Changes in Taylor Slough Vegetation from 1979 to 2010

Final Report

Contract # J5284-08-0020

Sonali Saha, Keith Bradley,
Craig van der Heiden

March 25, 2014

Report submitted by
Craig van der Heiden, CEO

The Institute for Regional Conservation
100 E Linton Blvd, Suite 302B
Delray Beach, FL 33483

SUBMITTED TO
JIMI SADLE
EVERGLADES NATIONAL PARK

Table of Contents

TABLES

FIGURES

SUMMARY

This study documents changes in vegetation in Taylor Slough, Everglades National Park, based on monitoring of five long-term transects from 1979 to 2010. We analyzed differences in percent cover of common plant species and total plot cover from the 1990s to 2010. We used data on water depth, total phosphorus (TP), and fire history to examine the drivers of observed change in composition. A Wetland Affinity Index was used to detect changes in species composition that indicate hydrological changes.

Total phosphorus in the water column, a cause of eutrophication in Everglade wetlands, varied across the study area. Total phosphorous levels were highest near the headwaters of Taylor Slough at the S-332 and S-332D structures, and declined southward. There were periodic pulses of phosphorus detected at recorders. Total phosphorous was the only variable that had a significant effect on total mean cover per transect.

Vegetation changes consistent with modification of water deliveries were observed, particularly in transects closer to water control structures. Transect 1, which was the closest to structures and the L-31W canal at the head of Taylor Slough, showed the most dramatic long-term vegetation changes, which we suspect resulted from eutrophication caused by the influx of phosphorous. In this transect we detected the establishment of *Typha domingensis* in 25% of plots in 2007 and 35% of plots in 2010. This is the first record of this species across 20 years of sampling this transect and a potential indicator of nutrient influx into Taylor Slough and subsequent eutrophication. Overall species composition in Transect 1 changed as well, with a large increase in total vegetation cover and an altered assemblage of dominant species, also potentially indicating eutrophication. Transects 4 and 5 also show evidence of change due to increased water deliveries due to the operation of the S-332D, as indicated by increases in total vegetation cover and *Cladium jamaicense* cover, and a sudden increase in Wetland Affinity Index values in 2003.

We found that the cover *C. jamaicense* has increased throughout the study period in transects 1, 2, 4, and 5 and was variable in Transect 3. *Muhlenbergia capillaris* cover was variable within most transects across years. It showed a decrease in Transect 1 and an increase in Transect 5. *Panicum tenerum* shows a significant increase over time in all five transects, while other common species such as *Centella asiatica, Eleocharis cellulosa, Pluchea rosea,* and *Rhychospora tracyi* fluctuated across years without discernible temporal patterns in most transects. There was a temporal trend in total vegetation cover in transects 1 and 5 with cover increasing from 1995 through 2007. In transect 4, the total cover increased from 1997 to 2007 but then

declined again in 2010. There was variation in total cover across years with no trend or increase in time in transects 2 and 3.

Wetland Affinity Index values for transects 1-3 indicated a large vegetation response to increases in water from 1979 to 1995, and thereafter remained stable, with slight evidence of drying conditions from 1995 to 2010. The index showed variability in transects 4 and 5 from 1995 to 2010, with a major increase in wetland affinity in 2003 indicating increased water levels prior to the 2003 sampling, corresponding to the movement of water deliveries to the S-332D structure and observed hydrological changes. Index values for transects 4 and 5 dropped, but were still above 1990s values.

Using Two-way Indicator Species Analysis (TWINSPAN) Taylor Slough vegetation was classified into categories representing marsh hydrology (i.e. wetter and drier). When using classification or Detrended Correspondence Analysis (DCA) techniques we could not discern any clear patterns attributed to nutrients, fire, or other factors.

Introduction

This study summarizes changes in vegetation in Taylor Slough based on monitoring of five permanent transects from 1979 to 2010. These permanent transects were established to record changes in vegetation that might occur because of changes in water delivery regimes (Olmsted et al., 1980). Taylor Slough is located in the southeastern portion of Everglades National Park (EVER), starting to the north of the park's main entrance and flowing south nearly 30 km into Florida Bay. Dominant vegetation includes freshwater marshes dominated by species such as *Cladium jamaicense*, *Muhlenbergia capillaris*, *Eleocharis cellulosa*, and *Panicum hemitomon*. Species associated with longer hydroperiods occupy the central portions of the slough with lower elevations and longer hydroperiods, and species tolerant of drier conditions occupy the periphery of the slough at higher elevations. All of these species are common throughout peninsular Florida in oligotrophic wetlands. As Taylor Slough approaches Florida Bay, increased salinity causes a major shift in vegetation. Closer to Florida Bay freshwater marshes are replaced by saline estuarine environments dominated by Rhizophora mangle.

