the potential for improvement where necessary. The success of any measures taken will be reported in subsequent update reports on dune slack monitoring.

Multivariate Data

Power analysis for multivariate data such as species composition is not possible by any direct means. The distributions of counts for each species are not normal, their variances are unlikely to remain constant through time, and the values are correlated with each other. In addition, there is no way to specify the change in these values that one wants to have the power to detect. For example, one cannot specify a 10% change, because this does not mean a 10% change in every species. Some taxa will become less abundant while others will become more abundant and some will be unaffected. Additionally, some species will disappear altogether and other species will come in that weren't there before. Accordingly, the number of different scenarios that exist for potential changes in species composition is infinite.

For single variables, power analysis was conducted by calculating the following: 1) the difference between values (e.g., species richness or shrub cover) for each site in 2004 vs. 2009; 2) the standard deviation of those differences; and 3) a change in the original mean value for all sites (i.e., mean of the 2004 data) of 20%, 50%, or 80% (e.g., mean of 2004 data $\pm$ [mean of 2004 data*0.2]). Using the number of samples (sites), the standard deviation of the differences between each site by year, the change in means we wish to detect (20%, 50%, or 80%), and statistical confidence level ($\alpha=0.05$), the power was calculated using Power and Sample Size (Version 3.0) (Dupont and Plummer 1990).

Change in Percent Shrubs and Trees

The power to detect large changes in vegetation structure (i.e., growth forms) was low, and these results indicate the need for many more sites to be included in the monitoring network to improve power for these variables (Table 1).

Table 1. Power values for detecting a 20%, 50%, and 80% change in mean percent cover values by growth form (trees or shrubs) ($\alpha=0.05$).

% Change	Shrubs	Trees
20%	0.08	0.09
50%	0.30	0.34
80%	0.63	0.72

Change in Species Richness (All Sites)

Based on statistical analysis of 2004 and 2009 data, the power to detect a 20% change in species richness across all sites was nearly 90% (Table 2). Power to detect larger changes was close to or equal to 100%.

Table 2. Power values for detecting a 20%, 50%, or 80% change in mean species richness ($\alpha=0.05$).

% Change	Power
20%	0.89
50%	0.99
80%	1.00

Change in Species Richness (Individual Sites)

The power to detect relatively small changes in species richness was mostly low at individual sites but almost uniformly high for larger changes (Table 3). Thus, with the current array of sites and transects, the power to detect changes of 50% or more is very good.

Table 3. Power values for detecting a 20%, 50%, or 80% change in species richness by site (alpha=0.05).

Site	Level of Change		
	20%	50%	80%
HHA	0.06	0.15	0.38
HHB	0.61	0.99	1.00
HHC	0.20	0.93	1.00
LSA	0.52	0.99	0.99
LSB	0.63	0.99	1.00
NPA	0.90	0.99	1.00
NPB	0.98	1.00	1.00
NPC	0.24	0.95	0.99
PLA	0.57	0.99	1.00
PLB	0.21	0.94	0.99
PLC	0.11	0.64	0.96
RPA	0.33	0.98	1.00
RPB	0.405	0.99	1.00
SMA	0.576	0.99	1.00
SMB	0.33	0.98	1.00

Change in Individual Species over Time (All Sites)

The twelve most abundant species, as determined by cover and frequency, were subjected to power analysis to assess whether the current methods are sufficient to detect trends in these taxa (Table 4). In general, the power to detect a 50% change in cover was relatively high in most species. The power to detect very large changes of ~80% was even higher. Species that had low power values in this regard were *Phragmites australis* and *Toxicodendron radicans*.

Table 4. Power values for detecting a 20%, 50%, and 80% change in mean percent cover values by species (alpha=0.05).

%	AmmBre	ClaMar	DesFle	DicAcc	Juncus spp.	KalAng	MyrPen	PhrAus	PinRig(T)	SciCyp	ToxRad	VacMac
20%	0.21	0.42	0.42	0.10	0.28	0.13	0.42	0.05	0.10	0.13	0.08	0.28
50%	0.67	0.95	0.99	0.42	0.95	0.42	0.95	0.08	0.82	0.64	0.16	0.90
80%	0.95	0.99	1.00	0.82	0.99	0.77	1.00	0.14	0.99	0.96	0.52	0.99

AmmBre = *Ammophila breviligulata*, ClaMar = *Cladium mariscoides*, DesFle = *Deschampsia flexuosa*, KalAng = *Kalmia angustifolia*, MyrPen = *Myrica pensylvanica*, PhrAus = *Phragmites australis*, PinRig(T) = *Pinus rigida* (tree), SciCyp = *Scirpus cyperinus*, ToxRad = *Toxicodendron radicans*, VacMac = *Vaccinium macrocarpon*.

Summary of Power Analyses for Dune Slack Vegetation Change

It should be reiterated here that the sampling methodology used in previous years has heretofore been effective in capturing various spatial and temporal trends in plant communities. These results can be found in Smith (2005), Smith et al. (2008), and Smith et al. (2010). Power computations are something different altogether and the analyses described above indicate that the power to detect specific levels of change is quite different among the different variables. For example, the power to detect small changes in species richness or species composition is high, whereas it was low for estimates of percent trees and shrubs. With respect to the latter, only large changes in wetland character will be revealed by the data. It is important to note, however, that these power analyses were done on only 15 of the 26 IS wetlands that were common to both the 2004 and 2009 surveys. The addition of the 11 new IS wetlands in 2009 might improve power (another power analysis will be conducted for all 26 IS sites after the next vegetation survey scheduled for 2014).

For individual species, power levels were variable for detecting 50% and 80% changes in mean values but uniformly low for detecting a 20% change. Smooth sawgrass (*Cladium mariscoides*), wavy hair-grass (*Deschampsia flexuosa*), rush (*Juncus* spp.), northern bayberry (*Morella pensylvanica*), and cranberry (*Vaccinium macrocarpon*) had power values of > 0.90 for a 50% change (even higher for 80%). Tapered rosette grass (*Dichanthelium acuminatum*), sheep laurel (*Kalmia angustifolia*), poison ivy (*Toxicodendron radicans*), and common reed (*Phragmites australis*) had very low power values for all levels of change due to the high variability in abundance among sites.

Increasing sample size is one way to increase power (as was already done in 2009); however, a second dataset including these new sites is needed for re-evaluation of power. Analyzing more data from future monitoring will refine the picture of statistical power. Adding another 10 wetlands (or more if possible) might further improve detectability. Increasing the number of transects within the wetland might also be helpful in terms of increasing the power for certain individual wetlands. However, given the logistical difficulties of adding more sampling while trying to confine data collection to as short a time window as possible (to minimize temporal variation in biomass and development in plants over the course of the growing season), it may turn out that having low power for various components of the protocol will have to be acceptable.

