



Monitoring Protocol for Kettle Pond Vegetation of Cape Cod National Seashore, Massachusetts

Natural Resource Report NPS/NER/NRR—2012/561



ON THE COVER

Aerial photograph of Wellfleet kettle ponds

Photograph by: Stephen Smith, Cape Cod National Seashore

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Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised By	Changes	Justification

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Background and Objectives

Background and History

Scattered throughout Cape Cod National Seashore (CACO) (Massachusetts, USA) are numerous freshwater lakes and ponds of glacial origin. Collectively known as “kettle ponds” due to their roughly circular shapes, these waterbodies were created by melting blocks of glacial ice that left depressions on the outwash plain nearly 18,000 years ago. As sea level rose and pushed the groundwater table upward, these depressions became flooded. Depending on land surface elevation relative to groundwater elevation, seasonally (vernal ponds) or permanently (kettle ponds) flooded ponds developed. Today, there are 16 kettle ponds within CACO in the towns of Truro and Wellfleet (Figure 1).

Kettle ponds provide critical habitat for a variety of plant and animal life. A number of aquatic plant species designated by the State of Massachusetts as Endangered, Threatened, Special Concern, and Watch Listed occur around pond edges (LeBlond 1989). The ponds are also a major attraction for humans. With this brings a number of concerns, including trampling and denudation of shoreline and littoral zone vegetation, erosion, bather urination, and septic effluent (that adds nitrogen and phosphorus to the system) from houses surrounding the ponds (Roman et al. 2001). More broadly, water quality of rainfall can influence pond pH and nutrient status (Portnoy et al. 2001). Toxic metals in precipitation and groundwater can also be potential problems. Finally, there are biotic threats to pond communities—especially exotic plant species such as *Phragmites australis* (common reed) and *Lythrum salicaria* (purple loosestrife). In Massachusetts, there are many species of invasive submerged aquatic vegetation (SAV) which have not yet been found in the kettle ponds but are an ongoing concern. These and other invasive taxa have the potential to seriously compromise biological diversity and habitat structure as they have in many other wetland systems.

Rationale for Monitoring Kettle Pond Vegetation at CACO

Much attention is focused on CACO’s kettle ponds from the standpoint of preservation and management, given that they are highly valued as aesthetic, cultural, and ecological resources. Accordingly, CACO already has in place two separate monitoring programs to analyze conditions of hydrology and water quality—two of the most important factors regulating aquatic vegetation (Mitsch and Gosselink 2007). Changes in hydrologic regimes and pond trophic status will be detected through CACO’s Hydrological Monitoring Protocol and Kettle Pond Water Quality Monitoring Protocol, respectively (Portnoy et al. 2007, Medeiros 2011). In fact, water quality data from kettle ponds have been collected for decades, with some water clarity records dating back to the 1950s (Portnoy et al. 2001). In general, the ponds are acidic, softwater systems with surface waters of low pH, alkalinity, and conductivity (Portnoy et al. 2001). Water clarity is very high in many ponds and dissolved nutrient concentrations are relatively low (Portnoy et al. 2001). Surface water total phosphorus levels are characteristic of oligotrophic to mesotrophic lakes (<50 µg/L); whereas total nitrogen falls within the oligotrophic range (<400 µg/L) (Nurnberg 2001, USEPA 2001).



Figure 1. Map of Cape Cod National Seashore kettle ponds in the towns of Truro (T) and Wellfleet (W), MA.

Whereas hydrology and water quality of kettle ponds have been monitored frequently by repeatable methods, aquatic plant communities of these systems have not been routinely evaluated. Roman et al. (2001) developed preliminary methods to assess vegetation in relation to environmental parameters and determined that the vegetation reflected the trophic status of ponds. Plants tend to integrate a variety of physical, chemical, and biological factors over time and may therefore be a good indicator of long-term change in pond environments. The structure of aquatic plant communities is also important, in that it influences habitat characteristics for pond wildlife (Henning and Remsburg 2009). Thus, plants are the link between top-down and bottom-up processes that regulate pond functioning. In addition, vegetation is relatively straightforward to monitor, compared to aquatic invertebrates and fish. This makes plant communities a good indicator of overall ecosystem integrity and, given their importance from a cultural and natural resource standpoint, it is vital that their status is assessed and evaluated on a routine basis. This protocol was written to provide scientists and managers with reliable, useful information on vegetation communities in the kettle ponds in a standardized manner.

Objectives of Protocol

Management Objectives

CACO has not yet developed specific management objectives for kettle pond vegetation; however, the ponds potentially can be managed in very tangible ways. For example, human access and foot traffic can be controlled, and development in the watershed could be limited or managed in various ways. In general, the preservation of native pondshore plant communities, particularly as it relates to state-listed rare species and infestations of invasive species, is a high priority. In addition, any shifts in plant communities that indicate rapid changes in trophic status would provide valuable information for determining whether human-related impacts on hydrology and/or nutrient cycles are occurring and whether certain management actions might be needed to ameliorate the effects.

Monitoring Objectives

The original sampling objectives of the report on kettle pond aquatic vegetation by Roman et al. (2001) in 1995 were based upon characterizing the attributes of plant communities in five specific kettle ponds relative to their trophic status. These ponds were selected non-randomly and were five of 10 ponds, known as the “primary ponds,” for which CACO has extensive water quality monitoring data. A subsequent report in 2005 focused on analyzing changes in vegetation between 1995 and 2005, re-evaluating the original methods used to assess the vegetation, and testing several newly added components of monitoring. In addition, the other five primary ponds were added to the monitoring network. As such, this initial protocol will only be able to make inferences about these individual ponds, rather than all the kettle ponds in general. In a statistical context, the desirable level of power for the monitoring protocol is 80% to detect a 20% change in important kettle pond vegetation variables.

Following the basic premise of the two previous reports, the primary monitoring objective of this protocol is to assess whether CACO’s kettle pond vegetation is changing over time. Some basic environmental parameters that are available as part of this protocol (e.g., sediment organic matter) and from other monitoring programs (e.g., climatological, hydrological) can then be used to formulate possible reasons for change. However, additional research that is focused on more specific hypotheses (e.g., influence of human-associated nutrient inputs) may be needed to answer the question(s) more fully.

History of Protocol Development and Recent Revisions to Methods

In 1995, Charles Roman (NPS CESU Coordinator, Northeast Region) and CACO staff led an effort to develop a conceptual model of the kettle ponds based on relationships between various environmental factors and aquatic macrophyte species composition. Details on the methodology and analyses can be found in Roman et al. (2001). In this study, five of the 10 primary ponds (Duck, Ryder, Great-T, Gull, and Herring), spanning a substantial trophic gradient, were characterized with respect to porewater and sediment quality and macrophyte species composition. Here it is important to discuss some of the methodologies used since revisions were made in subsequent sampling in 2005. In 1995, sampling of vegetation was conducted along five linear transects per pond. Transect positions were randomly chosen from the perimeter of each pond (using a randomization tool in ARCGIS ver. 9.2 and were oriented perpendicular to the shoreline, following the elevation gradient from the upland into deep water. Each transect originated within the upland border (i.e., where there was a shift from wetland to non-wetland plant taxa as defined by indicator status [USACO 1999]) and continued into the pond along the bottom until rooted vegetation was no longer encountered. PVC monuments were installed to mark transect start points and GPS locations of the start points were collected. Actual ground elevations along transects at 1-m intervals were surveyed by optical leveling. Plant species composition was assessed by line cover over each 1-m interval along the length of each transect. In other words, the linear distance that each species covered within each 1-m segment was recorded and converted to a percentage (e.g., if 25 cm of the segment ran through *Juncus pelocarpus*, a value of 25% cover was given to the species). For each 1-m segment, percent cover was then given a score based on a modified Braun-Blanquet ordinal scale (<1%=1; 1–5%=2; 6–10%=3; 11–25%=4; 26–50%=5; 51–75%=6; and 76–100%=7). It should be noted that with this method multiple species growing at different heights can be recorded along the same segment of transect, with cover exceeding 100%.

Sediment cores (using a 4-inch inside diameter coring tube) were taken to a depth of 10 cm from the midpoint of each 1-m interval and analyzed for bulk density, particle size fractionation, and % organic matter. Finally, hand-drawn maps of shoreline plant communities were created. The results of this work suggested that macrophyte growth form (i.e., floating leaved vs. rosette-forming emergents) was a good indicator of overall trophic state, as was the total cover of aquatic macrophytes (Roman et al. 2001).

In 2005, in an effort to re-evaluate these methods and analyze vegetation changes that may have occurred since the 1995 study, a similar survey was conducted. Modifications and additions were made to the 1995 study and are described in detail below:

- i) Revisions to spatial scale: To broaden the spatial scale of sampling, the other five primary ponds, Long Pond, Dyer Pond, Great Pond, Spectacle Pond (Wellfleet), and Snow Pond (Truro), were added to the monitoring network in 2005. This set of ten ponds comprises a group that will continue to be monitored annually for hydrology and water quality.
- ii) Revisions to vegetation work: Short sections of several transects were surveyed by SCUBA in 1995. Because of equipment costs and the many operational difficulties (required expertise and training of crew) of repeating this method, a decision was made to limit the transect survey lengths to distances that could be surveyed using a

viewscope or snorkeling gear (generally 20 m or less from the shoreline, depending upon slope). In 2005, field tapes were run along the pond surface instead of along the bottom. This limits disturbance to the pond bottom since the surveyors don't have to look underwater at the field tape to determine their position along the transect. Instead, with the help of small floats attached to the line, the meter marks can be read at the surface. For the vast majority of transects, which have littoral zone slopes of <10%, the difference in total length between a transect run along the bottom vs. the surface would be less than 20 cm over a distance of 20 m. Also, differences between ground vs. surface transect distances will be minimal between survey years when pond levels are very different. For example, the difference in the corresponding ground distance between a field tape run 20 m along a pond surface that is 2 m-MSL vs. 1 m-MSL is only 7 cm or 3.5 mm per meter.

In addition to the transect surveys, area cover by species was recorded (using the modified Braun-Blanquet scale) in 10×5-m plots oriented so that one 10-m side of the plot (left side looking out toward the middle of the pond) began at each transect's upland border origin and continued towards the pond along the transect (Figure 2). In a few cases where the transect distance was < 10 m (e.g., transect # 3 in Ryder Pond) the plot was still established out to 10 m with the knowledge that part of the plot would consist of vegetation-free open water. These plots are hereafter referred to as "box plots," even though they are rectangular in shape. The rectangular dimensions were chosen based on the difficulty of seeing the composition of vegetation in dense shoreline shrub areas (i.e., 10 m of shrubby vegetation along the shoreline was too wide to generate an accurate cover score). Box plots were established because it was obvious that transects represented very thin slices of the perimeter pond vegetation and often failed to record species that were present in very close proximity to the transect. Also, because there can be a high degree of spatial variability in both total vegetation cover and species composition within just a few meters, a small offset of the transect from its original bearing can result in the omission or inclusion of numerous plants.

Another addition to the vegetation work was the "meander survey." This consisted of a thorough exploration of the shrub, littoral, and deep water zones of each pond by foot and canoe (with the aid of a viewscope to assess SAV). The objective was to compile as complete a species inventory as possible for each pond. The meander survey was added so that species growing outside transects or box plots could be recorded.