Engineering projects implemented to drain the Everglades in the early 1900s disrupted the natural flow regime within Taylor Slough. Canals and levees constructed to the east of Taylor Slough in the late 1960's further dried the slough. The construction of the L-31 canal along the park's border (1968-70) cut through the slough and isolated it from much of its headwaters. The drained wetlands forming portions of the historical headwaters of the slough outside of the park were subsequently put into agricultural use. The L-31W canal also directed surface waters from Taylor Slough and it's headwaters to the east instead of downstream (Van Lent et al., 1993). Further south, Ingraham Highway (now Main Park Road) also served as a partial barrier to water flowing to the south while at the same time possibly serving to impound water to the north. Current water depths in parts of Taylor Slough are thought to be at least 1-2 feet lower than historic levels (Van Lent et al., 1993).

Efforts to rehydrate Taylor Slough were initiated in 1980 with the construction and operation of water control structures designed to pump water from drainage canals back into the slough. Between 1980 and 1999, water was pumped directly from the L-31W canal into Taylor Slough through water control structure S-332, which served as a point source for water delivery into the central channel of the slough. In an effort to recreate more natural sheet flow, as part of Everglades restoration efforts, pumping was shifted north in 2000 to the newly constructed S-332D structure. Three water detention areas were created outside of the park to prevent water loss into the L-31W canal. These detention areas were created in former farm fields. During high water the degraded western bank of the L-31W canal between the Park and detention areas allowed water to enter the slough. This directs water to flow across wetlands located in Taylor Slough headwaters towards the middle of the slough, although water still originates as a point source, it is somewhat more spread out. Additionally an increase in the L31N stage reduced water losses due to seepage.

Water column nutrient levels, particularly phosphorus, are a concern in Everglades wetland ecosystems because of the effects on vegetation composition. Small increases of phosphorus in the naturally oligotrophic Everglades wetlands causes changes in biogeochemical processes, which in turn lead to changes in vegetation such as an increase in biomass (Noe et al., 2001). Another common and conspicuous result of phosphorus influxes is the invasion of *Typha domingensis*, a large herb that has the ability to outcompete most other plant species resulting in the formation of monospecific stands. Due to the problem of nutrient enrichment, quality standards for waters entering Everglades National Park (EVER) at Taylor Slough were established under a consent decree resulting from a lawsuit between the U.S. government and the State of Florida (SFWMD, 2012). Water entering Taylor Slough, measured at the S-332D structure, must have a 12 month flow weighted mean of less than 11ppb total phosphorous and no more than 53.1% of samples may exceed 10ppb (Mo et al., 2010).

In an effort to understand vegetation dynamics in relation to water deliveries to Taylor Slough, Olmsted et al. (1980) established three vegetation monitoring transects spaced from 0.3 to 5 km downstream of the newly constructed S-332 structure (Figure 1) and reported baseline vegetation conditions in 1979. In 1997, transects 4 and 5 were established in Taylor slough headwaters to broaden the sampling domain (Figure 1). Subsequently, Armentano et al. (2006) analyzed population dynamics of dominant species from 1979 until 2003 and discovered that changes in abundance in response to hydrological change occurred within no more than 3 or 4 years of management intervention. Increase in abundance of indicator species of longer hydroperiod plant species (*C. jamaicense* and *E. cellulosa*) were documented and indicator species of shorter hydroperiods (*M. capillaris*) declined. These changes were attributed to modification of water management operations between 1980-1999, which raised Taylor Slough marsh water depths above those of the previous two decades. During 1993–1999, water deliveries by S-332 were much higher than before, reflecting both high rainfall and operational choices, and thereafter water levels decreased. The changes in abundances of the three indicator species occurred with a mild decline in water depths during the post-S-332 period.

Following the detection of *T. domingensis* in Taylor Slough during this study, other authors have reported evidence of eutrophication. Sadle (2008) mapped *T. domingensis* in 36 acres of marsh adjacent to the S-332 structure. Surratt et al. (2012) suggest that phosphorous loads and rates associated with the S-332 structure were causing eutrophication, as evidenced by the appearance of *T. domingensis,* and that phosphorus influx problems can be dated back to the period in which the S-332 structure became operational. Other authors have also suggested that eutrophication is occurring in upper Taylor Slough (Gaiser et al., 2006; Right et al., 2004; Trexler et al., 2003).

Because water delivery decisions can have unforeseen consequences the National Park Service and The Institute for Regional Conservation (IRC) have continued to monitor the original three 1979 vegetation transects as well as the two established in 1997. Data from a sixth transect established in 2007, in southern Taylor Slough, are not presented in this report. The aim of continued monitoring is to understand how Taylor Slough vegetation responds to changes in water quantity and quality. Because of the detection of *T. domingensis* an additional objective of this study was to examine the patterns of *T. domingensis* occurrence in Transect 1 and long-term changes specific to that transect and the nearby Transect 2. Vegetation changes in all transects were evaluated in relation to water column nutrients, hydrology, elevation, soil depth, and fire.

Study Site and Methods

Study Sites

Data from five vegetation monitoring transects were analyzed in the study. All transects are located in or adjacent to Taylor Slough (Figure 1) and vary in distances from water management structures (e.g. canals or pumping stations), which influence water depth. Transects 1-3 lie within the slough at increasing distances from the S-332 and S-332D structures (0.5, 2.0, and 3.8 km from S-332, respectively) and were first established in 1979 (Olmsted et al., 1980). Transects 4 and 5 are outside of slough's main drainage flow, located to the north of it in its headwaters, and were established in 1997 (Armentano et al., 2006). Transect 4 is the northernmost of all five transects, located 5.8 km to the north of S-332. Transect 5 is 1.2 km from S-332, between Transects 1 and 5.