Power Analysis of Environmental Variables

The power to detect changes in pH and conductivity was high. For pH, power values for detecting changes of 20%, 50%, and 80% were all 1.00. For conductivity, these values were 0.62, 0.99, and 1.00, respectively. With respect to soil OM, power to detect significant change was very low at 0.067. As such, a very large number of additional samples would need to be collected during the next survey to increase statistical probability of detecting change. Therefore, this parameter does not appear to be a useful parameter for long-term monitoring and should be deleted from the sampling. Power analysis was not conducted for hydrologic variables because they are continuous, non-linear variables with large fluctuations that do not represent sample (wetland) variability *per se*.

Field Methods

The following sections provide an overview of field operations. These procedures are described in more detail in the SOP section of this document.

Field Season Preparations and Equipment Setup

Prior to the field season, it is important that the lead biotech set aside some time to become familiar with the vegetation he/she is likely to encounter and the process of identifying unknown specimens. Historic data, field guides (see SOP#2), and electronic documents summarizing key morphological attributes for identifying species are available in CACO's North Atlantic Coastal Laboratory (NACL) library and on the NACL server.

The entire crew, including the Project Manager, also must make sure that all equipment is available (see Equipment list in SOP#1) and in working order before use. Before conducting the actual sampling, vegetation data from the last (most recent) survey should be extracted from the database so that it can be used as a reference, if needed. Finally, both members of the two-person field crew should review the entire protocol and make sure that they understand all the components of sampling, quality assurance, and data management.

Sampling Procedures

A discussion of all sampling procedures can be found in the SOPs below.

End-of-Day Procedures

Upon returning from the field, any voucher specimens collected as unknown specimens should be identified (see SOP#5). Field notes/datasheets should immediately be checked for completeness and accuracy and then photocopied. The backup copies should be stored in a separate folder in a fireproof cabinet. If there is time, it is advisable to enter data the same day they are collected. Alternatively, one day a week can be set aside for this purpose. As a general rule, the time between data collection and entry should be minimized to the greatest extent possible and in no case should be longer than one week.

Throughout the day, and especially at the end of the day, each crew member should check themselves and each other for attached ticks. If any are discovered, they should be carefully removed in a manner prescribed in the "tick safety" presentation—a Powerpoint file located on the NACL server. Anyone who finds an attached tick must then fill out a safety documentation form and submit it to the Project Manager, who will then forward all information to the Chief Safety Officer.

End-of-Season Procedures

At the completion of the field season, the lead biotech is responsible for writing an end-of-season report. The report should outline the activities undertaken, summarize key findings, and discuss any problems or issues that arose and suggestions for revisions/improvements. The crew must thoroughly inspect all the equipment to ensure that each item is in working order and a list of items that need replacing or repair is compiled. The vehicle assigned to the dune slack wetland monitoring crew for the season should be thoroughly cleaned.

All field workbooks, datasheets, and notes should be organized and given to the Project Manager for safe keeping. It is imperative that all the data be entered into the electronic database and a preliminary QA/QC of the data be conducted before the field crew leaves at the end of the season.

Data Handling, Analysis, and Reporting

Recommendations for Data Summaries and Statistical Analyses

There are many different ways in which to analyze the dune slack vegetation data (Kent and Coker [1996] can be consulted for a comprehensive view of vegetation description and analysis). In general, analyses should be based upon the kinds of research or management questions driving the monitoring. Changes in the floristic composition of understory and, particularly, overstory strata will almost always be an important management consideration. Changes in environmental variables are also important in understanding these systems. For cover class data, ordination techniques are an excellent way to describe spatial and temporal variability. Changes in species composition over time and space can be illustrated using principal components analysis (PCA). For non-parametric data (e.g., Braun-Blanquet cover rankings) non-metric multidimensional scaling (NMSD), clustering, Analysis of Similarities (ANOSIM), and Similarity Percentages (SIMPER) would be used (Clarke and Warwick 2001).

For univariate data, the means and standard errors of the mean (standard deviation divided by the square root of the number of samples) should be calculated and plotted. To examine temporal shifts, mean values calculated from different surveys (e.g., 2004 vs. 2009) can be compared. Statistical validation of such changes can be conducted using paired or independent T-tests or repeated measures ANOVA. Regression analysis can also be used to assess longer temporal trends—for example, change in shrub percentages over the last three sampling periods (note: regressions must be based on at least three datasets, since a trend cannot be defined by only two points).

For some level of data quality control, it is recommended that a random resample of the vegetation at 5% of the sites (2 sites per year of sampling) be conducted. In this way, variability in cover class estimates can be documented. In addition, a comparison between primary and secondary surveys can be included in the report for the sampling year.

Recommended Reporting Schedule

Reporting should be done after every season of fieldwork (once every five years) to assess temporal trends. The report should include background information about the project, a summary of what was accomplished during the season, and some basic analyses of the data (see previous section).

Personnel Requirements and Training

Roles and Responsibilities

General oversight and implementation of the protocol is provided by the Project Manager, which, ideally, will be a Plant Ecologist or Botanist. The Project Manager's specific duties include staff selection, training, and supervision, data analysis, reporting and interpreting results, and protocol evaluation. The data collection portion of the protocol can be carried out with a biotech accompanied by a student intern/volunteer. The biotech will supervise all aspects of data collection and processing, including several aspects of QA/QC, such as data entry and proofing. The Project Manager is responsible for ensuring that information is collected in a way that will be compatible with the existing database structure. The Inventory and Monitoring (I&M) Coordinator provides supervision and oversight of CACO's Prototype Monitoring Program and is responsible for ensuring that all project, Program, NPS, and scientific standards are met.

Qualifications and Training

The ability to make rapid, accurate IDs in the field is critical to completing fieldwork in a timely manner. Minimally, the lead biotech should be very familiar with the majority of plant taxa likely to be encountered. Where deficiencies occur, the Project Manager should assist the technician in developing the knowledge and skills required for identification (including the use of field guides, etc.). For unknown species that cannot be identified in the field, the crew must be able to use taxonomic keys and other relevant materials for confirmation. It is extremely helpful to allot some time prior to sampling to become familiar with the plant communities of the monitoring network and to develop skills in estimating percent cover (see SOP#5).

Ideally, both members of the field crew will have a good working knowledge of dune slack wetland mensuration techniques and plant community ecology. Additionally, both members of the field crew will be trained in the following areas:

- Implementation of the specific field procedures and methods in this protocol
- GPS navigation and compass use
- Tick bite prevention and treatment
- General field safety (e.g., prevention of poison ivy, heat exhaustion, etc.)
- Vehicle safety and driving etiquette
- Equipment maintenance and storage
- Use of two-way radios
- Computer use guidelines
- Data entry and basic principles of data QA/QC, database functionality
- Data storage guidelines.

Operational Requirements

Annual Workload and Field Schedule

To complete data collection in a timely manner for all 26 sites (or more for later surveys if new sites are added), the field crew should plan to visit at least one site per day. This totals roughly 12 days or the equivalent of approximately five weeks of field work on vegetation alone and provides an adequate buffer for cancellations due to inclement weather. It also ensures enough time for gathering data on environmental variables—especially water quality and hydrology, since surface water disappears quickly during hot weather in the summer.