- iii) Establishment of transect and box-plot markers: Unfortunately, nine of the 25 original PVC monuments that were installed in 1995 to mark transect start points could not be relocated in 2005 (see Appendix C). Furthermore, some of the original GPS points were never differentially corrected and therefore could not be used to re-establish new monuments in the original locations. In such cases, new PVC monuments were positioned based on hand-drawn maps in Roman et al. (2001) showing their original locations. Transect start points (located randomly along the

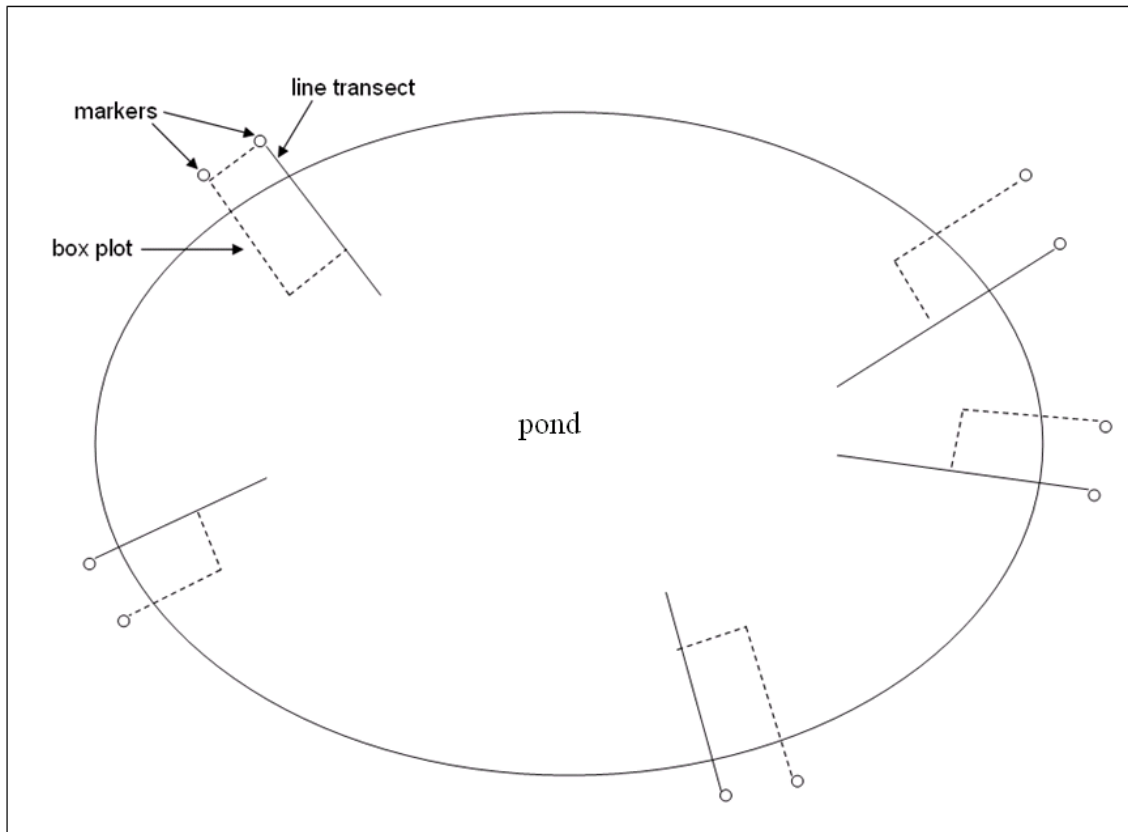


Figure 2. Diagram of transect and box plot configuration within a pond.

pond perimeter using ARCGIS) at the five newly added ponds were marked using zinc-plated steel dowels (0.5-cm diameter, 1-m length), which are inconspicuous to the general public but obvious enough to be found by the surveyors. Also, unlike the PVC monuments, these dowels are long enough that at least 30 cm will remain exposed even if significant bank erosion occurs. These also serve as one corner of the box plot (the bottom left hand corner when looking out toward the middle of the pond). Another dowel was inserted 5 m away, at a right angle to the transect, to demarcate the other “bottom” corner of the box plot (Figure 2). All markers were GPSed to within 2–3 m horizontal accuracy. Finally, the nearest tree to each dowel was tagged at about chest height with an aluminum tree tag on which a unique number is inscribed. These tags can serve as backup markers if the dowels cannot be found.

- iv) Environmental variables: Porewater nutrients were sampled in 1995 but not in 2005. Porewater chemistry can be extremely heterogeneous in both space and time and over small and large scales for each, especially along pondshores that are subject to variable periods of wetting and drying depending on elevation gradients (Blodau and Moore 2002, Sebestyen and Schneider 2004, Antheunisse and Verhoeven 2008). As such, vast numbers of samples are usually required to adequately characterize the root

zone environment. In addition, the length of time it takes to collect porewater samples and analyze them greatly exceeds the typically length of a seasonal employee's work term. Moreover, available nutrients are incorporated into plant and animal biomass that eventually becomes incorporated into the sediment as organic biomass. Thus, sediment organic matter (OM) is a stable, integrative, and reliable measure of trophic status (de Vicente et al. 2010). As such, we focused on quantifying sediment OM and bulk density as was done in 1995. In 1995, sediment cores were taken to a depth of 10 cm at every meter interval. In 2005, cores were taken from every other meter interval along transects >10 m and at every meter interval along transects ≤10 m. A slightly smaller corer was used in 2005 (2.3 cm smaller in diameter) due to the fact that the one-way valve that was purchased to construct the corer only fit into a 4.8-cm diameter coring tube.

For the five ponds first sampled in 1995, various components of plant community composition and structure were compared in 1995 vs. 2005 using transect data. These included taxonomic composition, relative proportions of the different growth forms (e.g., woody or floating leaved taxa), distances that vegetation extended pondward from the shoreline, and species richness. Data on trees rooted upslope of transects that had branches overhanging the transects were excluded from this analysis because growth of overhead branches can contribute substantially to changes in vegetation cover. This is problematic because any changes would not necessarily represent changes in pond conditions. Additionally, vegetation extending farther than 20 m from the onshore transect start points was not surveyed. Finally, a number of taxa could only be identified to genus; thus, all species within certain genera (specifically *Utricularia*, *Lycopus*, *Galium*, *Salix*, and *Xyris*) were lumped together. Since many non-vascular bryophytes could not be reliably identified, even to genus, these data also were excluded from the analyses.

Statistical Analysis of Existing Data

Non-metric multidimensional scaling (NMDS) was used to visualize similarities in species composition between years. Changes in taxonomic composition based on raw cover scores for each pond were assessed using Analysis of Similarities (ANOSIM) (Clarke and Warwick 2001, Roman et al. 2002), based on Bray-Curtis similarity matrices. Raw cover scores were used instead of transforming the data to mid-point percentages in order to prevent dominant species from overwhelming the importance of less dominant species in the community analyses. Summed cover class values for individual species or growth forms were calculated (Hunter 2005, Hunter and Bell 2007, Thompson et al. 2001) and compared using non-parametric Wilcoxon signed rank tests (Lehmann & D'Abrera 1975). Maximum distances that vegetation extended into the pond were compared using Student's t-tests. Species richness, sediment organic matter, and bulk density were also analyzed using t-tests. Since 2005, cores were only taken from every other meter interval along transects >10 m, only cores that corresponded in their location along transects between 1995 and 2005 samplings were used to analyze temporal change. Some of the 1995 data had bulk density values with no corresponding organic matter content, which explains the differences in sample size numbers between the two variables (see Appendix D for sampling list). In addition, for Duck and Gull ponds, no bulk density data from the 1995 survey could be found.

Power analyses for all variables were conducted using Statmate™ (ver. 2.0) software (GraphPad™), which can be used to analyze nonparametric as well as parametric data.

Determination of statistical power for nonparametric tests can be conducted simply by adjusting the result obtained for the corresponding parametric test (Bredenkamp 1980, Singer et al. 1986). In this regard, the Statmate™ program applies a correction factor to account for a non-parametric distribution (Lehmann and D'Abrera 1975). For all variables, the minimum percent change in mean values required to achieve a power level of 80% were calculated.

Results of Vegetation Analysis

General Characteristics of Plant Communities in 2005

In 2005, the most abundant species in the 10 primary ponds, as determined by transects, were *Eleocharis acicularis*, *Clethra alnifolia*, *Juncus militaris*, *Chamaedaphne calyculata*, and *Vaccinium corymbosum*. The least abundant species were *Xyris difformis*, *Juncus greenii*, and *Fimbristylis autumnalis*. Only two wetland species (i.e., those with an indicator status of OBL [obligate wetland], species found in wetlands more than 99% of the time; FACW [facultative wetland], species found in wetlands between 67% and 99% of the time; or FAC [facultative], species are found in wetlands between 33% and 67% of the time [USACOE 1987]), *Typha angustifolia* and *Phragmites australis*, were nonnative. Eight were nonnative upland species. No state or federally listed rare species were found, although there are known occurrences at specific ponds. These rare species (e.g., *Drosera filiformis*, thread-leaved sundew) are highly inconspicuous and easy to overlook when water levels are high (as they were in 2005) (Neill et al. 2009). Furthermore, these species are monitored as part of a separate program to track their status at regular intervals (Massachusetts Natural Heritage Program, New England Plant Conservation Program).

In terms of the structural composition of vegetation encountered along transects, Long Pond had the highest cover of graminoids while Spectacle Pond had the lowest (Figure 3). Herring Pond had the highest cover of floating-leaved herbaceous species, while Duck, Dyer, and Great (W) ponds had none. Rosette-forming herbaceous plants (e.g., *Lobelia dortmanna*) were plentiful in Gull Pond and few in Herring Pond. Shrub vegetation exhibited much less variability but was most abundant in Herring Pond and least abundant in Long Pond. However, the relative abundance of this group is determined by the distance that transects extend into the upland, which was somewhat subjective and based on the Roman et al. (2001) surveys. The width of the shrub band around ponds is also determined by slope. Ponds with steeper banks have thinner bands of shrubs than those with gentler slopes.

Transect species richness (number of species recorded along all transects in each pond) ranged between 14 (Duck Pond) and 44 (Herring Pond) with an average of 25 species per pond (Figure 4a). Species richness determined from the meander surveys matched the transect data very closely with respect to relative differences among ponds (Figure 4b). Actual values, however, were substantially higher, which justifies the addition of this survey method to the protocol.

Ordination of species cover data from transects showed that the ten ponds separated out from each other with little clustering (Figure 5). Gull and Herring ponds were somewhat distinct from the other ponds as indicated by their relative positions. This was due to the abundance of *Lobelia dortmanna* in Gull Pond and water lilies (*Nymphaea*, *Nuphar*) and *Clethra alnifolia* in Herring Pond. Duck and Dyer ponds were relatively close as a result of both having relatively sparse vegetation and similar abundances of *Chamaedaphne calyculata*. Other than these ponds, there were no other obvious groupings or outliers.

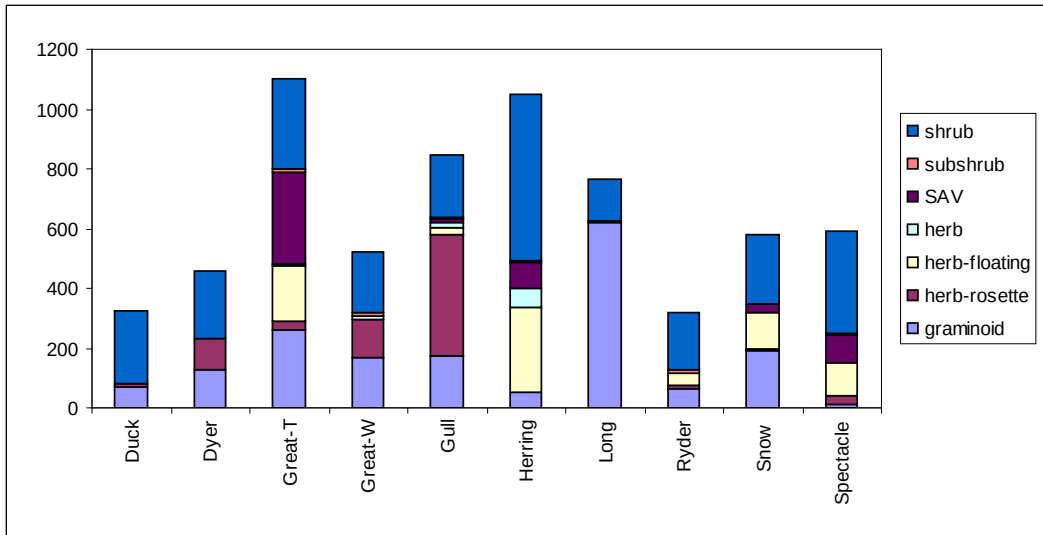


Figure 3. Summed cover class scores (all transects pooled for each pond) of taxa falling into various growth form categories in 2005.