Sampling methodology follows the original study design by Olmsted et al. (1980). Transect lengths vary from 0.4 to 1.9 km long. Transects 1-3, were placed perpendicular to the direction of the slough's drainage, thus crossing a hydrological and elevation gradient. Twenty permanently marked 1 m x 5 m plots were placed along each transect. Each of these plots was divided into five 1 x 1 m subplots. Data were collected in the dry season during each sampling event to minimize influence of seasonality.

Changes in Species Composition

Following Olmsted et al. (1980) and Armentano et al. (2006), we used percent cover as a metric of plant abundance and dominance because cover is a good surrogate for biomass, and responds to changes in variables such as water depth, hydroperiod, nutrient availability, and fire frequency. All plant species present and rooted within the plot were identified and recorded in each subplot. Each subplot was divided visually into four quadrants and cover for each species was estimated to the closest 5% in each quadrant. Total cover of each plant species was recorded, defined as the percent of the area covered by all live and dead vascular vegetation (not periphyton) as viewed from above. These four measurements were then averaged to produce a cover value for each subplot. For analyses these data were averaged across subplots resulting in total cover of each species per plot. Additionally, total vegetation cover and species richness were determined in the 20 plots along each transect.

For analyses we focused on the most common plant species encountered. We defined common species as those that occurred in all transects and at all sampling events. Analyses of cover change for each of seven common species (*Centella asiatica, C. jamaicense, Eleocharis cellulosa, Muhlenbergia capillaris, Panicum tenerum, Pluchea rosea, Rhyncoshpora tracyi*) and total cover data were conducted by using plot value as a replicate per transect per year. Though the plots show microhabitat variation in relation to elevation, we decided to treat them as random replicates representing the transect instead of classifying them into *M. capillaris* and *C. jamaicense* plots as done by Olmsted et al. (1980). No clear cut differences in cover existed in plots from 1990 onwards for either of these two species. We used analysis of variance (ANOVA) with year as the categorical variable and plots per transect as response variables to test for year effect on total vegetation cover and cover of each of the common species.

Wetland Affinity Index

Dominance by hydrophytic species can be quantified by summarizing the data using wetland indicator values (Reed, 1988). These values were revised in 1996, and while currently not published, the list is due for publication soon (S. Mortellaro, USFWS, personal communication). The calculations used herein follow the revised 1996 classification. This classification assigns a probability for each plant species in the region to occur in a wetland (PUSFWS). The Wetland Affinity Index (WAI), or simply the weighted mean probability of occurrence in wetlands for all species combined in each one square meter quadrat, is calculated by the following formula:

$$WAI = \sum XiWi \Big/ \sum Wi$$

Where: X*i* = PUSFWS for indicator category, *i*, based on the above-noted 1996 classification; PUSFWS = Probability that a plant species in the region occurring in a wetland; and W*i* = Weight = Percent Frequency by plants in indicator category *i.* WAI, as an artificial index of dominance by hydrophytic vegetation, allows the quantification of the degree of dominance by inundationtolerant species. This helps to elucidate patterns of vegetation change due to changes in hydrology.

Soil Depth and Elevation

Elevations were recorded in 1997 by EVER using a Topcon Self-Rotating Laser Leveler (Armentano, unpublished data in files at EVER). Elevations were recorded in relation to reference benchmarks calibrated to National Geodetic Vertical Datum of 1929 (NGVD 1929) near each transect. Soil depth was measured in 2010 with a rod pushed to the underlying limestone bedrock for each of four quadrats of each subplot and was expressed as average depth per plot.

Water Depth and Hydroperiod Effects on Total Cover

We obtained data on water depth from monitoring wells installed and maintained by EVER (DBHYDRO). The wells record real-time data on stage height at multiple locations within the park. We chose stations ES112 (Transect 1), TSB (Transect 2), R127 (Transect 3), CR2 (Transect 4), and NTS10 (Transect 5) because they were in the vicinity of transects, allowing us to relate vegetation data to water depth. The stations were installed at different points in time so the data from each station is available over a different time periods. For example, the monitoring station TSB, located near transect 2 by the Taylor Slough Bridge, is the oldest station and has recorded data for the longest time period (from 1960 onwards). To ensure uniform comparisons data were used for the period in which recording at all stations overlapped, from July 29, 2001 to December 2, 2009. Hydroperiod was calculated as total number of days per year with standing water above soil level. Once the plot elevation was known, the stage height was converted into the water depth per plot by subtracting stage height at the hydrostation from plot elevation. Relevant adjustments were made to ensure that plot elevation and stage height were using comparable geodesic references.

To determine the best predictor of water depth regimes during the dry season (March-May) we obtained daily values of water depth per plot per transect starting one, two, and three years prior to the sampling season in question. For example, to determine the best predictor of water depth in March 2007, we correlated its value with average water depth per plot from October 2005 to October 2006, from October 2004 to October 2005, and from October 2003 to Oct 2004. We found that the correlation of dry season water depth in plots was highest with mean water depth per plot one year prior to sampling. We used water depth averaged over one year prior to sampling vegetation and total cover per transect per sampling year to analyze how the water depth influenced total plant cover.