Facility and Equipment Needs

The field crew will require use of normal office space and a computer linked to the NACL server. Internet connectivity is necessary as plant identification and general research can be aided by referencing various Web sites, such as the U.S. Department of Agriculture PLANTS and other databases (see SOP#2). A small amount of additional space will be necessary for storage of unidentified plant specimens. The crew will also require a vehicle (preferably a pick-up truck) with four-wheel drive capability. All other equipment needs are listed in SOP#1.

Startup Costs and Budget Considerations

Project-specific costs are primarily limited to personnel, which includes a plant ecologist/botanist and either two biological technicians or a biological technician and a student intern/volunteer. The I&M Coordinator and Project Manager will also contribute to overall staffing costs for the project. Other costs will generally be related to equipment repair and replacement, vehicle maintenance, etc.

Potential Future Enhancements and Revisions to Protocol

In order to enhance the power to detect subtle changes in dune slack vegetation, more sites should be added to the existing 26 IS wetlands. If possible, it would be advantageous to add at least 10 more sites. This would bring the total to 36, which could still be monitored in a reasonable time frame during July–August.

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Standard Operating Procedure (SOP) #1. Preparations and Equipment Setup Prior to Field Season

Cape Cod National Seashore
Dune Slack Wetland Vegetation Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

Preparation

To prepare for the field season, the field crew must complete the following activities:

- Review the entire protocol and discuss with the Plant Ecologist/Botanist
- Review species lists and plant characteristics for species identification
- Retrieve and review prior data for reference
- Visit actual sites or similar habitats to become familiar with vegetation, practice identification skills, and rehearse setting up plots
- Consult maps of site locationsInspect equipment and compile the items listed below

Equipment List

- Field tape (100 m)
- Vials for storage of Porewater samples
- Ziploc bags for storage of soil samples
- Water quality meter
- Compass
- Datasheets/field notebooks
- GPS unit with site coordinates
- Hardcopy map of site locations with plot layout diagrams
- List of species previously found in plots (legacy data)
- Plant identification materials (field guides, digital images, etc.)
- Waders
- Insect repellent
- Pre-contact solution for prevention of poison ivy and poison sumac
- Bayonet for point intercept data collection
- Cell phone and two-way radio with Park contact numbers

Standard Operating Procedure (SOP) #2. Training Observers

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

Identification of Plant Taxa

At the beginning of the season, the Project Manager (botanist, plant ecologist) will take the field crew out to actual sites or similar habitats and review as many different taxa as possible. The field crews are to review a list of species (from historic data) they are likely to encounter and study characteristics, images, or actual samples from the NACL or Salt Pond Visitor Center herbaria.

In addition, the following guidebooks are recommended for plant identification:

- Garrett E. Crow and C. Barre Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America, Volume I, Pteridophytes, Gymnosperms, and Angiosperms: Dicotyledons. Univeristy of Wisconsin Press, WI.
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- University of Massachusetts. The UMass Cranberry Station. An Illustrated Guide to the Weeds of Cranberry Bogs in Southeastern New England.

The following web sites are also recommended:

- <http://plants.usda.gov/>
- <http://www.ct-botanical-society.org/docs/fernchart.html>
- <http://www.ct-botanical-society.org/>
- <http://hua.huh.harvard.edu/FNA/>

Standard Operating Procedure (SOP) #3. Using the Global Positioning System

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

General Use

Note: these instructions are for the use of Garmin GPSmap 76S units (which are the ones currently in use). For all other GPS models, consult with CACO's GIS Specialist. Keep the GPS unit dry at all times. In wet conditions, the unit should be placed inside a clear plastic bag. This will not interfere with its ability to function properly. Do not leave the unit on for long periods of time between uses, as the batteries will drain quickly. When crossing waterbodies (tidal creeks, ponds, streams, etc.), the unit should be kept in a waterproof container or pouch. If the unit is accidentally dropped into water, do not attempt to turn it on. Return to the office and consult with the Project Manager for the proper course of action.

Satellite reception may vary substantially depending upon interference from trees, topography, structures, weather, and satellite configurations. The unit should be held face up (i.e., the display screen facing upward). Also make sure that the antenna is pointing skyward.

Recording Points

The datum for all coordinate values is NAD-83 and the coordinate system is Universal Transverse Mercator (UTM) (Zone 19T).

To record new points on Garmin GPSIII Plus units (the most current technology at CACO), follow this procedure:

- Press the "menu" button (starting from any screen) twice.
- Highlight the "Waypoints" option and hit "Enter".
- Press "menu" again and select "New Waypoint".
- Hit the "menu" button one more time, select "Average position" and press "Enter".
- Wait until a satisfactory accuracy level (shown onscreen under "estimated accuracy") is obtained (usually requires measurement > 100 position counts)

Navigating

Thick canopy cover presents a problem in navigating with GPS units in that satellite reception is significantly hindered. In such cases, it is advisable to move into any open areas in the nearby vicinity. If satellite reception is still poor, it will be necessary to use hardcopy maps of the sites. For more information on the use of GPS technology, refer to the technical manuals for the specific GPS unit being used.

Standard Operating Procedure (SOP) #4. Finding and Setting Up Transects

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

Site and Plot Information

Currently there are 26 IS sites (photographs of IS wetlands can be found in Appendix III) with permanent transects in this protocol. All site metadata (coordinates, transect lengths, transect end-point locations, and position relative to wetland shape) are saved on the NACL server in:

Y:\I&M_Projects\Dune_Slack_Wetlands\Methods&Metadata.

In general terms, sites are scattered throughout the extent of the Province Lands, from near Hatches Harbor (at the west end of Provincetown) to east of High Head (north Truro) (see Figure below).

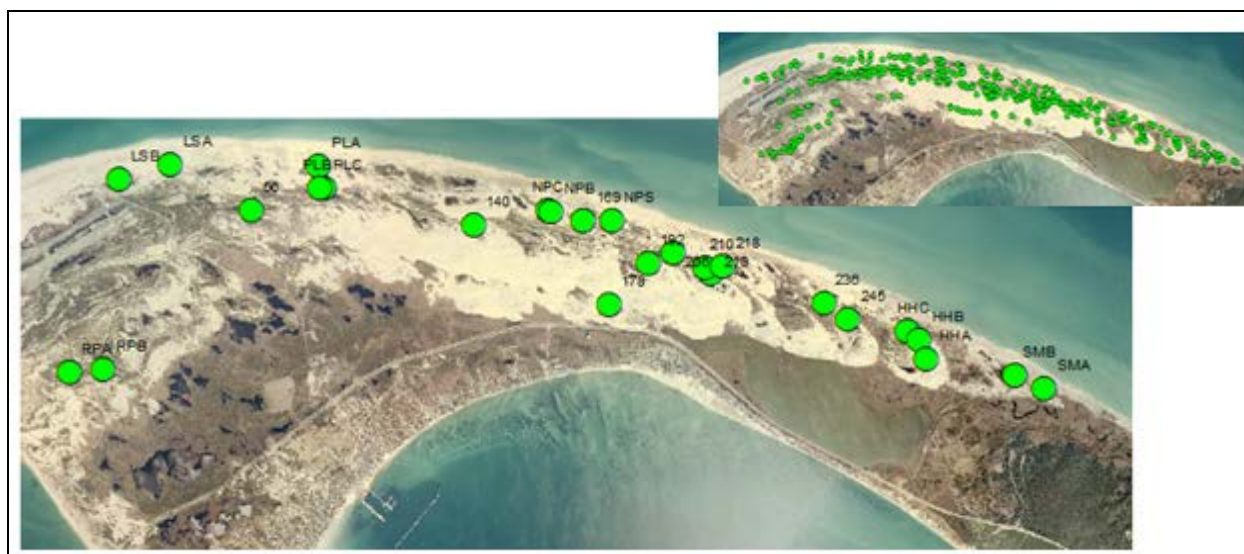


Figure SOP4-1. Map of 26 intensively-monitored sites across the Province Lands dunes.