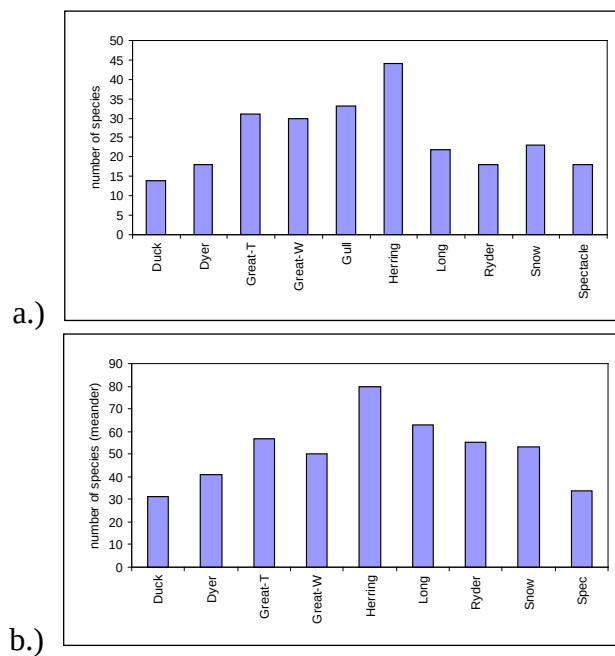


Figure 4. Species richness by pond in 2005 as determined from a) transects and b) meander surveys.

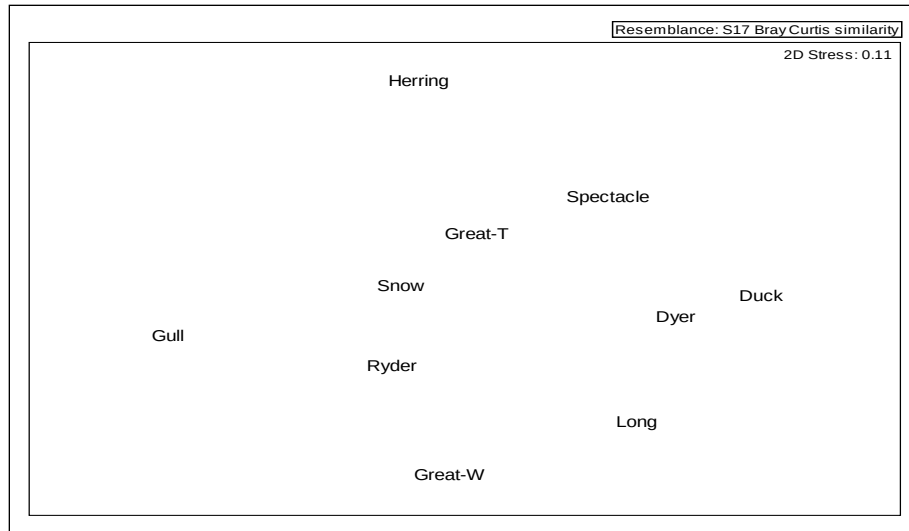


Figure 5. NMDS of species composition among ponds in 2005 (based on transect cover class scores).

Species cover class scores from the 5×10-m box plots were subjected to NMDS (Figure 6a). The results reveal a similar picture as the transects with respect to clustering. For example, Dyer, Duck, and Long ponds are relatively close in ordinal space, while Herring and Gull ponds separate out from the rest. The reasons for this are the same as those described above, except that the box plots documented more *Clethra alnifolia* and *Eleocharis acicularis* in Long Pond (which brought it closer to Dyer Pond) than the transects did.

Changes in Plant Communities between 1995 and 2005

While differences in the plant community composition in 1995 vs. 2005 were evident, most were relatively minor (Figure 6b) and lacked statistical significance (Table 1). Species composition in Duck, Gull, Herring, and Ryder ponds were statistically similar between years. Only Great-Truro Pond exhibited a significant change, which was mainly due to changes in the cover of *Utricularia* spp., *Juncus militaris*, and *Gratiola aurea*. *Utricularia* spp. and *J. militaris* were higher in 2005 compared to 1995, while *G. aurea* was lower. Appendix A lists the specific contributions of individual species to the percent dissimilarity among years for each pond. The same trends were found when ANOSIM was conducted on species presence/absence data (Table 1).

Change in the Cover of Growth Forms (All Species Pooled within Group) between 1995 and 2005

Only Ryder Pond, where woody cover decreased, showed a statistically significant difference in the cover of woody species (trees, shrubs and subshrubs) in 1995 vs. 2005 (Table 2). Most of the ponds also showed no significant changes in the cover of herbaceous species except in Duck Pond, where cover was much less in 2005 than in 1995. No significant differences were found for floating-leaved or SAV groups in any pond. Despite the lack of statistical significance, it is noteworthy that the summed cover class values of many groups increased, despite the high water levels in 2005.

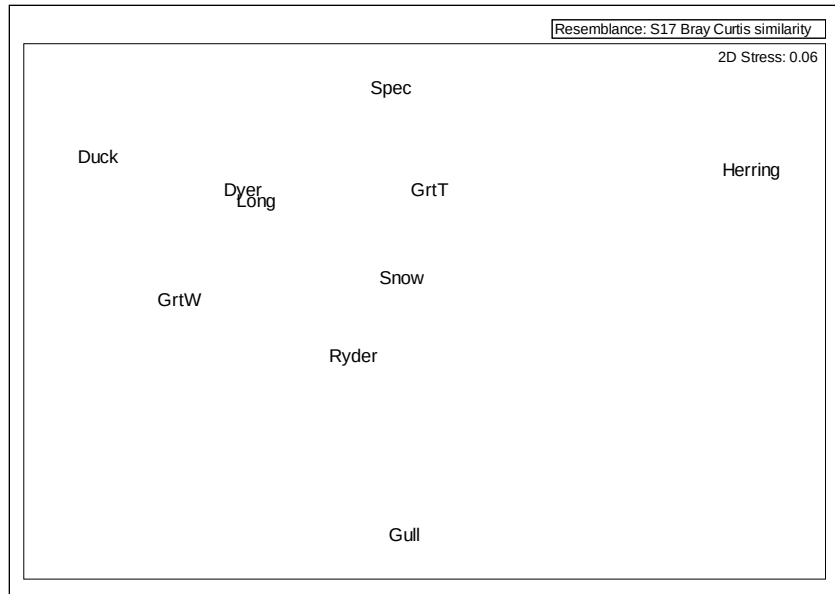


Figure 6a. NMDS of species composition among ponds in 2005 (based on box-plot cover class scores).

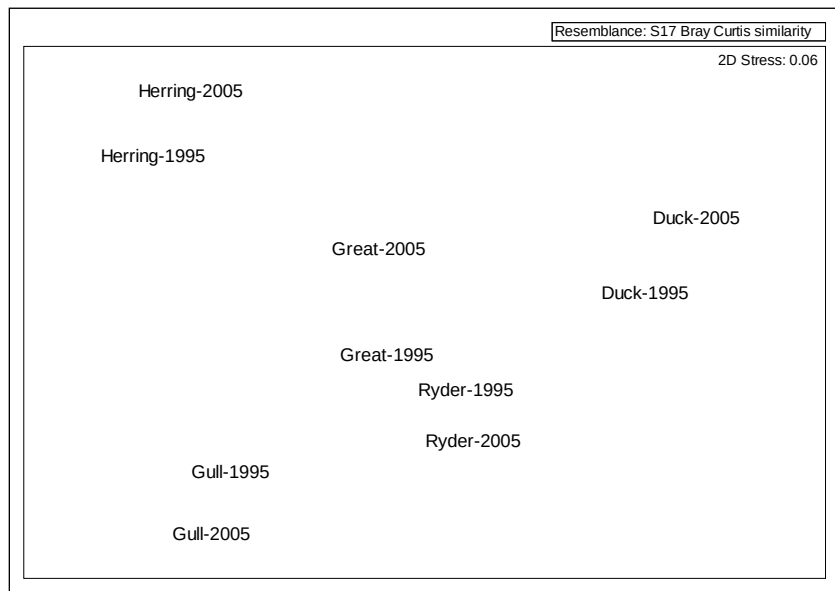


Figure 6b. NMDS of species composition for each pond and year of survey (based on transect cover class scores).

Table 1. Results of ANOSIM for cover class scores and presence/absence data comparison between 1995 and 2005 (significant results in bold).

Cover Class Scores	global R	p value ($\alpha=0.05$)
Duck	-0.024	0.88
Great(T)	0.033	0.01
Gull	-0.002	0.50
Herring	-0.006	0.72
Ryder	-0.023	0.87
Presence/absence	global R	p
Duck	-0.025	0.92
Great(T)	0.029	0.02
Gull	0.005	0.23
Herring	-0.008	0.81
Ryder	-0.027	0.94

Power analysis –power analysis cannot be done on multivariate data

Table 2. Summed cover class (CC) values, % change in these values between 1995 and 2005, and p values for Wilcoxon signed rank tests by growth form.

		Duck	Great (T)	Gull	Herring	Ryder
Woody	sumCC-95	140	271	148	519	203
	sumCC-05	197	271	194	651	147
	% change	41%	0%	31%	25%	-28%
	Wilcoxon p	0.31	0.95	0.19	0.07	0.02
Herbaceous	sumCC-95	168	737	739	909	176
	sumCC-05	99	978	854	1094	210
	% change	-41%	33%	16%	20%	19%
	Wilcoxon p	0.03	0.19	0.86	0.27	0.94
Floating-leaved	sumCC-95	0	123	49	200	20
	sumCC-05	0	182	24	350	40
	% change	0%	48%	-51%	75%	100%
	Wilcoxon p	-	0.15	0.26	0.41	0.26
SAV	sumCC-95	0	45	56	124	0
	sumCC-05	0	52	0	86	0
	% change	0%	16%	-100%	-31%	0%
	Wilcoxon p	*	*	*	*	*

* too few species (n=4) to conduct statistical test

Power analysis – the power to detect change was very low with the exception of non-woody species. Only very large changes in the cover of the various growth forms met the 80% criteria for acceptable power.

Woody	80% chance of detecting a change of 34%
Herbaceous y	80% chance of detecting a change of 6%
Floating	80% chance of detecting a change of 89%
SAV	80% chance of detecting a change of 78%

Change in Maximum Distance Vegetation Extends into Each Pond between 1995 and 2005

The mean maximum distance that aquatic vegetation (any species) extended downslope into the ponds from the transect monument (all ponds pooled) averaged 16.7 m in 1995 and 16.1 m in 2005 (Figure 7). Note that these data include only the first 20 m of each transect. For transects with vegetation beyond this point a value of 20 m was used. These values are statistically similar. Within individual ponds, distances were much more variable among transects. As a result, there is very low statistical power to detect change in almost every pond. The exception is Herring Pond, where distance values had a much smaller variance.

No statistically significant differences were evident between 1995 and 2005 in maximum distances that vegetation extended downslope into individual ponds by growth forms (Figure 8).

Change in Species Richness from 1995 to 2005 (from Transects)

The total number of species (all ponds) was 111 in 1995 vs. 123 in 2005. However, mean species richness (all ponds pooled) was 35 in 1995 and 29 in 2005. These values are statistically indistinguishable. For individual ponds, average species richness per transect ranged between 7 (Duck Pond) and 22 (Great Pond) in 1995 and between 6 (Duck Pond) and 18 (Herring Pond) in 2005 (Figure 9). Only Duck Pond ($p=0.043$) and Great Pond ($p=0.006$) had significantly less species in 2005 compared with 1995. The other ponds showed no statistically significant difference between years.

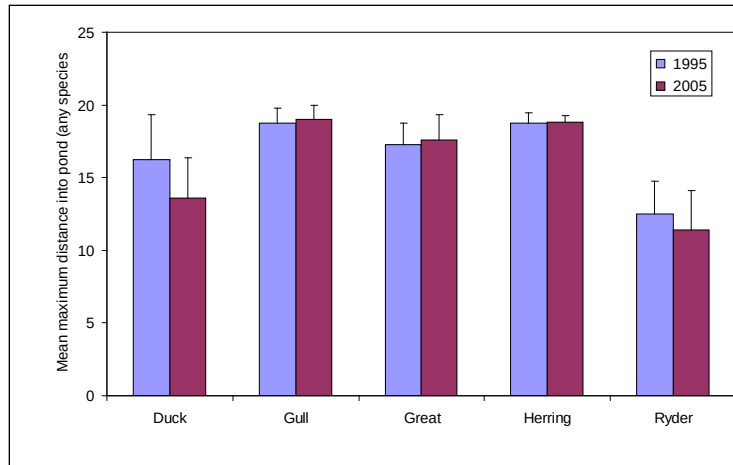


Figure 7. Mean maximum distance (m) that vegetation extends downslope into each pond by year (no statistically significant differences between years for any pond).

Power analysis results –there is sufficient statistical power to detect change in the distance variable for the ponds as a group. For individual ponds, there was a high level of variability in the amount of change required to achieve acceptable power.