Total Phosphorus in Water Column

For transects 1 and 2 we analyzed the effects of nutrient concentration in water column and water depth against total cover over time. Data on total phosphorus (TP), which were available from 1999, were obtained from the Florida Coastal Everglades Long Term Ecological Research website, (see website for the protocol on data collection and analyses http://fce.lternet.edu/data/core/metadata/?datasetid=LT_ND_Rubio_001.v7). We performed a stepwise linear regression to assess the effects of two independent variables: TP and water depth on total cover per plot. Data were only analyzed for Transects 1 (stations TS Ph1a and TS Ph1b) and 2 (TS Ph2) because of the proximity of sampling stations (Figure 2). Analyses were not performed on transects 3, 4, and 5 because water column TP was not available at a nearby recorder.

Fire Effects

Fire effects were analyzed for every sampling event/transect combination. The fire database maintained by EVER has records of each fire in the park (Taylor, 1981). Burn polygons are drawn after each fire that occurs in the park. We obtained the data and assumed that if a plot was within a burn polygon the plot burned and used fire data per plot as an independent variable and total cover as the response variable. We added the number of times a plot was burned before sampling was conducted. We used fire records from 1978 onwards to calculate fire frequency and time since fire. If a plot within a transect burned three times (time measured in yearly increments) between 1978 and prior to 2010 sampling, the fire frequency was assigned a value of 3. Similarly, time since fire was calculated as the total number of years to the last fire per plot per sampling year. Regressions were used to analyze the effects of fire frequency and time since fire on total cover.

Species Composition

We applied two ordination techniques to elucidate patterns in plot species composition. Two-way Indicator Species Analysis (TWINSPAN; Hill 1979) was used to as a classification procedure. Detrended Correspondence Analysis (DCA; Ter Braak and Prentice, 1987) was used to depict spatial distribution of samples and species in relation to axes that might be correlated with environmental variables such as water depth, fire history, and or nutrients. We applied these analyses to all transect/year combinations, including the baseline data collected in 1979. These 1979 data were averages taken from tables in Olmsted et al. (1980). We used species presence/absence data to evaluate extent of intra-transect variation among years and inter-transect variation in species composition. We pooled plot data within each transect/sampling year combination to get the mean percent cover per combination per species for each transect. Thus, we had 29 sampling transect/year combinations. We eliminated species that occurred in less than 5% of all transect/year combinations to eliminate bias generated by random occurrences and not reflecting true habitat conditions (McCune and Grace, 2002).

Results

Soil Depth and Elevation

Of all transects in the study, 4 and 5 have the highest elevation (1.62 and 1.32 m respectively; Table 1) and shallowest soils (14.74 and 25.06 cm respectively; Table 1). Transects 1 and 2 have intermediate elevation (1.14 and 1.04 m respectively) and soil depth (40.74 and 31.92 cm respectively), and Transect 3 has the lowest elevation and greatest soil depth (0.82 m and 50.12 cm respectively, Table 1). Elevation and soil depth are negatively correlated ($r^2 = 0.87$, $p < 0.001r = -0.701$, $p < 0.001$). This pattern in elevation leads to differential water depths across transects. Transect 3 is the wettest and 4 is the driest. Transects 1-3 are dominated by marsh vegetation, while transects 4 and 5 contain mostly wet prairie vegetation. In the Everglades, higher elevation areas that tend to have shorter durations and lower depths of flooding are classified as wet prairies, while areas of lower elevation are called long-hydroperiod marshes (USFWS, 2007; Rutchey et al., 2006).

Temporal Changes in Species Composition

Common species which occurred in all transects in all years were *Cladium jamaicense*, *Muhlenbergia capillaris*, *Eleocharis cellulosa*, *Panicum tenerum*, *Centella asiatica*, *Pluchea rosea,* and *Rhynchospora tracyi*. Some of these species showed statistically significant changes in percent cover between 1997 and 2010, particularly *C. asiatica, C. jamaicense,* and *P. tenerum*. Table 2 summarizes mean percent cover per species per transect per year. Table 3 provides the summary of ANOVA results (test statistics not repeated in the text). Figures 3 to 7 depict the percent cover of common species and total cover over time including data from 1979.