For each IS site, five permanent vegetation transect locations were established at each site by running a field tape along the main “axis” of the wetland. At five randomly chosen points along that axis (chosen using Arcview 3.2 randomization tools), transects were laid out perpendicular to the main axis (determined subjectively based on shape) of the wetland from a few meters into the upland edge to the opposite edge (upland edge is where hydrophytic vegetation ends). PVC pipes (0.5-inch diameter) were then inserted into the upland at least 1 m away from the wetland edge (where hydrophytic vegetation starts) to demarcate the end points of each transect. The end points of each transect were marked using a hand-held garmin GPS76S unit (accuracy to ≤ 5 m) and can be found using a similar instrument. A field tape is stretched from one end point (marked with a PVC pipe) to the other across the wetland. It is sometimes difficult to lay the field tape out straight in dense shrubs. In such cases, the tape must be threaded through the woody stems. The metadata for each transect should be consulted so that the proper transect length is attained when laying out the tape. Any large bends or curves in the tape will result in substantial deviations in spatial coordination with previous surveys.

Standard Operating Procedure (SOP) #5. Conducting the Monitoring

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

Conducting the Vegetation Sampling

Transects

When conducting transect vegetation monitoring, crews must be careful to walk on only one side of the transect tape so as not to trample the vegetation to be assessed. Additionally, the point-intercept rod is actually placed 0.5 m perpendicular to one side of the transect line to avoid vegetation impacted by laying out the field tape. Vegetation is then recorded at these offset locations at 0.5-m intervals along the line (opposite the side that is walked on; see Figure below) starting and ending at the PVC poles that mark the transect ends. All species making contact with the point-intercept rod (0.5-cm diameter, 2-m long wooden dowel) which is placed vertically at each sampling point are recorded. Transects must be surveyed in late-July or early-August for consistency with prior surveys. This time period coincides with the development of maximum plant biomass.

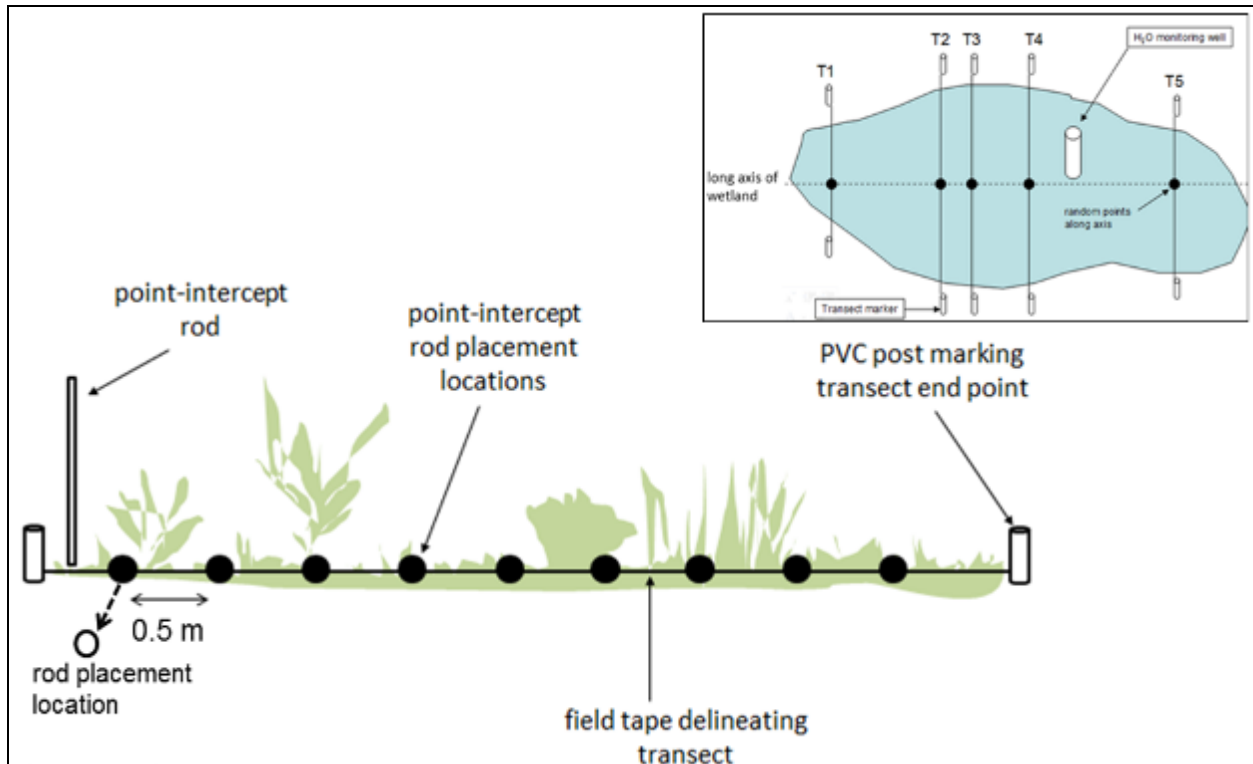


Figure SOP5-1. Diagram outlining the point-intercept method of vegetation monitoring along transects.

Conducting the General (Whole Wetland, Non-transect Based) Vegetation Surveys

The following “whole-wetland” data are collected at each site following transect monitoring:

- Percent cover of trees vs. shrubs vs. herbaceous vegetation is estimated visually to the nearest 5%.
- Cover (horizontal area occupied) by species – estimated visually based on Braun-Blanquet cover class values (0=0%, 1=<1%, 2=1-5%, 3=6-25%, 4=26-50%, 5=51-75%, 6=76-100%).

Estimating species and growth form cover can be challenging when working in large, complex wetlands. In some situations it is best to climb up on an adjacent dune for a better view of the wetland. In most cases, it is necessary for the crew to meander through the entire wetland in a zigzag fashion and then make a decision on an appropriate cover category for each species and growth form. Note that the cover for all species within a defined area can add up to >100% since there are different height layers of vegetation (see Figures below).