All ponds 80% chance of detecting a 10% change in the distance variable among all ponds

Individual ponds

Duck	80% power to detect a change of 77%
Great	80% power to detect a change of 10%
Gull	80% power to detect a change of 1%
Herring	80% power to detect a change of 10%
Ryder	80% power to detect a change of 30%

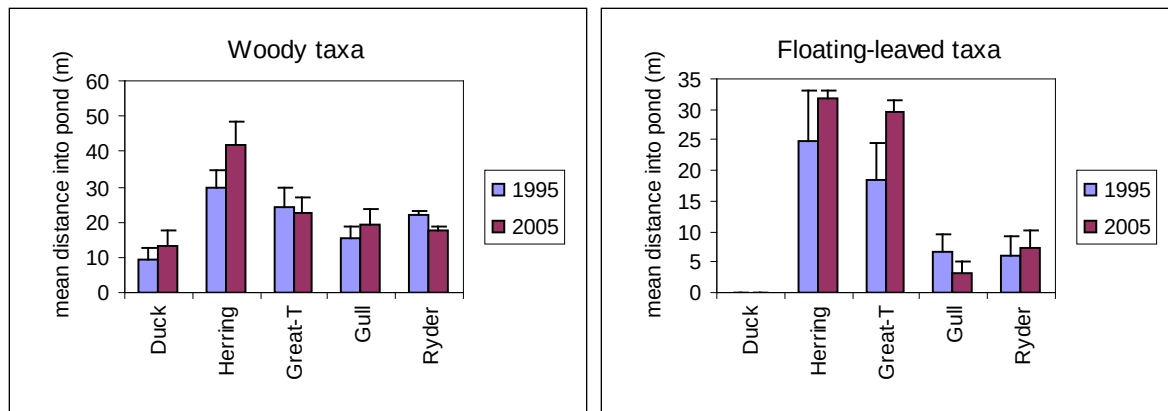


Figure 8. Average maximum distance (m) that vegetation extends downslope into each pond by growth form and year.

Power analysis – the power to detect changes in the maximum distance variable within various growth forms was very poor within individual ponds with the exception of non-woody species in Ryder pond.

Duck	Woody	80% power to detect a change of 32%
	Herbaceous	*
Great	Woody	80% power to detect a change of 31%
	Herbaceous	80% power to detect a change of 106%
Gull	Woody	80% power to detect a change of 127%
	Herbaceous	80% power to detect a change of 350%
Herring	Woody	80% power to detect a change of 33%
	Herbaceous	80% power to detect a change of 48%
Ryder	Woody	80% power to detect a change of 41%
	Herbaceous	80% power to detect a change of 12%

* too few data to run analysis

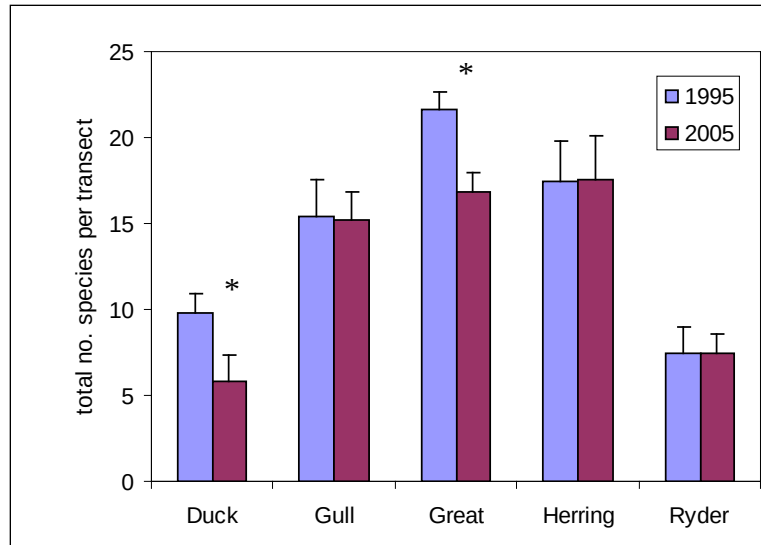


Figure 9. Average number of species per transect by pond and year (asterisks indicate statistically significant difference between years).

Power analysis – there is an 80% chance of detecting a change of 19% in mean species richness across all ponds.

Power analysis – the power to detect change in species richness was high, with all ponds having at least an 80% probability of detecting a < 20% change.

Duck	80% power to detect a change of 12.7%
Great	80% power to detect a change of 1.8%
Gull	80% power to detect a change of 5.4%
Herring	80% power to detect a change of 2.5%
Ryder	80% power to detect a change of 5.9%

Sediment Analysis

Change in Sediment Characteristics from 1995 to 2005

Mean bulk densities and % organic matter (all transects pooled for each pond) exhibited consistent patterns among all five ponds (Figure 10). Bulk densities were consistently lower in 2005 than in 1995 while organic matter was higher in 2005 than in 1995. For bulk density, all differences were statistically significant ($p \leq 0.01$) except for Herring Pond (Note: the inverse relationship between bulk density and organic matter is expected, since organic matter weighs much less than inorganic material). For organic matter, only Gull Pond showed a statistically significant difference.

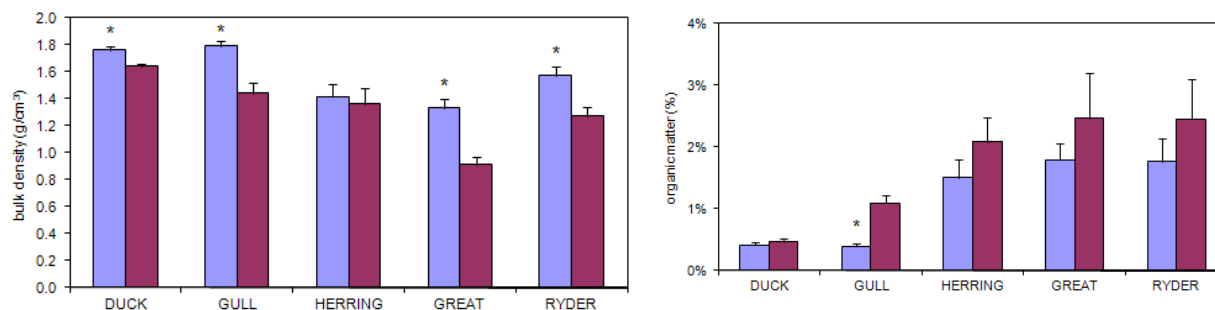


Figure 10. Mean bulk density (g/cm^3) and % organic matter (top 10 cm of sediment) by pond and year (blue histograms = 1995 data, red histograms = 2005 data; numbers above histograms indicate number of samples; asterisks indicate significant difference between groups).

Power analysis – the power to detect changes in sediment bulk density was fairly good in individual ponds, but poor when all ponds were grouped together. Curiously, the opposite is apparent for sediment organic matter, where power was higher when all data was pooled vs. analyzed by pond.

Sediment bulk density

All	80% power to detect a change of 76%
DUCK	80% power to detect a change of 5%
GULL	80% power to detect a change of 15%
HERRING	80% power to detect a change of 28%
GREAT	80% power to detect a change of 17%
RYDER	80% power to detect a change of 14%

Sediment % organic matter

All	80% power to detect a change of 20%
DUCK	80% power to detect a change of 34%
GULL	80% power to detect a change of 55%
HERRING	80% power to detect a change of 62%
GREAT	80% power to detect a change of 89%
RYDER	80% power to detect a change of 61%

Transect Topography (elevation profiles) – Re-surveys of transect elevations indicate that there has been little change since 1995. The average standard deviation calculated from 1995 vs. 2005 values ranged between 0.02 cm (Duck Pond) and 0.09 cm (Ryder Pond), averaging only 0.05 cm. Much of this is attributable to small measurement errors and/or slight spatial variances in setting up the transects.

Water Level Comparison 1995 vs. 2005

Not surprisingly, water levels were different in 1995 than they were in 2005 (Table 3); however, the magnitude of difference was inconsistent among ponds. Gull and Herring ponds were remarkably similar, whereas Great (T), Duck, and Ryder ponds were all over 0.5 m higher in 2005. Regressions of water-level change between 1995 and 2005 vs. summed cover class values for each growth form are shown in Table 4. These data illustrate the relationship between herbaceous cover (particularly forbs and sedges) and water level.

Table 3. Pond stages in 1995 and 2005 (Diff = 2005-1995 water surface elevations).

Pond	1995 Sample Date	Elevation 1995 (m-MSL)	2005 Sample Date	Elevation 2005 (m-MSL)	Diff (m)
Duck	7/31	2.30	7/19	2.97	0.67
Great (T)	8/21	2.00	8/18	2.87	0.87
Gull	8/14	1.98	8/18	2.00	0.02
Herring	8/22	1.90	8/17	1.94	0.04
Ryder	8/18	1.80	8/19	2.37	0.57

Table 4. Regression of changes in the summed cover class values by growth form with changes in pond stage (1995–2005).

Cover class values	Duck	Great (T)	Gull	Herring	Ryder	R2	Trend
Forb	-6	-25	2	-4	3	0.74	-
Grass	-6	-4	-5	-2	-1	0.28	-
Rush	-8	2	-1	3	1	0.12	-
Sedge	-2	-5	-1	1	0	0.80	-
SAV	0	4	-1	-4	0	0.60	+
Floating	0	5	1	3	0	0.18	+
Shrub	2	-4	2	2	-3	0.14	-
Tree	0	0	-1	1	0	0.00	
Fern	0	-1	-1	-2	0	0.06	+
Diff in water level (2005-1995)	+0.67	+0.87	+0.02	+0.04	+0.057		

Discussion of Results and Considerations for Future Monitoring

Statistical analyses revealed that only one pond (Great-T) had a significantly different community composition in 2005 than in 1995. Although the majority of individual species exhibited change between 1995 and 2005, collectively, the changes were not substantial enough to yield a significant ANOSIM value. However, having the ability to detect only large changes in communities is not necessarily a major shortcoming for monitoring and assessment. Even though minor shifts in vegetation may be statistically significant, they may be biologically meaningless (ecologically insignificant). While having the precision to detect such changes may be desirable, they may essentially be “background noise” in what is a relatively stable condition. Conversely, large changes are more likely to reflect an important shift. In other words, even though the sensitivity to detect small changes is low, one may have more confidence in the validity of statistically significant differences.

For kettle ponds, one obvious confounding factor in interpreting vegetation change is water-level fluctuation. Significant changes in certain herbaceous species may partially be the result of hydrologic conditions during one particular year. Deep water tends to suppress emergence, while dry years can provide opportunities for seed germination as well as rapid vegetative expansion (Smith et al. 2002, Nishihiro 2004). Accordingly, many years of data encompassing a variety of hydrologic conditions may be needed to analyze kettle pond vegetation trends, particularly with respect to herbaceous taxa. That said however, kettle ponds are quite dissimilar to coastal plain ponds, where the vegetation can change quite dramatically with water-level fluctuation (Neill et al. 2009). The vast majority of shoreline plants in CACO kettle ponds are perennial species rather than annuals which are much more abundant in coastal plain ponds. Water levels may influence the density of stands of perennial plants, but species composition is much less affected, as they are long-lived compared to annuals. Furthermore, the available data show that there has been very little to no change in kettle pond vegetation over the past decade. Finally, changes in water levels have a much greater influence in coastal plain ponds due to the gentler slopes in these systems. Most of CACO’s kettle ponds have comparatively steep slopes. Thus, water-level changes do not translate into large changes in inundation across a wide expanse of the shoreline like they do in coastal plain ponds.

As a way to compensate for this variability, it would be optimal if subsequent surveys could be conducted during a year that is closer to the baseline year (1995) in terms of pond stage during the growing season. However, predicting this several months ahead of the field season could be extremely difficult, if not impossible. Regardless, until many years of data are available, herbaceous data may be better handled by transforming cover values to presence/absence. By doing this, large differences in abundance will not influence the results, except on occasion where a species totally fails to emerge at all due to extremely high or low water levels. Granted, the sensitivity for detecting real trends of vegetation change above and beyond annual variability is compromised. However, this may be necessary in order to reduce the effects of natural, short-term fluctuations.