Transect 1 (Figure 4): Three species showed significant differences in cover across years were *C. asiatica, C. jamaicense,* and *P. tenerum* ($P < 0.05$). *E. cellulosa* was nearly significant ($P < 0.10$). *C. jamaicense* cover doubled after 2003, and *E. cellulosa* almost tripled after showing substantial declines in 2003. *P. tenerum* increased dramatically from 0.56% in 1995 to 6.02% in 2010. Cover of *C. asiatica* peaked in 2003, followed by subsequent decline, it's 2010 cover was almost identical to 1979. *M. capillaris*, *P. rosea, and R. tracyi* showed no significant changes in cover among. Total vegetation cover showed a significant increase from 39% in 1995 to 71% in 2010 ($P < 0.05$). Figure 4 suggests that in 1979 *C. jamaicense* had less cover while *M. capillaris* had a higher cover. Transect 1 was evaluated for additional changes in species composition between 1979 and 2010. The assemblage of dominant species in Transect 1 changed considerably (Figure 4). In 1979 the transect was dominated by *M. capillaris,* with smaller amounts of *C. jamaicense* and *C. asiatica* (otherwise all other species had cover of <1%). In 1995 there was a co-dominance of *E. cellulosa* and *C. jamaicense,* with substantial *Panicum* *hemitomon, R. tracyi,* and *M. capillaris.* By 2010 the cover of all five of these had increased. *C. jamaicense*, which doubled in cover, overtook *E. cellulosa.* The next most common species, replacing *R. tracyi* and *M. capillaris,* were *T. domingensis* and *P. tenerum.* Three species showed notable increases in cover during the study. *T. domingensis* appeared in plots for the first time, with a cover of 12.15% in five plots in 2007 and 6.96% in seven plots in 2010. *Crinum americanum* increased from 0.40% to 2.25% and *Paspalum monostachyum* from 0.70% to 4.75%. Also of note is the appearance of *Echinochloa muricata* in 2010, a species that can indicate disturbance (Gann et al., 2011).

Transect 2 (Figure 5): All species showed significant differences ($P < 0.05$) in cover across years except *P. rosea. C. jamaicense* rose from 10.77% in 1992 to 30.81% in 2010. *M. capillaris* declined from 17.45% in 1992 to 7.64% in 2010. *E. cellulosa* peaked in 1999 followed by a decline in 2003 at which point it stabilized. *P. tenerum* increased in cover from 0% in 1992 to 2.68% in 2010. *R. tracyi* had spikes in cover in 1997 and 2010 and had low cover in 1992 and 2003. *C. asiatica* fluctuated, with a low of 1.70% in 1995 and a high of 6.09% in 2007. *P. rosea* did not show a temporal change. Total cover shows fluctuation among years with peak cover occurring in 1999. When data from 1979 were plotted in addition to other sampling years, *C. jamaicense* and *M. capillaris* appeared to have stabilized following initial declines. *C. asiatica* has remained steady across years while *P. tenerum* has shown dramatic increase since 1979. Contribution of other species to the cover has dwindled. Transect 2 was also evaluated for additional changes in species composition since 1979. In 1979 there were two species with cover of >5%, *M. capillaris* with a cover of 13.4% and *C. jamaicense* with a cover of 5.2%. By 2010 *C. jamaicense* became dominant, increasing cover six times to 30.8%. In contrast, cover of *M. capillaris* fell almost in half to 7.6%. Two new species became common, *E. cellulosa* with a cover of 5.7% and *Schizachyrium rhizomatum* with a cover of 5.5%.

Transect 3 (Figure 6): Four species showed significant differences ($P < 0.05$) in cover across years: *C. jamaicense, E. cellulosa, M. capillaris,* and *P. tenerum. M. capillaris* cover peaked in 2007 following a low in 1999. *P. tener*um increased from 0.58% in 1996 to 2.49% in 2010. Neither *C. jamaicense* nor *E. cellulosa* showed a temporal pattern. Abundance of *C. asiatica*, *P. rosea*, *and R. tracyi* did not vary among years. Total cover showed a significant temporal change with a major decline in 2003 and a peak in 2007. Total cover has risen sharply from 1979 while the contribution of species such as *C. jamaicense* and *M. capillaris* has remained steady over years.

Transect 4 (Figure 7): Five species showed significant differences ($P < 0.05$) in cover across years: *C. asiatica, C. jamaicense, P. rosea, P. tenerum,* and *R. tracyi.* Increases in cover for *C. jamaicense* changed from 18.36% in 1997 to 33.80% in 2010, *P. rosea* from 0.46% to 1.29%, in

2010). *P. tenerum* increased throughout the study from 0.85% in 1997 to 2.10% in 2010. *R. tracyi* had peaks in cover in 1997 and 2010. Abundance of *E. cellulosa* and *M. capillaris* did not show significant changes. Total cover fluctuated among years with a peak coverage occurring in 2007. The cover of plots increased in 2007 but the majority of the contribution to cover was made by submerged species that occurred beneath the emergent vegetation.

Transect 5 (Figure 8): All species showed significant differences in cover across years except *E. cellulosa*. *C. jamaicense* increased from 12.20% in 1997 and climbed to 29.70% in 2007. *M. capillaris* increased from 15.91% in 1997 to 31.80% in 2007. *P. tenerum* increased from 1.15% in 1997 to 2.62% in 2007. *R. tracyi* and *C. asiatica* fluctuated without patterns. Abundance of *E. cellulosa* did not change significantly. Total cover showed a significant rise from 42.83% in 1997 to 65.08% in 2007, and declined slightly in 2010.