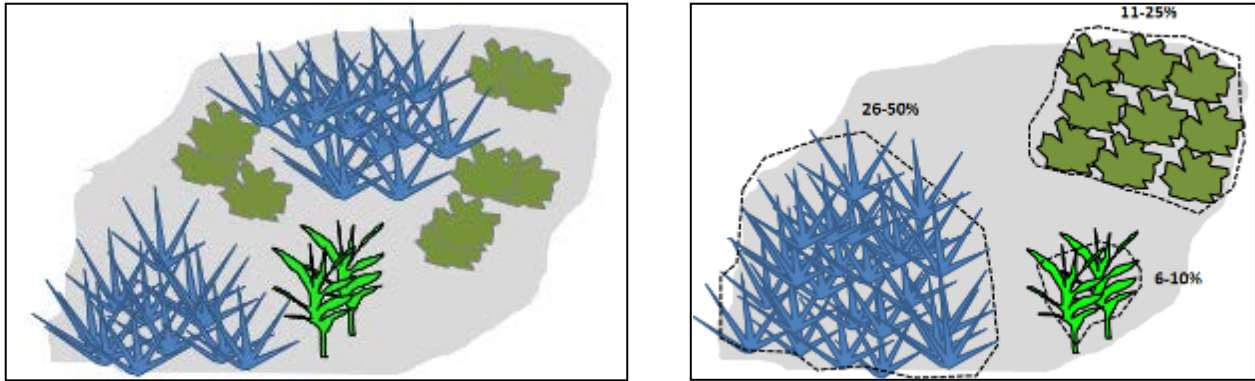


Figure SOP5-2. Conceptual diagram of vegetation with a dune slack wetland (left) and the process by which the cover of each species is estimated visually (mental consolidation of each species and comparison to overall wetland area).

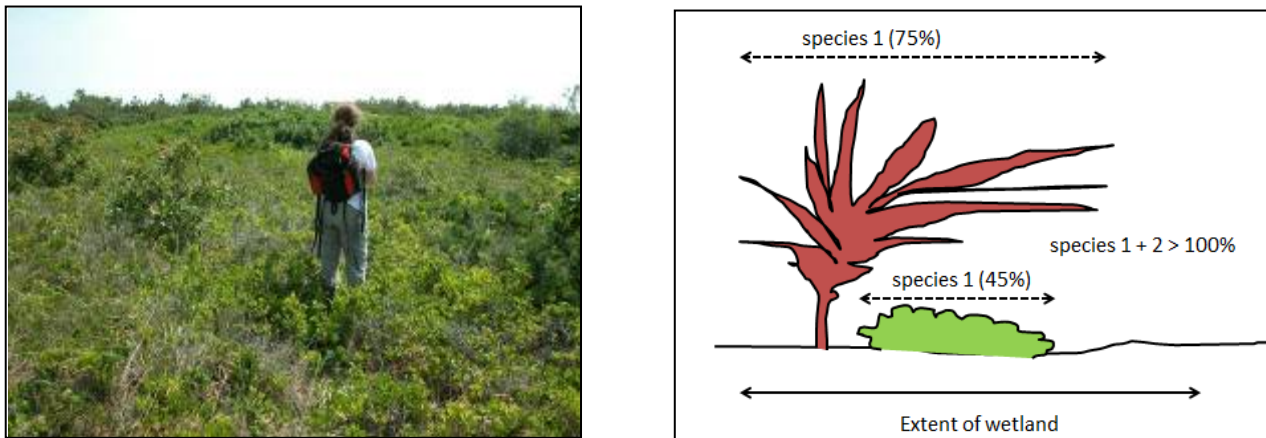


Figure SOP5-3. Photo of biological technician conducting a meander survey to assess cover by species across a dune slack (left) wetland and example of vegetation layering resulting in total cover of > 100% across the surveyed area (right).



Figure SOP5-4. Photo of a graminoid-dominated, “open” wetland (left) compared with a shrub- and tree-dominated, “closed” wetland.

Conducting the Environmental Monitoring

Within the 26 IS dune slack wetlands, a number of variables are characterized. These include hydrology (water level fluctuation), basic porewater chemistry (pH, conductivity), and soil organic matter content.

Hydrology – There are two ways in which hydrology is monitored in these systems. The first involves manual recording of water levels in fixed groundwater wells. In the original 15 IS wetlands, groundwater wells (PVC screen) are already established. Note: wells still need to be installed in the other 11 wetlands before the next survey in 2014. Well installation simply involves hammering a 1-in diameter PVC well screen into the perceived deepest point in the wetland (determined subjectively). Well length should be sufficient to span a distance of -2 ft (below ground) to + 2 ft (above ground). Hydrology is monitored once every two weeks by measuring the level of the water surface relative to the ground surface. If water levels are below ground surface of the wetland an electronic tape is used to measure from the top of the well (which has a known elevation) to the water's surface below ground. If surface water is present, its depth can be measured using a meter stick placed next to the well. Monitoring should begin when there is still surface water in all wetlands – generally in April or May, although this varies depending on the amount of winter precipitation. Water levels should be monitored until the end of August.

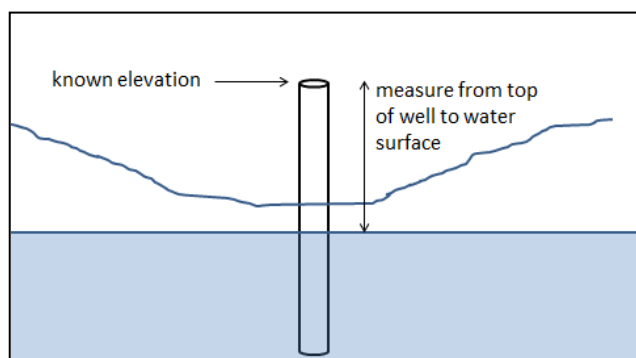


Figure SOP5-5. Diagram (left) and photo (right) of hydrologic monitoring well setup in a dune slack wetland.

The second method is to use a pressure transducer logging device (e.g., HOBO™ transducer). These instruments measure water pressure on the unit itself and can be directly converted to water depths after compensating for barometric pressure (refer to CACO Hydrologic Monitoring Protocol document; Y:\I&M_Projects\Physical_Resources\Hydrology_1\ HYDRO PROTOCOL\FINAL_PROTOCOL_SEPTMBER 2012). Loggers should be set for a recording frequency of 30 min. These data give one the ability to track fine scale variability in water levels over a period of many months (optimally April–September). The logger is placed at the bottom of the well with the sensor end at the bottom. It is necessary to measure the distance from the logger sensor to the ground surface so that water depth values can be corrected to indicate surface water depth (if possible, actual elevations (m-MSL, NAVD) should be obtained for the ground surface adjacent to each well and the

top of the wells themselves using a real time kinematic (RTK) GPS unit or an autolevel that can be tied into a known benchmark so that the water levels of all IS wetlands can be related to one another). Note: the biolab currently does not possess enough loggers to record hydrology in all the IS wetlands yet (as of 2013). However, this method is included because there is an expectation that eventually we will have enough units for each site.