Fortunately, this does not present as much of a problem with woody species, which persist throughout the year and tend to reflect multi-year hydrologic conditions. Thus, until many years

of data have been collected, comparisons of plant communities should focus on the dynamics of woody vegetation - its downslope encroachment/upslope retreat along elevation gradients, shifts in species composition, etc. An exception to this is the analysis of data on mature trees that are rooted well outside the wetland but have an overhanging canopy. As mentioned previously, these data are excluded from analysis since cover can be influenced by factors completely unrelated to the wetland. For example, cover can vary substantially if large branches or entire trees fall over during a storm, or if the tree simply dies. Over the longer term, maturation of upland trees will result in a progressive increase in cover that has little or nothing to do with in-pond processes.

While repeated monitoring of line transects are useful, it is clear that they represent a very small proportion of the vegetation communities within ponds. This apparently troubled Roman et al. (2001) as suggested by the following text in their original report:

“In addition to quantifying plant cover along the line, we also noted any species which fell within 1 m on either side of our transect line for each interval. We designated the cover of those plants on either side of the transect line as S = sparse; M = moderate; and D = dense coverage adjacent to that interval. In cases where a plant barely touched the line but densely filled much of the area within 1 m on one or both sides of the line, we have scored it both numerically and alphabetically (e.g., 1 for <1 cm on the line and D for dense within 1 m off the line)”.

The box plots may ultimately prove more valuable in documenting pond-wide changes in vegetation. In fact, more box plots should be established (in the manner previously described for locating transects in random fashion) in the ponds so that a much larger area of vegetation is analyzed. Transects, which represent one side of the box plots, can still be monitored to provide a basis for comparison with the 1995 dataset.

Despite the abovementioned challenges, the addition of five more ponds to the protocol in 2005 is expected to increase our ability to detect, analyze, and interpret spatial patterns and trends in pond vegetation, although this cannot be validated until a subsequent survey is conducted that includes these new sites. If possible, it would be highly desirable to add all the other kettle ponds to the monitoring network so that inferences can be made about “the universe” of kettle ponds within CACO. Given that few changes in vegetation structure and composition were evident over the 10-year period between 1995 and 2005, a monitoring frequency of once per decade is probably sufficient. This interval is likely to capture the kinds of vegetation changes that could trigger further studies and/or management activities.

Field Methods

The following sections provide an overview of field operations. These procedures are described in further detail in the Standard Operating Procedures (SOP) sections of this document.

Field Season Preparations and Equipment Setup

Prior to carrying out this protocol, the entire crew, including the project manager, must make sure that all equipment is available (see Equipment list in SOP#1) and in working order before use. It is also important that the lead biotech become intimately familiar with the vegetation he/she is likely to encounter and the process of identifying unknown specimens (see SOP#2). Field guides 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. Equally important is familiarization with GPS technology and use, which is described in SOP#3, and canoe safety guidelines.

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 field crew should review the entire protocol and make sure that they understand all the components of sampling, methods to insure data quality, and data management procedures.

Sampling Procedures

A detailed "cookbook" outline of the sampling procedure can be found in SOP#4. Briefly summarized, vegetation sampling is conducted along transects where line cover is estimated along contiguous 1-m segments. Area cover is also estimated in 5×10 m box plots, where one side of this rectangular area is the line transect. Finally, a whole-pond meander survey (species tally) is conducted. Sediment sampling is conducted at 2-m intervals along the transects before any vegetation work has been done.

End-of-day Procedures

Upon returning from the field each day, any voucher specimens collected as unknown specimens should be identified (SOP#4). Field notes/datasheets should immediately be examined for completeness and accuracy and then photocopied. The backup copies should be stored in a separate folder, preferably in a separate location. Originals should be stored in a fireproof safe. If there is time, it is advisable to enter data the same day that it is collected. Alternatively, one day a week can be set aside for data entry. 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. The victim 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 to the protocol and/or SOPs. 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 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 before the field crew leaves at the end of the season.

Data Handling, Analysis, and Reporting (to be developed further)

Overview of Data Procedures

In terms of quality assurance/quality control (QA/QC), this protocol incorporates a number of different procedural elements designed to maintain a high level of integrity. For example, the collection of field data involves thorough training of personnel and the implementation of standardized field procedures. Hardcopy documentation of all data is maintained in field notebooks and duplicate copies are stored separately. Data entry is completed at the end of each day or, when this is not possible, within a week of when the fieldwork was conducted. Data entry is done with two people to assure accuracy and improve probabilities that errors will be detected.

A number of built-in controls, such as range limits and look-up tables, have been incorporated into the database as a means to assure data quality. Once the data have been entered, each entry is double-checked or “proofed” for verification of accuracy. As an additional QA/QC check, the project manager should examine at least 10% of the data to look for illogical or obviously mistaken values (e.g., outside possible range limits), spelling errors, inconsistencies in naming conventions, duplicate records, etc. Any changes to records will be duly noted on the original field forms so that the electronic and hardcopy data forms match. Once the project manager has gone through this process of validation, the data will be saved to the NACL server (Y drive).

Recommendations for Routine Data Summaries and Statistical Analyses

The reader should refer to Roman et al. (2001) for a description of analyses that can be completed with the kettle pond vegetation and environmental data. Changes in floristic composition and species richness are important themes as well as the pondward encroachment or landward retreat of vegetation along the elevation gradient. For cover class data, ordination techniques are an excellent way to illustrate spatial and temporal variability. Non-metric multidimensional scaling (nMDS), clustering, and analysis of similarities (ANOSIM) are appropriate techniques to use.

For univariate data (e.g., species richness or sediment properties) the means and standard errors of the mean (standard deviation divided by the square root of the number of samples) should be calculated. To examine spatial or temporal differences between two groups of data (e.g., species richness in Long Pond in 1995 vs. 2005), the data should be tested for normality and homogeneity of variances and transformed if necessary. For comparisons between two groups of data, paired or independent T-tests can be used. For multiple groups, repeated-measures ANOVA is appropriate. Regression analysis (linear and curvilinear) can also be used to assess longer temporal trends over many survey years (note: regressions should be based on at least three datasets since a line cannot be defined by only two points). Notwithstanding, regressions can be conducted on environmental data for a single year of sampling (species richness or % cover vs. the environmental data- both within pond and between ponds).

The data for each variable can be grouped according to wetland indicator status (i.e., obligate, facultative wetland, facultative, facultative upland, upland) and growth habit (i.e., shrubs, trees, floating-leaved, etc.). Such grouping can provide a good indication of community shifts related to succession.

Recommended Reporting Schedule

Because the interval between sampling events will be in the range of ~10 years, reporting should be done after every season of fieldwork to assess decadal trends. The report should include background information about the project, a summary of what was accomplished during the season, some basic analyses of the data (see previous section), and a qualitative evaluation of the current methodology.

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 protocol can be carried out with two seasonal biological field technicians ("biotechs") or a biotech accompanied by a student intern/volunteer. In the case of the former, each biotech can take turns doing the sampling while the other records the data. In the latter situation, the biotech should be responsible for acquiring the data (i.e., actually doing the measurements and counts) while the assistant fills out the field datasheet. The lead biotech will also supervise all aspects of data processing, including several aspects of QA/QC, such as data entry and proofing. The project manager is responsible for coordination with the data manager to ensure 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 Ecosystem 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 identifications of species 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 (Appendix). 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 back at the office or laboratory. It is extremely helpful to allot some time prior to sampling to become familiar with the plant communities of the monitoring network by consulting legacy data and to practice estimating percent cover (see SOP#5).

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

- General safety guidelines for working at CACO
- 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
- Canoe safety guidelines
- Computer use guidelines
- Data entry and basic principles of data QA/QC, database functionality
- Data storage guidelines

Operational Requirements

Basic Field Schedule

It is recommended that sediment samples be collected first, before the bottom is disturbed by conducting the vegetation sampling. The vegetation meander surveys should be done next, which provides a good opportunity for field crews to sharpen their plant identification skills and familiarize themselves with the kettle pond flora. Transect and box plots surveys are completed last.

Facility and Equipment Needs

The field crew will require use of normal office space and a computer linked to the local NACL server. Internet connectivity is also desirable, as plant identification and general research can be aided by referencing various websites 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 Data 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.

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SOP#1: Preparations and Equipment Setup Prior to Field Season.
Version 1.0 (December 2007)

Cape Cod National Seashore
Kettle Pond Vegetation Monitoring Protocol
Standard Operating Procedure #1
Preparations and Equipment Setup Prior to Field Season

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

1.1 Preparation

To prepare for the field season, the field crew is advised to complete the following activities:

1. Review the entire protocol (~2days)
2. Review species lists and characteristics for identification (~3 days)
3. Retrieve and review prior data for reference
4. Visit actual sites or similar habitats to become familiar with vegetation, practice identification skills, and rehearse setting up plots (~3 days)
5. Consult maps of sites and transect/plot locations (~ 1day)
6. Inspect equipment and compile the items listed below (~ 1day)

1.2 Equipment List

- 2 field tapes
- Coring tube
- Cooler for sediment samples
- Compass
- Datasheets/field notebooks
- Hammer, rubber mallet
- Tree tags with unique ID numbers
- Aluminum wire
- GPS unit with sample site coordinates
- Hardcopy map of site locations with plot layout diagrams
- List of species previously found in plots
- Plant identification materials (field guides, digital images, etc.)
- Waders
- Viewscope
- Personal Flotation Devices (lifejackets)
- Anchoring pole to mark end of transects
- Insect repellent

- Pre-contact solution for prevention of poison ivy and poison sumac and post-contact wash (such as Technu™)
- Inflatable raft and canoe

SOP#2: Training Observers.
Version 1.0 (December 2007)

Cape Cod National Seashore
Kettle Pond Vegetation Monitoring Protocol
Standard Operating Procedure #2
Training Observers

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

2.1 Identification of Plant Taxa

At the beginning of the season, the project manager (botanist, plant ecologist) should take the field crew out to several sites and review as many different taxa as possible (~ 2days), after which the crew can be tested on their identification skills. It is also advisable for field crews to sit down with a list of species they are likely to encounter and study characteristics, images (found in Y:\Images\Ponds\kettle pond plant images), or actual samples from the NACL or Salt Pond Visitor Center herbaria.

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

- Dwelley, M. J. 2000. Trees and shrubs of New England. Down East Books: Camden, ME.
- Gleason, H. A., and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. New York Botanical Garden: Bronx, New York
- Holmgren, N. H. 1998. Illustrated Companion to Gleason and Cronquist's Manual: Illustrations of the Vascular Plants of Northeastern United States and Adjacent Canada. The New York Botanical Garden: Bronx, NY.
- Magee, D. W., and H. E. Ahles. 1999. Flora of the Northeast: A manual of the vascular flora of New England and adjacent New York. University of Massachusetts Press: Amherst, MA
- Newcomb, L. 1977. Newcomb's wildflower guide. Little, Brown and Company: Boston, MA.
- Stuckey, I. H., and L. L. Gould. 2000. Coastal Plants from Cape Cod to Cape Canaveral. University of North Carolina Press: Chapel Hill, NC.
- Svenson, H. K., and R. W. Pyle. 1979. The Flora of Cape Cod. Cape Cod Museum of Natural History: Brewster, MA.
- Crow, G. E., and C. B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America. Vol. 1. Pteridophytes, Gymnosperms, and Angiosperms: Dicotyledons. Univ. of Wisconsin Press. Madison, Wisconsin. 536 pp.
- Crow, G. E., and C. B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America. Vol. 2. Angiosperms: Monocotyledons. Univ. of Wisconsin Press. Madison, Wisconsin. 456 pp.

If the field crew encounters plant species that cannot be identified with a high degree of certainty, they should collect a voucher sample and bring it back to the laboratory for further assessment. The Plant Ecologist should be able to help with such “unknowns” as well.

SOP#3: Using the Global Positioning System.
Version 1.0 (December 2007)

Cape Cod National Seashore
Kettle Pond Vegetation Monitoring Protocol
Standard Operating Procedure #3
Using the Global Positioning System

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

3.1 General Use

CACO's GIS Specialist can provide training to the field crew prior to any field work.

General use: 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 use 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 GIS Specialist 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.

3.2 Recording Points

GPS coordinates for transect start locations were collected with a Garmin (GPSIII Plus) using the point averaging function. The data points were saved in the unit, uploaded onto a PC, and saved as an excel file named "All_pond_monitoring_pts_2005" on the NACL server (Y drive). The locations are also found in Appendix C. 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 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 counts of >100)

3.3 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 located in the office of the GIS Specialist. Again, maybe the GIS Specialist should take the crew out for training and practice.