Wetland Affinity Index

The results of Wetland Affinity Index are shown in Figure 9. Wetland Affinity Index values for transects 1-3 indicated a large vegetation response on each transect to increases in water from 1979 to 1995. These changes coincide with the first major changes in water deliver regimes, and thereafter showed stability, with slight evidence of drying conditions over time for transects 1, 2, and 3. Transect 1 increased 189% from 1979 to 1995 and transect 2 increased 102%. Transect 3 showed the lowest change of 22%. Between 1995 and 2010 Index values dropped 8%, 2%, and 6%, respectively. The index showed variability in transects 4 and 5 from 1995 to 2010. Both showed a major increase in index values from 1997 to 2003, of 41% and 89%, respectively. Thereafter both declined, although transect 4 values remained 11% higher than in 1997.

Relationship between Total Cover and Water Depth

Because some species showed increases and others declined over time, we used total cover as a metric for evaluating changes in vegetation. Dramatic rises in total cover relate to productivity of the system which increases or decreases in relation to nutrients, light, water, and disturbances (e.g. fire, herbivory). We plotted water depth and total cover per plot across years and analyzed the relationship between water depth and total cover at the transect level.

For transect 1 the relation between water depth and total cover was non-significant in 1993, 1995, and 1999. Only in 2007 ($r^2 = 0.38$, $P < 0.001$) and 2010 ($r^2 = 014$, $P < 0.01$) were significant trends observed between total cover and water depth (Figure 10). We did not find a significant correlation between total cover and mean water depth per plot when data were pooled across years ($r^2 = 0.07$, $P > 0.05$). The highest mean water depths were observed in 1999 and 2010, and the greatest total vegetation cover was in 2007. Total cover was not correlated with water depth in transect 2. The lowest cover was observed in 2003, and greatest cover in 2007 (Figure 11).

No significant relationship was found between mean cover and mean depth for transect 3 from 1979 to 2010. The total cover was greatest in 2007 and the lowest in 2003 (Figure 12). For transect 4, a strong negative correlation was found between mean water depth and mean cover ($r^2 = -0.34$, $P < 0.0001$). The greatest depth occurred in 1999 followed by 2010, and the lowest in 2007 while the total cover was highest in 2007 and lowest in 1997 (Figure 13). A significant temporal decline in water depth was observed from 1997 to 2010 ($r^2 = -0.340$, $P < 0.001$, Figure). For transect 5, a significant negative correlation was observed between mean water depth and total cover per transect ($r^2 = -0.13$, $P < 0.001$). The water depth was lowest in 2007 and greatest in 2009, the total cover was greatest in 2007 and lowest in 1997 (Figure 14).

Relationship between Total Cover and Hydroperiod

Hydroperiod is the duration of time water is above the soil surface. Here we express plot hydroperiod per sampling year based on data from the year prior to which plots were sampled. Hydroperiod and mean water depth per plot were correlated for the global data set ($r^2 = 0.48$, $P < 0.05$, $\beta = -0.001$). Total percent cover per plot was weakly explained by hydroperiod for transect 4 ($r^2 =0.24$, $P < 0.001$, $\beta = -0.19$) and transect 5, ($r^2 =0.17$ $P < 0.001$, $\beta = -0.10$) with a total cover decreasing with increasing hydroperiod.

There was a non-significant weak correlation for transect 1 ($r^2 = -0.04$, $P = 0.08$), and no correlation was observed between hydroperiod and total cover for transect 2 ($r^2 = 0.01$) and transect 3 ($r^2 =0.008$).

Patterns in Species Richness

We compared cumulative species richness for each transect, and total richness across transects for each study year. Transect 3 had the lowest cumulative species richness with 49 species recorded across the study period. All other transects were within a narrow range, from 67 species in transect 1 to a high of 75 in transect 5. Richness varied little among years, with a low of 70 species across the five transects in 2007 and a high of 79 in 2010. In transect 1, species richness generally increased over time. There was no temporal pattern detected in the other transects.

Fire Effects on Changes in Total Cover

We analyzed changes in total cover in relation to plot fire history for the global dataset and per transect. Fires were infrequent. Of the 120 1 x 5 m subplots, the mean number of burns was 1.3, with a maximum of four. Forty-nine of the plots (40.1%) did not burn at all during the study period. Burns were patchy, typically covering only some of the plots on a transect. Plots on transects 4 and 5 received more burns (2.1 and 3.0, respectively), than those on transects 1-3 (0.3, 0.4, and 0.6, respectively). Analysis of combined data for all transects showed a non-significant weak trend in total cover with fire frequency (Figure 15). No significant effects of fire frequency were observed when data were analyzed separately for each sampling year/transect combination. For example, for transect 2, we analyzed effects of time since fire and fire frequency for 1992, 1995, 1999, 2003, 2007 and 2010 data separately. The combined data set was also analyzed to test for effect of time since fire on total cover per plot which did not show any effect of time since fire on total cover. When analyzed separately, transect 1 showed no effect of time since fire on total cover for any of the sampling years. For transect 2, no significant relationship was found between time since fire and total cover. For transect 3 no relationship was found between time since fire and total cover for any of the sampling years. For transects 4 and 5, a weak negative (r^2= 0.10, P = 0.08) correlation was found for total cover and time since fire for sampling year 1995. For other sampling years and transects no relationship between time since fire and total cover was found.