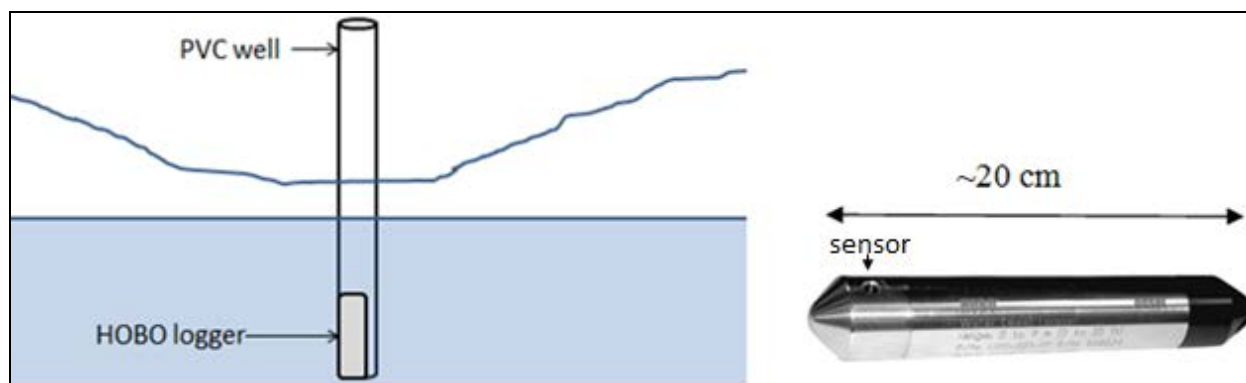


Figure SOP5-6. Diagram of a HOBOT pressure logger inside a PVC well screen (left) and a photo of an actual logger (right).

Porewater Quality – Porewater is collected in mid-July and mid-August from the mid-points of the three middle vegetation transects (i.e., three samples per wetland; see Figure below). Samples are obtained by inserting a 2-mm diameter stainless steel probe into the sediment to a depth of 10 cm and then drawing 30 ml of pore-water into a syringe fitted over top of the probe. The probe is simply hollow tubing with the end crimped and small slits cut into the bottom to allow water to pass through. Samples are squirted into individual vials (or other appropriate container) then placed in an ice-filled cooler and transported back to the laboratory where they are analyzed for pH, conductivity, and salinity on a hand-held, multi-parameter water quality meter (Oakton Multiparameter PCS Testr 35; see <http://www.4oakton.com/> to access guide for calibration and use).

Soil Properties - Three samples of sediment from each wetland (20-cm depth) are obtained by coring with a 5-cm diameter butyrate tube from the same locations that porewater samples are collected (middle points of three middle transects, see Figure below). Before coring, a serrated knife is used to cut around the outside of the tube to prevent compaction. The cores are placed in Ziploc bags, transported back to the laboratory, and dried in a convection oven at 105°C for 48 hours. For bulk density and organic matter determination, dried sediment is weighed so that bulk density can be calculated as grams of dry soil per cm³ (total volume of a 10-cm core in a 4.8-cm diameter coring tube is cm³). Particle size fractions are separated by multiple sieving/shaking through 1–2, 0.5–1, 0.25–0.5, 0.1–0.25, 0.05–0.1, and <0.05-mm sieves. For organic matter determination, a ~10-ml subsample of the sediment is placed in a pre-weighed ceramic dish and weighed. The dish is then placed in the muffle furnace and set to 500°C for five hrs. After letting the dish and sample cool down for at least one hr, the dish is weighed again to determine the amount of weight lost after burning. The percent

organic matter of the original sediment sample is then calculated as this percentage of the original (whole subsample) dry weight. Samples must be stored in a desiccator if they cannot be weighed within one hour after burning.

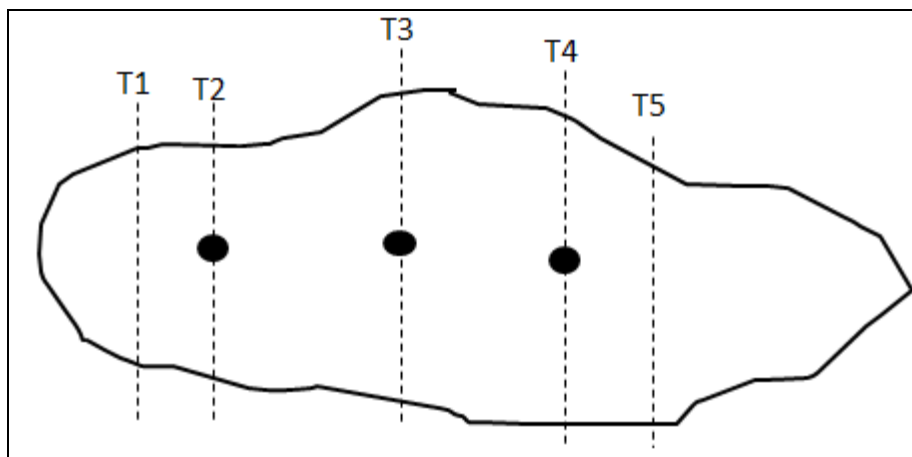


Figure SOP5-7. Standard porewater and soil coring sampling locations in a wetland

Identifying and Recording Unknown Species

In the event that a species cannot be identified in the field, a voucher sample should be collected from outside the transects. Flowers or fruit, even if they are last year's growth, are very helpful in identification. In general, specimens should appear "typical" and healthy, based on leaf shape, color, etc. In the case of small plants, roots or underground stems are also used in identifying specimens. If no specimens can be found outside the transects, a small amount of material (i.e., a branch, or portion of the stem with a few leaves) should be harvested in a way that will not compromise the survival of the plant. If this is not possible or there is reason to suspect that the species may be rare with State or Federal status, a digital photograph can be taken instead. Samples can be stored in a refrigerator on a short-term basis (i.e., ~ one week) or air-dried and pressed flat between two pieces of cardboard for long-term storage.

There are several different tools available for identification. The simplest way is to tap into the expertise of the resident plant ecologist/botanist. Color photography, identification guides, taxonomic keys, and the NACL and Salt Pond Visitor's Center herbaria are other sources of information. As a last resort, if the specimen still cannot be identified, the plant should be listed as "unidentified <growthform>" in the database (i.e., unidentified tree/shrub/graminoid/fern etc.).

Standard Operating Procedure (SOP) #6. Reporting

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

Reporting

Three types of reports will be generated after each field season:

- Monitoring report - report of results and documentation of work accomplished;
- Analytical report - analyses of trends, identification of causal factors, and comprehensive assessments of resource condition and ecosystem integrity; and
- Protocol review reports - assessments of the efficacy of monitoring methods, the validity of design assumptions, and the overall utility of the protocol for answering the monitoring questions.

The manner in which these reporting objectives are met will be determined by the Project Manager and the I&M Coordinator.

Standard Operating Procedure (SOP) #7.

Data Management

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

File Management

Image files for the current season will be stored in a separate images folder to facilitate cataloguing of all image files at the Park. The I&M Project directory is intended to hold all current and frequently accessed files. An archive directory was established to house information for each monitoring program more permanently at the end of each year.

The data must be stored in at least two local locations. The first storage location will be in the designated project archive on the NACL server (which is backed up daily). Files in the archive will be stored in read-only file format. The second location will be on a DVD that will be stored in a fireproof cabinet. Paper worksheets and notes will be filed and stored.