A programmatic SOP for use of GPS for all CACO monitoring projects is in development. In the future, this SOP will be incorporated by reference and adapted as necessary for this protocol when it is completed. In the meantime, standards will be established and training provided in collaboration with the GIS Specialist.

SOP#4: Vegetation Sampling.
Version 1.0 (December 2007)

Cape Cod National Seashore
Kettle Pond Vegetation Monitoring Protocol
Standard Operating Procedure #4
Vegetation Sampling

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

Vegetation sampling should start by early July and end by late August. A monitoring frequency of once per decade is proposed. Field crews should attempt to collect the vegetation data within ~ 2 days for each pond.

4.1 Setting Up the Line Transects

In 1995, the transect starting points were originally marked with a cement-filled 4-inch diameter PVC monument - some of which could not be found in 2005 due to bank erosion that had buried them in soil and plant litter. For these transects, a zinc-plated, 0.5-cm diameter steel dowel was hammered into the ground as nearest the point as possible based on our best guess from hand-drawn maps. Steel dowels were also used to mark new transects in the five ponds that were added to the monitoring protocol (Spectacle, Great (W), Dyer, Snow, and Long). In addition, the nearest tree to each marker was tagged with an aluminum tree tag which is etched with a unique numeric ID (see Appendix C. The coordinates of each transect marker were recorded with a Garmin™ 76S GPS unit (average position) and are contained in the metadata file. The easiest way to find markers is to navigate to the general area using a GPS unit, then look for either a tree tag or the marker itself. In some cases, marker locations have been further identified by describing certain landscape features in close proximity. This information is also contained in the metadata.

Once the marker is found, the “zero” end of a field tape is attached to it. Run out the field tape along the ground according so that it is perpendicular to the shoreline.. When the tape reaches the water’s edge, pin it down with a tent stake and continue to run out the tape along the pond surface by either swimming it out using an inflatable raft or by canoe. The tape can be kept afloat using 1–2 small buoys that can slide along underneath it. Once a distance of 20 m is reached, set an anchoring pole (jam it into the sediment so that it is stable) and attach the handle end of field tape to it.

4.2 Recording Vegetation Along Transects

The field crew should aim to collect all the vegetation data specified below for each pond within 2 days (dependent, of course, upon having suitable weather conditions for fieldwork). The line intercept method is used to quantify the extent of linear cover by species for meter intervals along the transect tape. For each meter interval, plant species intersecting the transect line directly above and below the transect line are scored in eight categories (<1 cm = 1; 1-5 cm = 2; 5-10 cm = 3; 10-25 cm = 4; 25-50 cm = 5; 50-75 cm = 6; and 75-100 cm = 7). Canopy trees (i.e., those with trunks originating outside the transect but with limbs overhanging the transect – i.e., not rooted within the transect) were differentiated from pondshore seedlings/saplings (i.e., plants with stems rooted within the transect) in the notes section of the worksheet. A viewscope or snorkeling gear is used to determine the cover of submerged vegetation.

4.3 Setting Up the Box Plots

The transect line serves as the left side of the rectangular 5×10-m box plot from the perspective of looking out toward the middle of the pond. We chose to establish a 5×10 rather than a 10×10 based on the difficulty of seeing all the vegetation across 10 m of the shoreline shrub zone, which is typically quite dense. Locate the marker that indicates the other corner of the plot onshore. Then run another field tape out 10 m from this marker, parallel to the line transect. Mark this corner with a buoy so that the boundaries of the full plot are clearly visible.

4.4 Recording Vegetation in Box Plots

Record all species of vegetation occurring within the box plot (do not include overhanging vegetation) and assign a cover class value (same scale used for line transects but now based on percent cover by area) to each. Record the larger, most conspicuous vegetation first and then meander (by wading or raft – depending on water depth) through the plot to get an estimate of the cover of smaller, less conspicuous taxa. For benthic macrophytes, use of the viewscope or facemask is necessary.

4.5 Recording Vegetation in Meander Surveys

For the shrub zone, the observers simply walk and/or paddle around the peripheral edge of the pond, and record the presence of all species observed within a 5-m zone adjacent to the open part of the pond (defined as that part dominated by emergent herbaceous vegetation). For the littoral zone and out into deep water, all species that can be seen from the surface of the water are recorded. Obviously, some submerged vegetation existing in deep areas will be missed, but this will be a minor part of the plant community.

4.6 Identifying Unknown Species

In the event that a species cannot be identified in the field, a voucher sample should be collected and put in a Ziploc bag. Specimens should be taken outside the box plot area. Flowers or fruit, even if they are last year's growth, are very helpful in identification. In general, the 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. 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.

If no specimens can be found outside the box plots, a small amount of material (i.e., a branch, or portion of the stem with a few leaves) should be harvested from the plot 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.

There are several different tools available for identification. The simplest way is to consult 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 (e.g., unidentified tree/shrub/graminoid/fern etc.).

SOP#5: Collecting Data on Environmental Variables.
Version 1.0 (December 2007)

Cape Cod National Seashore
Kettle Pond Vegetation Monitoring Protocol
Standard Operating Procedure #5
Collecting Data on Environmental Variables

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

The field crew should allow ~ 1 day per pond to collect all the environmental data specified below (dependent, of course, upon having suitable weather conditions for fieldwork) beginning in early June.

5.1 Recording Pond Water Level

The elevation of the water table at the time of surveying is determined by optical leveling. An autolevel is set up near established benchmarks at each pond (usually a permanent hydrologic monitoring well (GPS locations can be found on the NACL server). The top of the well case (known elevation) is then sighted in relation to a stadia rod placed at the water's edge.

5.2 Collecting Sediment Samples

Starting at the first meter interval, sediment cores are taken from the midpoint of every other meter interval using a 30×4.8-cm (ID) clear polycarbonate tube. The coring tube is attached to a one-way valve which creates suction pressure once the tube is filled with sediment. To the other end of the valve is a long PVC pole so that the bottom can be reached from the surface of the pond when sampling from a watercraft. Cores are extruded by placing the coring device on the bottom at the appropriate location along the transect. The corer is pushed into the sediment to a depth that will fill the entire coring tube and then brought up quickly. To obtain the top 10 cm of sediment, the air valve on the core is opened to release the vacuum and the bottom part of the sediment sample is slowly dropped out of the tube until a 10-cm depth is contained within the tube. This portion is put into a Ziploc bag, labeled, and put into a cooler for transport back to the laboratory.

5.3 Processing Sediment Samples

At the laboratory, the sediment samples are removed from the Ziploc bags and placed in pre-weighed aluminum drying dishes. They then should be dried in the convection oven at 105°C for at least 30 hrs. After removal from the oven, the samples are 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).

A subsample of dried, homogenized 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 5 hrs. After letting the dish and sample cool down for at least 1 hr., the dish is weighed again to determine the amount of weight lost after burning. The % organic matter of the original sediment sample is then calculated as this percentage of the original (whole subsample) dry weight. Store in a dessicator if the samples cannot be weighed 1 hour after burning.

5.4 Recording Terrestrial and Pond-floor Elevations Along Transects

Topographic change can occur as a result of ice movement, slope erosion, etc. Transect elevations should be resurveyed every 10 years. For the terrestrial part of the transect, the optical level is used at the starting point to record the relative elevations of every meter interval until the transect intersects with the water. Then, for points along the transects within the pond, water depth readings can be used to determine the relative elevations of the pond floor.

SOP#6: General Safety Guidelines.
Version 1.0 (January 2006)

Cape Cod National Seashore
Kettle Pond Vegetation Monitoring Protocol
Standard Operating Procedure #6
General Safety Guidelines

Revision History Log:

Revision #	Date	Author	Changes Made	Reason for Change

All project staff will receive the training and implement the measures established in the park's programmatic SOP # P2 - Safety Standards and Procedures for Monitoring Projects, which is incorporated by reference. Special attention should be paid to the elements of the programmatic SOP addressing tick bites and Lyme disease, heat stress, and poison ivy.

In addition to the basic requirements of the programmatic SOP, the following measures will be implemented as part of the Kettle Pond Vegetation 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 personnel should 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.

Appendix A. SIMPER analysis of individual ponds between years of sampling.

Duck Pond Average dissimilarity = 68.32

Species	1995	2005	Av.Diss	Diss/SD	Contrib%	Cum.%
	Av.Abund	Av.Abund				
VacCor	14.6	16.2	11.79	1.18	17.26	17.26
Sphagnum	2.4	17.4	10.21	1.77	14.95	32.21
ChaCal	11.6	20.6	9.03	1.2	13.22	45.43
SmiRot	8.6	9	6.47	1.07	9.46	54.89
EleAci	9.4	3.8	5.17	1.17	7.56	62.45
CypDen	7.6	3.4	4.39	1.6	6.43	68.88
CalCan	1.4	7.2	3.85	1.08	5.63	74.52
Juncus	2.8	0	2	0.99	2.93	77.44
EutTen	2	1	1.71	0.78	2.5	79.94
JunPel	2.4	0	1.45	1	2.12	82.06
JunEff	1.4	0	1.43	0.44	2.09	84.15
IsoTuc	0.2	2	1.33	0.53	1.95	86.09
GraAur	0	2	1.23	0.47	1.8	87.9
Grass2	2.2	0	1.21	0.47	1.77	89.67
VioLan	1.8	0	1.05	1.05	1.54	91.21

Great (T) Pond Average dissimilarity = 58.98

Species	1995	2005	Av.Diss	Diss/SD	Contrib%	Cum.%
	Av.Abund	Av.Abund				
Utric	14.8	51.6	9.1	2.0	15.5	15.5
JunMil	20.2	40.8	5.1	1.7	8.6	24.1
GraAur	17.6	1.2	3.8	1.0	6.4	30.5
NymOdo	18.0	22.6	3.7	1.6	6.3	36.8
VacCor	15.4	14.4	3.5	1.2	6.0	42.7
Myrio	9.0	9.2	2.7	1.1	4.6	47.4
LobDor	12.0	6.0	2.7	1.2	4.5	51.9
NymCor	3.0	10.2	2.4	1.0	4.0	55.9
Sphagnum	0.0	10.0	2.2	0.9	3.7	59.6
SmiRot	5.6	6.4	2.2	0.8	3.7	63.3
EleAci	2.0	10.2	2.1	1.8	3.6	66.9
CleAln	14.4	15.8	1.9	1.4	3.3	70.1
EutTen	3.0	8.0	1.5	1.6	2.6	72.7
NupLut	3.6	3.6	1.3	0.9	2.3	75.0
ChaCal	4.8	9.6	1.3	1.5	2.2	77.1
MyrPen	3.8	3.4	1.3	0.9	2.2	79.3
RhoVis	4.6	5.0	1.2	1.2	2.1	81.4
KalAng	4.4	3.0	1.0	1.3	1.8	83.1
VioLan	3.4	0.0	0.8	1.9	1.3	84.5
WooVir	2.8	0.8	0.7	0.6	1.3	85.7
LysTer	3.0	0.0	0.7	1.1	1.2	87.0
IleGla	1.8	2.2	0.7	0.7	1.2	88.2
HypCan	2.8	0.4	0.7	1.1	1.1	89.3
DroInt	2.4	0.0	0.6	1.2	1.0	90.2

Gull Pond Average dissimilarity = 59.81

Species	1995	2005	Av.Diss	Diss/SD	Contrib%	Cum.%
	Av.Abund	Av.Abund				
LobDor	37	55	7.92	1.21	13.23	13.23
GraAur	20.8	18.4	5.04	1.35	8.43	21.66
EleAci	21	10	4.87	1.91	8.15	29.81
SciPun	3.6	14.8	4.16	0.73	6.96	36.77
EriSep	2.6	14.2	3.38	1.08	5.64	42.42
CleAln	13.2	14	3.11	1.24	5.2	47.62
PonCor	4.8	8	2.97	0.76	4.97	52.59
IsoTuc	2	11.2	2.97	1.08	4.96	57.55
Chara/Nitella	11.2	0	2.68	0.65	4.48	62.02
RhoVis	7.4	8.4	2.43	1.19	4.07	66.09
NymCor	9.8	4.8	2.36	1.11	3.95	70.05
DesFle	6.2	2.2	1.86	1.08	3.12	73.16
CarPen	0	6.6	1.77	1.28	2.97	76.13
SmiRot	4.2	5.4	1.68	1.1	2.81	78.94
AlnRug	0.6	4.8	1.43	0.77	2.39	81.33
EutTen	2.2	3.2	1.16	0.93	1.94	83.27
Juncus	3	0	0.74	0.67	1.24	84.52
MyrPen	2.6	0	0.7	0.77	1.17	85.69
AroMel	0.6	2.4	0.62	1.13	1.03	86.72
VacMac	0.4	2	0.61	0.57	1.02	87.75
LysTer	0	2	0.59	0.78	0.98	88.72
VacAng	1.4	1	0.53	0.79	0.89	89.61
ToxRad	1.2	1	0.51	0.67	0.85	90.46