Nutrients in Water Column and Total Cover

The effect of total phosphorous on total cover was analyzed for transects 1 and 2 since nutrient data were available from sampling stations near these transects. Mean total phosphorous per year along with mean water depths were used as independent variables to perform a stepwise linear regression with total cover as the dependent variable. We used water depth as an independent variable in addition to total phosphorous so that effects of both the variables could be evaluated simultaneously, as water depth is an important variable affecting productivity of wetlands. We also averaged total phosphorous data from the southernmost portion of Taylor Slough to show the average values at and near inflows and those far from water management structures.

The values of total phosphorous at the S-332 structure showed several peaks, exceeding 10 ppb in some instances (Figure 16). Taylor Slough Bridge showed spikes in total phosphorous from December 2002 to June 2003. Mean total phosphorous was 5.21 ppb in the water column sampled at S-332 from 1999 to 2002 (station TS Ph1b) and 6.98 at S-332 from 2003 to 2010 (station TS Ph1a) with an average of 6.47. The water column sampled at Taylor Slough Bridge had an overall mean total phosphorous of 6.20 ppb. Stepwise linear regression showed that total phosphorous was the only variable which had a significant effect on total mean cover per transect (r^2 = 0.17, P = 0.033, β = 6.53; water depth P > 0.05). For transect 2, neither total phosphorus nor mean water depth had any significant effect on total cover. The average total phosphorous value for the southernmost part of Taylor Slough was 5.23 ppb, 15.6% lower than Taylor Slough Bridge and 19.2% lower than at S-332 (Figure 3).

Species Composition

Ordination analysis (TWINSPAN) categorized transects/year combination at low eigen value (0.20) into two groups "dry" and "wet" categories. Transects 1-3 sampled in 1979, and all transect/year combinations of transects 4 and 5 were categorized into the "dry group". The dry group harbored species that require shorter hydroperiods compared to the "wet group". Transects 1-3 censured from 1995 onwards were categorized into the "wet group". Indicator species for the dry group were: *Andropogon glomeratus* var. *pumilus, Andropogon virginicus, Aristida purpurascens, Schizachyrium rhizomatum, Teucrium canadense, Linum medium, Panicum rigidulum, M. capillaris,* and *Sabal palmetto*. The wet group indicator species included *Aeschynomene pratensis, Pontederia cordata, Nymphoides aquatica, P. hemitomon, E. cellulosa, C. americanum,* and *Paspalidium geminatum*. Species that did not show any preference were *C. asiatica, C. jamaicense, Ipomoea sagittata, Leersia hexandra,* and *P. tenerum*.

DCA results could not be used to determine patterns of vegetation composition. While several groupings did occur, axes could not be related to hydrology, nutrients, fire effects, or other factors.

Discussion and Conclusions

Water availability is an important environmental driver for rapid species changes in Taylor Slough wetlands (Armentano et al., 2006). However, when we add greater temporal replication with samples from 2007 and 2010 we find that the abundance of some common species has stabilized since 2003. Armentano et al. (2006) reported a significant increase in hydroperiod in transects 1 to 3 after the S-332 structure was installed and a decline when the operational station was moved north to S-332D. It is likely that the decline reported by Armentano et al. (2006) has continued slowly and water deliveries through the S-332D have now stabilized. Part of the observed variation in hydroperiod could be explained by rainfall variations and not solely water delivery schedules or structures.

Wetland Affinity Index values followed the trends in water patterns reported by Armentano et al. (2006). Following the operation of S-332 starting in 1980, vegetation in the transects and within the slough (transect 1, 2, and 3) shifted towards a much greater wetland affinity index, reflecting a transition to wetter conditions. When the S-332D structure began operations, index values showed a slight decline, tracking the drier conditions. This is in contrast to transects in the headwaters of Taylor Slough (transects 4 and 5), which began to receive more water with the operation of S-332D and showed a corresponding increase in index values.

Our results suggest that the pattern of temporal changes, especially for total cover which peaked in 2007 in all transects, are not solely related to the changes in water depth or hydroperiod. Particularly in upper Taylor Slough there were changes in dominant species assemblages and increases in percent cover of species such as *T. domingensis* and the appearance of *E. muricata*, a weedy species that was new for the Park (Gann et al., 2011). We suggest that increases in both species could be due to nutrient enrichment. The results of stepwise linear regression analysis suggest that in transect 1, phosphorous correlates to a rise in total percent cover and cover of species that are indicators of eutrophication. The stepwise regression allowed us to consider both phosphorous and water depth additively and eliminate water depth and phosphorous to get the best linear model affecting total cover. These results could be explained by year to year variations of water levels during sampling efforts and error in visual estimates; however, other indicators of eutrophication (as discussed below), corroborate the validity of the findings.

It is plausible that phosphorus enrichment facilitated expansion of cattail. Surratt et al. (2012) suggest that phosphorous loading into upper Taylor Slough has been an issue since the beginning of S-332 operations. Photographs of plots along transect 1 and at the site of the S332 taken by Olmsted (unpublished, NPS files) indicate that *T. domingensis* was not present in 1980, but that it was present in 1999 and expanded significantly by 2004 (Rutchey and Schall, unpublished). *T. domingensis* was common in an area outside of our study plots before 2004. The 2003 sampling does not capture this because it had yet to colonize the study plots. These results suggest that the observed changes in vegetation in transect 1 are probably a result of changes in nutrient regimes. The lack of large scale nutrient effects on vegetation suggests that the changes in nutrient regimes are not homogeneous across the Taylor Slough. If the latter is the case, other variables are required as indicators of water and habitat quality in an effort to prevent habitat degradation. This has been discussed in detail by Gaiser et al. (2005) who found that phosphorus is transported downstream primarily through biota rather than in the water column, making it difficult to detect influxes until their ecological effects are already well established.