Database files moved to an archive folder are considered permanent. Changes should not be made to these databases once archived. Copies of database files that are modified after archiving must include detailed revision notes stored in its internal database revision history table for reference. Any changes to data stored in an archived file must also be documented in a Word or text document stored in the same folder as the database. Whenever practical, data should not be changed via direct entry into a table.

Data Entry

Data entry should be completed as soon as possible after the field data are collected, generally within one week. If possible, data entry should be done by one of the technicians who performed the field work so that the technician's memory will aid in the transcription process. Data entry should ideally be done by two people. While the goal of data entry is to achieve 100% correct transcription entries, this is rarely accomplished. To minimize transcription errors, CACO policy is to verify a minimum of 10% of records to their original source. If possible, however, the original technician should check 100% of the data entry on the following day. Once the computerized data are verified as accurately reflecting the original field data, the paper forms are archived and the electronic version is used for all subsequent calculations.

Data Availability

This protocol, reports, data, and all other products will be available directly from CACO. Data can also be transferred using e-mail or ftp where available. Requests for data and reports before they are published on a CACO I&M website should be directed to:

Stephen Smith, Ph.D.

Plant Ecologist

Cape Cod National Seashore

99 Marconi Site Road

Wellfleet, MA 02667

stephen_m_smith@nps.gov

Standard Operating Procedure (SOP) #8. Preparations and Equipment Storage at the Conclusion of the Field Season

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

At the end of the field season, it is imperative that all equipment be inventoried, repaired (or replaced), if necessary, and stored in its proper location. The data and resulting products (e.g., reports) should also be organized and archived. To accomplish this, the field crew should follow these steps:

- Compile, clean, and return all equipment to its proper storage place.
- Clean the assigned vehicle and make sure it is left with a full tank of gas and sufficient oil.
- Organize and photocopy all field datasheets and notes. Give all data to Project Manager for safekeeping.
- Make sure all data have been entered into the electronic database and saved in the proper folder on the NACL server.
- Complete end-of-season report.

Standard Operating Procedure (SOP) #9. Dune Slack Wetland Monitoring Safety

Cape Cod National Seashore
Dune slack wetland Monitoring Protocol

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

In addition to the basic requirements of the programmatic SOP, the following safety measures will be implemented as part of the Dune slack wetland Monitoring Protocol:

- The Project Manager will encourage field staff to use insect repellent on their clothes.
- The Project Manager will provide light-colored coveralls if desired by field staff.
- Field crews are encouraged to perform periodic tick checks while in the field.
- The Project Manager will ensure adequate poison ivy pre-contact solution (such as Ivy Block™) and post-contact wash (such as Technu™) is available for the duration of the field season.

In addition, all project personnel are encouraged to recommend changes or additions to the programmatic safety SOP.

Appendix A. Current list of vascular plant species found thus far in dune slack wetlands Names are from USDA PLANTS database (<http://plants.usda.gov>) or are synonymous with names in this database.

Scientific Name	Common Name
<i>Acer rubrum</i>	red maple
<i>Agalinis purpurea</i>	purple false foxglove
<i>Agrostis hyemalis</i>	winter bentgrass
<i>Amelanchier canadensis</i>	shadbush
<i>Aronia arbutifolia</i>	red chokeberry
<i>Aster novi-belgii</i>	New York aster
<i>Baccharis halimifolia</i>	saltbush
<i>Betula nigra</i>	grey birch
<i>Bidens connata</i>	beggartick
<i>Calopogon tuberosus</i>	grasspink
<i>Carex crinita</i>	fringed sedge
<i>Carex nigra</i>	smooth black sedge
<i>Carex scoparia</i>	broom sedge
<i>Chamaedaphne calyculata</i>	leatherleaf
<i>Cladium marsicoides</i>	twig rush
<i>Clethra alnifolia</i>	pepperbush
<i>Cyperus esculentus</i>	yellow nutsedge
<i>Decodon verticillatus</i>	waterwillow
<i>Drosera intermedia</i>	spatula-leaf sundew
<i>Drosera rotundifolia</i>	roundleaf sundew
<i>Dulichium arundinaceum</i>	threeway sedge
<i>Eleocharis pauciflora</i>	fewflower spikerush
<i>Eriophorum virginicum</i>	tawny cottongrass
<i>Eupatorium pilosum</i>	rough boneset
<i>Euthamia graminifolia</i>	flat-top goldentop
<i>Hypericum canadense</i>	Canadian St. Johnswort
<i>Ilex glabra</i>	inkberry
<i>Ilex laevigata</i>	smooth winterberry
<i>Ilex verticillata</i>	winterberry
<i>Iris versicolor</i>	blueflag
<i>Juncus acuminatus</i>	tapertip rush
<i>Juncus brevicaudatus</i>	narrowpanicle rush
<i>Juncus bufonius</i>	toad rush
<i>Juncus canadensis</i>	Canada rush
<i>Juncus effusus</i>	common rush
<i>Juncus greenei</i>	Greene's rush
<i>Juncus militaris</i>	bayonet rush
<i>Juncus pelocarpus</i>	Brown-Fruited Rush

Scientific Name	Common Name
<i>Kalmia angustifolia</i>	lambskill
<i>Lycopus</i> sp.	bugleweed
<i>Lyonia ligustrina</i>	maleberry
<i>Lythrum salicaria</i>	purple loosestrife
<i>Morella pensylvanica</i>	northern bayberry
<i>Nyssa sylvatica</i>	black gum
<i>Onoclea sensibilis</i>	sensitive fern
<i>Osmunda cinnomomea</i>	cinnamon fern
<i>Osmunda regalis</i>	royal fern
<i>Panicum dichotomiflorum</i>	fall panicgrass
<i>Panicum lanuginosum</i>	panicgrass
<i>Panicum virgatum</i>	switchgrass
<i>Photinia melanocarpa</i>	black chokeberry
<i>Phragmites australis</i>	common reed
<i>Pinus rigida</i>	pitch pine
<i>Pluchea odorata</i>	saltmarsh fleabane
<i>Pogonia ophioglossoides</i>	snakemouth orchid
<i>Rubus hispidus</i>	bristly dewberry
<i>Salix cinerea</i>	grey willow
<i>Scirpus americanus</i>	American bullrush
<i>Scirpus cyperinus</i>	woolgrass
<i>Smilax rotundifolia</i>	roundleaf greenbrier
<i>Solidago rugosa</i>	wrinkleleaf goldenrod
<i>Solidago sempervirens</i>	seaside goldenrod
<i>Spiraea alba</i>	white meadowsweet
<i>Spiraea tomentosa</i>	steeplebush
<i>Thelypteris palustris</i>	marsh fern
<i>Toxicodendron radicans</i>	poison ivy
<i>Triadenum virginicum</i>	Virginia marsh St. Johnswort
<i>Typha angustifolia</i>	narrowleaf cattail
<i>Typha latifolia</i>	broadleaf cattail
<i>Utricularia cornuta</i>	horned bladderwort
<i>Vaccinium corymbosum</i>	highbush blueberry
<i>Vaccinium macrocarpon</i>	cranberry
<i>Viburnum dentatum</i>	southern arrowwood
<i>Viola lanceolata</i>	bog violet
<i>Xyris difformis</i>	bog yelloweyed grass

Appendix B. Intensive study site metadata.