Herring Pond Average dissimilarity = 67.73

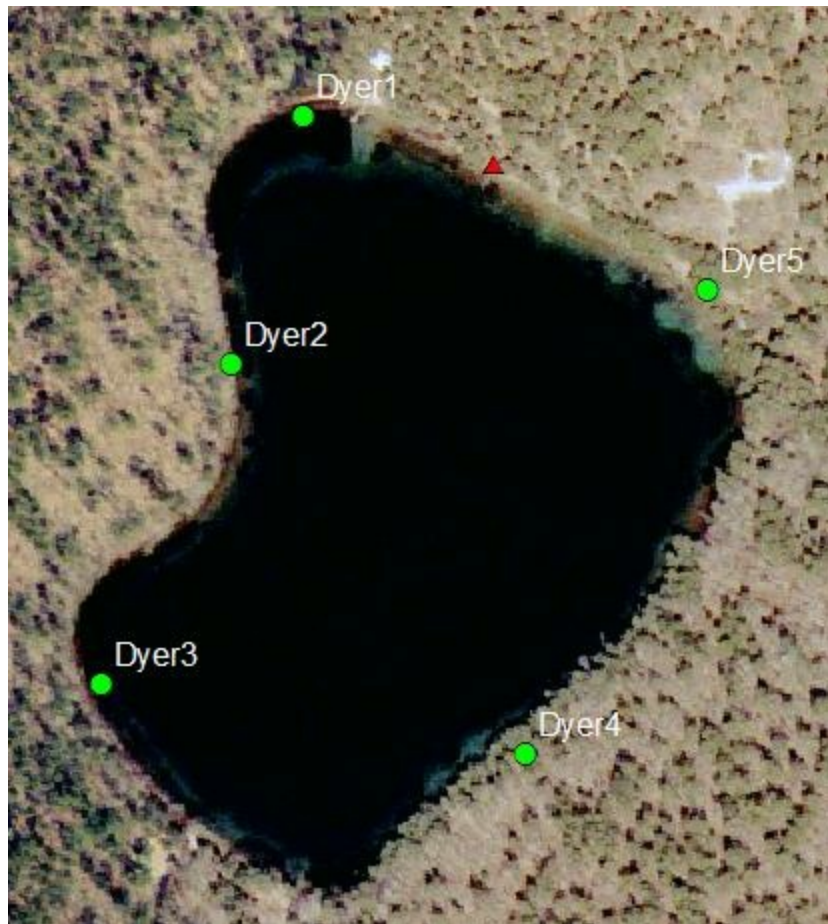
Species	1995	2005	Av.Diss	Diss/SD	Contrib%	Cum.%
	Av.Abund	Av.Abund				
NymCor	5.2	32.4	7.0	1.0	10.3	10.3
NymOdo	19.8	24.0	4.9	1.2	7.3	17.6
Chara	22.6	0.4	4.6	1.0	6.8	24.4
RhoVis	22.0	17.8	3.1	1.5	4.6	29.0
CleAln	29.8	39.4	3.1	1.3	4.5	33.5
NajFle	0.4	15.6	3.0	0.8	4.4	37.9
Sphagnum	10.4	20.8	2.9	1.7	4.3	42.2
ChaVul	12.0	0.0	2.9	0.5	4.3	46.5
NysSyl	7.4	13.6	2.9	0.9	4.3	50.8
DecVer	15.2	18.2	2.8	1.3	4.2	54.9
QueVel	5.2	11.2	2.5	0.7	3.7	58.6
VacCor	5.2	10.4	1.9	1.1	2.9	61.5
RosPal	3.8	8.2	1.8	0.7	2.7	64.2
BraSch	7.6	0.0	1.7	0.7	2.6	66.7
ThePal	8.0	3.0	1.7	0.8	2.5	69.3
CalCan	8.0	0.0	1.4	0.7	2.1	71.4
SmiRot	0.6	8.4	1.4	0.7	2.1	73.5
PonCor	3.2	5.2	1.2	0.8	1.8	75.3
TriVir	3.0	6.6	1.2	1.0	1.7	77.0
IleVer	4.0	1.0	1.1	0.6	1.6	78.6
VacMac	5.4	0.0	1.0	0.7	1.5	80.2
OnoSen	5.0	3.2	1.0	1.1	1.4	81.6
WooVir	1.4	4.8	1.0	0.6	1.4	83.0
GauPro	2.8	1.6	0.7	0.7	1.1	84.1
PhrAus	0.0	3.8	0.6	0.5	0.9	85.0
KalAng	3.4	0.0	0.6	0.5	0.9	85.9
PotEpi	1.8	1.2	0.6	0.7	0.9	86.8
LysTer	1.0	3.0	0.6	0.8	0.9	87.7
HydUmb	2.4	2.2	0.6	1.0	0.8	88.5
CicBul	1.2	2.8	0.6	0.9	0.8	89.3
LeeOry	1.8	2.4	0.5	1.0	0.8	90.1

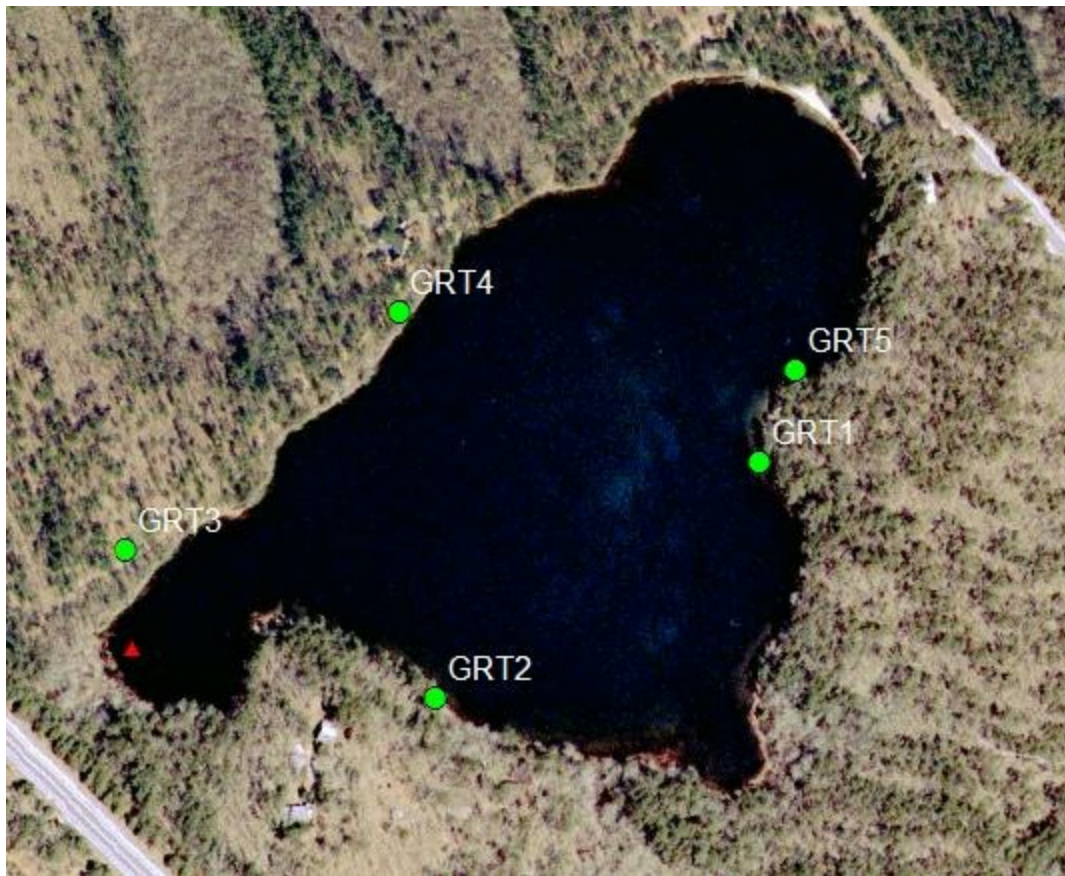
Ryder Pond Average dissimilarity = 71.74

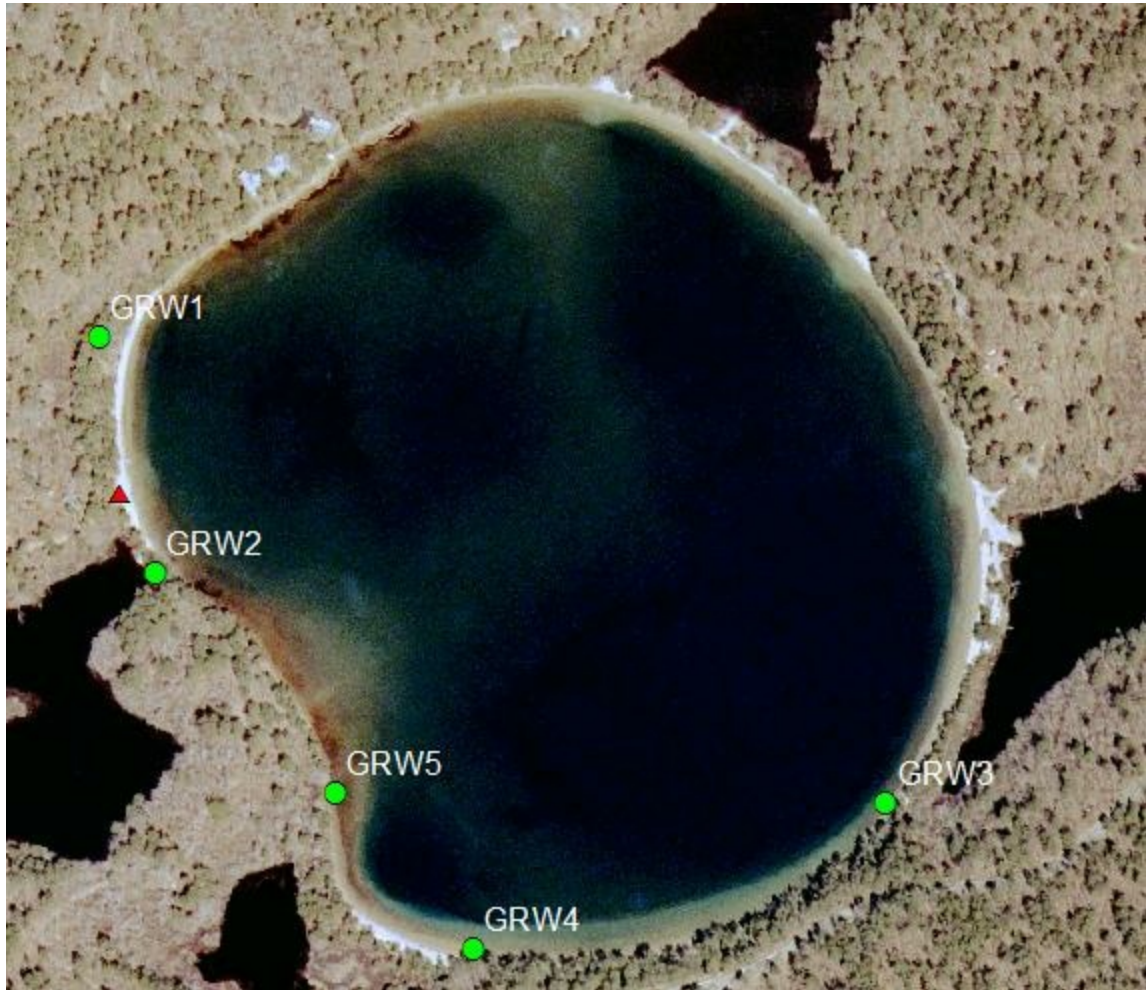
Species	1995	2005	Av.Diss	Diss/SD	Contrib%	Cum.%
	Av.Abund	Av.Abund				
CleAln	10.6	12.2	8.9	1.07	12.41	12.41
JunMil	10	8.2	8.45	0.99	11.78	24.19
NymOdo	3.6	8.4	7.95	0.73	11.08	35.27
MyrPen	4.8	8.4	6.47	1.05	9.02	44.29
ChaCal	7.6	3	5.43	1.14	7.57	51.86
VacCor	2.8	4.2	4.87	0.86	6.79	58.65
RhoVis	3.2	5.8	4.65	0.95	6.49	65.14
SmiRot	3.2	3.6	4.14	0.97	5.77	70.9
EleAci	2.2	2.6	3.07	0.65	4.29	75.19
ArcUva	1.8	1.8	2.61	0.63	3.64	78.83
DecVer	2.2	1.2	2.27	0.67	3.17	82.01
PonCor	1.6	2.2	1.92	0.92	2.68	84.68
EriSep	1.2	2.2	1.83	0.84	2.55	87.24
Quelli	1.4	0.4	1.34	0.6	1.87	89.11
BidCon	1.6	0	1.17	0.92	1.63	90.74

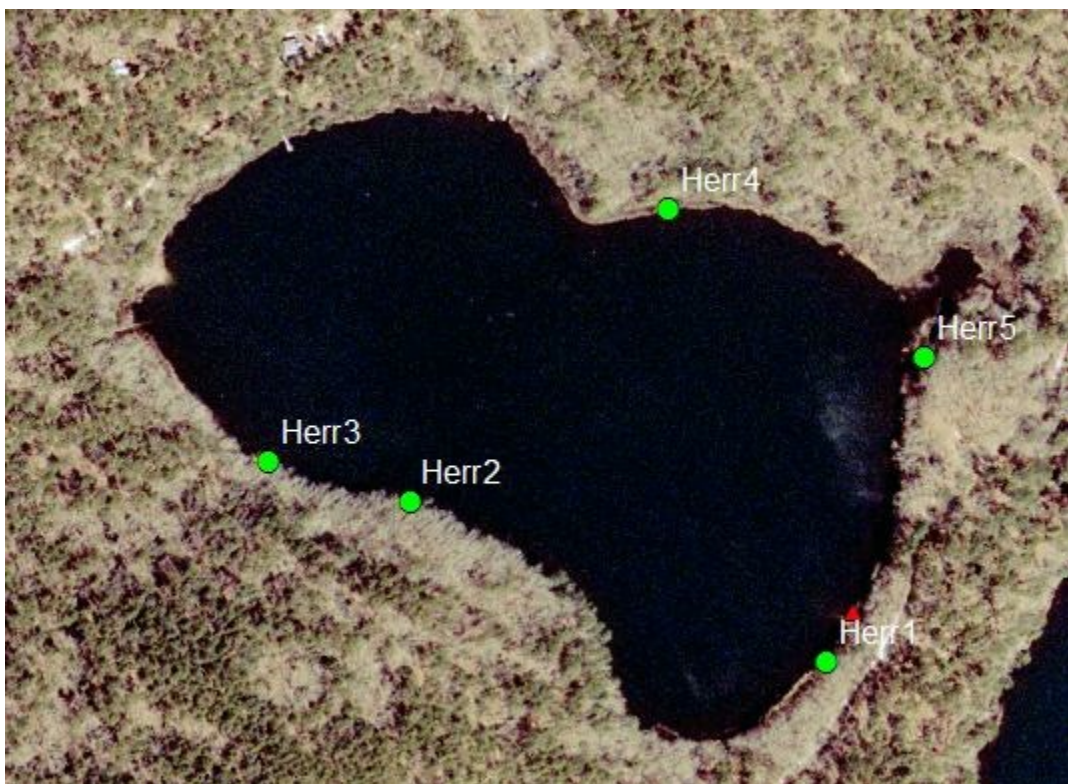
Appendix B. Aerial photos of ponds with transect start point locations.

















Appendix C. Metadata for the start points of transect sampling locations.

Site	UTM-E	UTM-N	Tree Tag #	Tree type	Notes
Duck1	417171	4642823	624	pitch pine	Original monument replaced with steel dowel
Duck2	417165	4642796	635	pitch pine	Original monument replaced with steel dowel
Duck3	416968	4642714	657	pitch pine	Original monument replaced with steel dowel
Duck4	416956	4642872	647	pitch pine	
Duck5	417029	4642938	605	pitch pine	west of fallen pine
Dyer1	416277	4643608	649	pitch pine	
Dyer2	416250	4643515	608	pitch pine	
Dyer3	416201	4643395	656	red maple	
Dyer4	416360	4643369	655	pitch pine	
Dyer5	416428	4643543	602	pitch pine	
GRT1	414766	4647448	639	pitch pine	monument is about 8 m upslope and to left of tagged tree
GRT2	414606	4647332	650	red maple	
GRT3	414453	4647405	617	red maple	
GRT4	414588	4647522	609		
GRT5	414784	4647494	616		
GRW1	416792	4643754	661	pitch pine	
GRW2	416824	4643620	659	pitch pine	
GRW3	417242	4643488	625	pitch pine	
GRW4	417006	4643404	604	pitch pine	
GRW5	416927	4643494	603	pitch pine	
Gull1	416575	4645721	665	pitch pine	
Gull2	416870	4645491	662	pitch pine	
Gull3	416689	4645098	no tag yet		Original monument replaced with steel dowel
Gull4	416451	4645080	648		
Gull5	416202	4645718	607		Original monument replaced with steel dowel
Herr1	416155	4646045	646	red maple	Original monument replaced with steel dowel
Herr2	415942	4646127	658	beech	Original monument replaced with steel dowel
Herr3	415870	4646147	695(621)	big red maple	Original monument replaced with steel dowel
Herr4	416074	4646276	611	black gum	
Herr5	416205	4646200	664	pitch pine	
Long1	416392	4643993	643	pitch pine	
Long2	416775	4643981	623	pitch pine	
Long3	416282	4644186	653	pitch pine	
Long4	416822	4644067	651	pitch pine	
Long5	416881	4644253	640	pitch pine	

Site	UTM-E	UTM-N	Tree Tag #	Tree type	Notes
Ryder1	414469	4646585	652	pitch pine	
Ryder2	414581	4646836	664	red maple	
Ryder3	414636	4646715	629	pitch pine	
Ryder4	414700	4646494	666	pitch pine	
Ryder5	414572	4646436	610	oak	
Snow1	414823	4647064	620	pitch pine	
Snow2	414774	4647011	660	pitch pine	
Snow3	414787	4646878	614	oak	
Snow4	414869	4646820	632	pitch pine	
Snow5	414927	4646892	667	pitch pine	
Spec1	417430	4644890	627	pitch pine	
Spec2	417413	4644877	606	white oak	
Spec3	417433	4644817	619	red maple	
Spec4	417505	4644879	626	red maple	
Spec5	417481	4644894	637	pitch pine	

Appendix D. Sediment core sampling locations for which data are available for both 1995 and 2005 (first number is transect, followed by meter interval; i.e., 1-4 = transect 1, 4-m line segment).

DUCK	HERRINGGULL	GREAT	RYDER
1_4	1_10	1_2	1_6
1_6	1_12	1_4	1_8
1_8	2_6	1_6	1_12
1_10	2_8	1_8	1_14
1_12	2_10	1_10	2_4
2_4	2_12	1_12	2_6
2_6	2_14	1_14	2_8
2_8	3_8	1_16	2_10
2_10	3_10	1_18	2_12
2_12	4_14	1_20	2_14
3_10	4_16	1_22	4_2
3_12	5_12	2_5	4_3
3_14	5_14	2_7	4_4
3_16	5_18	2_9	4_5
3_18		2_11	5_4
4_4		2_13	5_6
4_6		3_3	5_8
4_8		3_5	5_10
4_10		3_7	
4_12		3_9	
4_14		3_11	
5_4		3_13	
5_6		3_15	
5_8		3_17	
5_10		5_4	
5_12		5_6	
5_14		5_8	
		5_10	
		5_12	
		5_14	
		5_16	
		5_18	

Appendix E. List of plant taxa likely to be found in CACO kettle ponds.

<i>Acer rubrum</i>	<i>Hypericum mutilum</i>	<i>Scirpus cyperinus</i>
<i>Agalina purpurea</i>	<i>Ilex glabra</i>	<i>Sium suave</i>
<i>Agrostis alba</i>	<i>Ilex verticillata</i>	<i>Smilax rotundifolia</i>
<i>Alnus serrulata</i>	<i>Impatiens capensis</i>	<i>Sphagnum</i> spp.
<i>Amelanchier arborea</i>	<i>Isoetes</i>	<i>Thelypteris palustris</i>
<i>Amelanchier canadensis</i>	<i>Juncus acuminatus</i>	<i>Toxicodendron radicar</i>
<i>Apios americana</i>	<i>Juncus canadensis</i>	<i>Triadenum virginicum</i>
<i>Aronia arbutifolia</i>	<i>Juncus militaris</i>	<i>Utricularia</i> spp.
<i>Aronia floribunda</i>	<i>Juncus pelocarpus</i>	<i>Vaccinium corymbosum</i>
<i>Asclepias incarnata</i>	<i>Kalmia angustifolia</i>	<i>Vaccinium macrocarpo</i>
<i>Aster novi-belgii</i>	<i>Leersia oryzoides</i>	<i>Viola lanceolata</i>
<i>Betula populifolia</i>	<i>Leucobryum</i>	<i>Woodwardia virginica</i>
<i>Bidens connata</i>	<i>Lobelia dortmanna</i>	<i>Xyris caroliniana</i>
<i>Bidens frondosa</i>	<i>Lycopus uniflorus</i>	<i>Xyris deformis</i>
<i>Brassenia schreberi</i>	<i>Lycopus virginicus</i>	
<i>Calamagrostis canadensis</i>	<i>Lyonia ligustrina</i>	
<i>Carex albolutescens</i>	<i>Lysimachia terrestris</i>	
<i>Carex pensylvanicum</i>	<i>Maianthemum canadense</i>	
<i>Chamaedaphne calyculata</i>	<i>Monotropa uniflora</i>	
<i>Chara/Nitella</i>	<i>Myrica pensylvanicum</i>	
<i>Cicuta bulbifera</i>	<i>Myriophyllum humile</i>	
<i>Clethra alnifolia</i>	<i>Myriophyllum tenellum</i>	
<i>Coptus groenlandica</i>	<i>Najas flexilis</i>	
<i>Cyperus dentatus</i>	<i>Nuphar luteum</i>	
<i>Cyperus strigosus</i>	<i>Nymphaea odorata</i>	
<i>Decodon verticillatis</i>	<i>Nymphoides cordata</i>	
<i>Dicranum</i> (moss)	<i>Nyssa sylvatica</i>	
<i>Drosera filiformis</i>	<i>Onoclea sensibilis</i>	
<i>Drosera intermedia</i>	<i>Panicum wrightianum</i>	
<i>Eleocharis acicularis</i>	<i>Pinus rigida</i>	
<i>Eleocharis smallei</i>	<i>Polygala cruciata</i>	
<i>Epilobium</i>	<i>Polygonum careyi</i>	
<i>Erechtites hieracifolia</i>	<i>Polygonum pensylvanicum</i>	
<i>Eriocaulon septangulare</i>	<i>Polytrichum juniperum</i>	
<i>Euthamia tenuifolia</i>	<i>Pontederia cordata</i>	
<i>Fagus grandifolia</i>	<i>Potamogeton epihydrus</i>	
<i>Fimbristylis autumnalis</i>	<i>Pteridium aquilinum</i>	
<i>Fontenalis</i> (moss)	<i>Quercus alba</i>	
<i>Galium palustre</i>	<i>Quercus ilicifolia</i>	
<i>Galium</i> sp.	<i>Quercus seedling</i>	
<i>Gaultheria procumbens</i>	<i>Quercus velutina</i>	
<i>Gaylussacia baccata</i>	<i>Rhododendron viscosum</i>	
<i>Glyceria canadensis</i>	<i>Rhynchospora capitellata</i>	
<i>Gratiola aurea</i>	<i>Rhynchospora corniculata</i>	
<i>Holcus lanatus</i>	<i>Rosa palustris</i>	
<i>Hydrocotyl Thuidium</i>	<i>Salix</i> sp.	
<i>Hypericum canadense</i>	<i>Schoenoplectus pungens</i>	

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