Site number	Site name	Transect #	Tr Length (m)	E-coord (UTM)	N-coord (UTM)
391	SM-A	1	21.0	408776	4657134
		2	23.0		
		3	24.0		
		4	32.5		
		5	31.3		
388	SM-B	1	14.9	408477	4657258
		2	14.2		
		3	15.5		
		4	14.4		
		5	12.6		
368	HH-A	1	27.3	407593	4657423
		2	24.7		
		3	31.6		
		4	29.9		
		5	19.2		
363	HH-B	1	30.2	407515	4657617
		2	23.9		
		3	25.9		
		4	29.6		
		5	21.4		
361	HH-C	1	49.3	407402	4657704
		2	49.7		
		3	42.6		
		4	41.4		
		5	19.0		
247	NP-A	1	20.0	404426	4658792
		2	21.6		
		3	21.8		
		4	19.6		
		5	14.2		
not marked	NP-B	1	31.4	403822	4658889
		2	30.5		
		3	28.2		
		4	28.7		
		5	31.1		
228	NP-C	1	4.8	403790	4658895
		2	12.2		
		3	12.9		
		4	13.5		
		5	11.6		
111	PL-A	1	12.5	401482	4659342
		2	16.4		
		3	14.8		
		4	26.5		
		5	30.3		

Site number	Site name	Transect #	Tr Length (m)	E-coord (UTM)	N-coord (UTM)
116	PL-B	1	37.0	401538	4659109
		2	35.3		
		3	34.4		
		4	37.2		
		5	50.0		
112	PL-C	1	11.0	401492	4659110
		2	14.5		
		3	14.2		
		4	13.9		
		5	12.9		
42	LS-A	1	22.1	400008	4659344
		2	16.3		
		3	14.0		
		4	12.1		
		5	7.3		
not marked	LS-B	1	10.1	399462	4659214
		2	16.0		
		3	16.4		
		4	13.2		
		5	12.3		
11	RP-A	1	26.5	399102	4657297
		2	30.0		
		3	47.6		
		4	56.3		
		5	68.0		
19	RP-B	1	17.7	399341	4657322
		2	18.3		
		3	16.3		
		4	11.8		
		5	11.1		
236	-	1	36.5	406677	4658048
		2	33.8		
		3	32.4		
		4	27.3		
		5	21.8		
245	-	1	23.8	406875	4657600
		2	24.5		
		3	32.5		
		4	30.5		
		5	16.0		
206	-	1	25.8	405234	4658077
		2	26.9		
		3	29.6		
		4	29.2		
		5	25.6		
213	-	1	9.8	405430	4658276
		2	10.1		
		3	15.2		
		4	20.3		
		5	5.6		

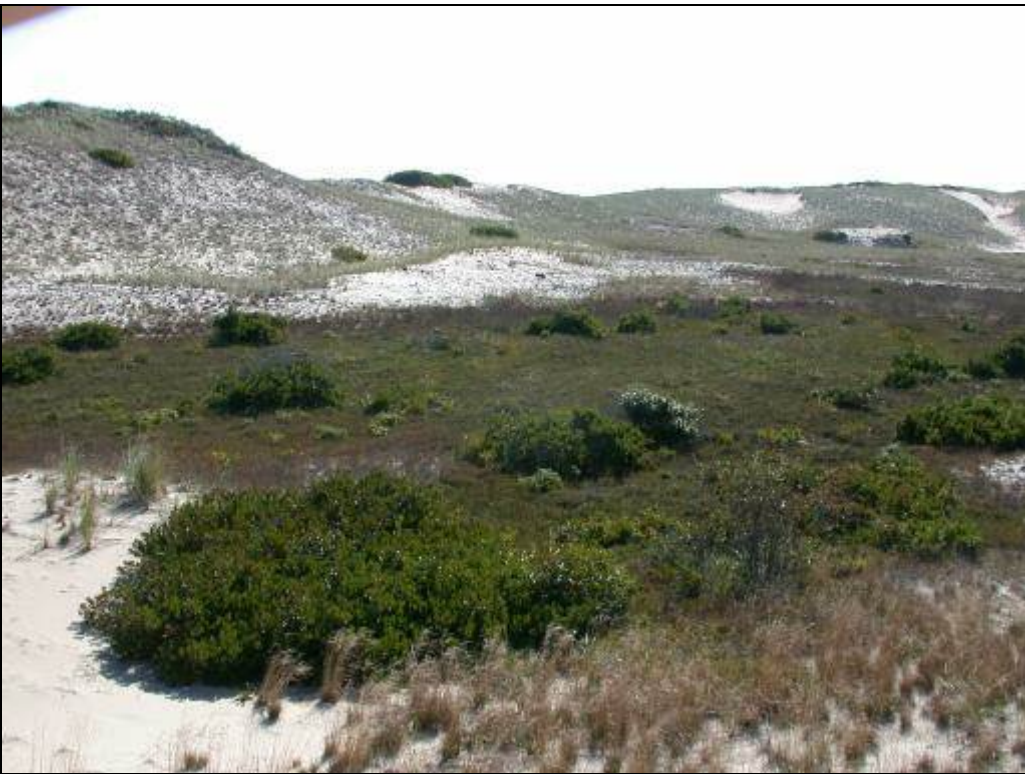
Site number	Site name	Transect #	Tr Length (m)	E-coord (UTM)	N-coord (UTM)
210	-	1	13.8	405365	4658324
		2	16.8		
		3	27.6		
		4	20.6		
		5	21.0		
140	-	1	4.6	403322	4658538
		2	9.6		
		3	10.8		
		4	10.8		
		5	8.5		
56	-	1	23.3	400848	4659301
		2	22.8		
		3	22.9		
		4	23.8		
		5	16.6		
192	-	1	12.1	404791	4658368
		2	26.0		
		3	23.8		
		4	21.1		
		5	20.4		
218	-	1	35.0	405648	4658076
		2	36.9		
		3	65.0		
		4	53.4		
		5	44.4		
169	-	1	33.4	404153	4658416
		2	32.5		
		3	31.7		
		4	23.0		
		5	22.7		
178	-	1	5.8	404401	4658523
		2	14.0		
		3	14.7		
		4	15.0		
		5	14.9		

Appendix C. Photos of intensively monitored dune slack wetlands.

Original sites (2004)



HHA



HHB

HHC



LSA



NPA



NPB



NPC



PLA





PLB



PLC

SMA – NO PIC



SMB

RPA – NO PIC

RPB



New sites as of 2009



Site 56



Site 140



Site 169



Site 178



Site 192



Site 206



Site 210



Site 213



Site 218



Site 236



Site 245

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 609/122822, November 2013

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

<http://www.nature.nps.gov/>

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