Transects 1 and 2 showed a remarkable change in species composition from 1990's onwards when compared to the transects first installed in 1979. Increases in water delivery into Taylor Slough caused transects 1 and 2 to show large changes in percent cover for species that are indicators of greater hydroperiod and a decrease in *M. capillaris* (Armentano et al., 2006). Transect 3 showed changes in species composition between 1979 and 1990s but not as dramatic as transects 1 and 2. Transects 4 and 5 show little change in species composition from 1997 to 2010.

The species turnover in transect 1 and the appearance of such species as *T. domingensis* and *E. muricata* indicates changes are occurring that are different from those observed between 1979 and 2003 (Newman et al. 1996). In addition, areas between the S332 structure and Transect 1 are now shifting from *T. domingensis* to Carolina willow (*Salix caroliniana*) (Rutchey and Schall unpublished). These changes appear similar to those seen following nutrient enrichment or other disturbances (Richardson et al., 2008) and are consistent with observed changes at other point source water inputs into ENP such as those along Tamiami Trail (Sadle personal communication). The appearance and increase of species associated with enrichment does not represent restoration to historical vegetation patterns, which is a stated goal of the C111 spreader project (Chief of Engineers report 2012). Visual observation of the area indicates that changes are linear and increase in severity as distance to the S-332 structure decreases. Mapping of the area indicates that cattail extends south from the structure for approximately 2 km, with some areas consisting of more than 95% cover (Sadle, 2008; Rutchey and Schall, unpublished).

This study, demonstrates that vegetation in Taylor Slough changed with increased hydrology. The vegetation cover within the plots changed to longer hydroperiod plants that are more tolerant of longer of wetter conditions, for example *E. cellulosa* and *C. jamaicense*. However, the increased water quantity also brought additional TP loads into the system. Increases in nutrients may have been happening for some time and have only recently been detected as phosphorous detection in the water column is limited. Gaiser et al. (2005) found there was a time lag in detecting phosphorous in the water column in wetlands in Shark River Slough in Everglades National Park. They attributed the time lag in detection to the ability of the ecosystem to assimilate added phosphorous through microbial removal and recycling. However, the experiment illustrated that the system is not static and the effects of added phosphorous accumulate over time until an ecosystem state change occurs (Gaiser et al. 2005). If this occurs the resulting eutrophication in Taylor Slough will be difficult to reverse. We recommend that further investigations, including other taxonomic groups, should be made to quantify changes in Taylor Slough, especially in its headwaters; such as work on periphyton, standing crops of algae, aquatic consumers, and soil and plant nutrient analysis along transects as a means of understanding the spatial extent of nutrient enrichment in Taylor Slough (Childers et al. 2003). Additionally, periodic monitoring of the five transects in this study, as well as transect 6 (installed in 2007), should be done to document future changes. Periodic vegetation mapping should be conducted to track the spread of *T. domingensis*, as well as other indicators of eutrophication. Current vegetation conditions should also be more accurately determined to the north of the S-332 structure in association with the degraded bank of the L-31W. Now that water deliveries have shifted to this area, changes due to nutrient enrichment in the headwaters of Taylor Slough are possible. Ultimately, water entering Taylor Slough should be monitored to determine if there are seasonal peaks in TP, why these are occurring and if they are attributing to long term changes in Taylor Slough vegetation.

Acknowledgments

We thank Department of Interior's Critical Ecosystem Studies Initiative for funding this project (# J5284-08-0020). Data sets were provided by the Florida Coastal Everglades Long-Term Ecological Research (LTER) Program. This material is based upon work supported by the National Science Foundation through the Florida Coastal Everglades Long-Term Ecological Research program under Grant #9910514. Jimi Sadle provided guidance and valuable data throughout most of the project, and Craig Smith collaborated with sampling in 2007. Mike Barry assisted with the Wetland Affinity Index. Jesse Hoffman conducted the vegetation sampling in 2007, and he and Steven Hodges assisted with data entry. Discussions with Jay Sah and Mike Ross substantially improved the quality of the manuscript.

References

Armentano, T.V., J.P. Sah, M.S. Ross, D.T. Jones, H.C. Cooley, C.S. Smith. 2006. Rapid responses of vegetation to hydrological changes in Taylor Slough, Everglades National Park, Florida, USA. *Hydrobiologia* 569: 293-309.

Chief of Engineers report 2012. Chief of Engineers Report signed for C-111 Spreader Canal Western Project**.** http://www.evergladesplan.org/pm/projects/project_docs /pdp_29_c11/013012_c111_chiefs_report.pdf

Childers, D.L., R.F. Doren, R. Jones, G.B. Noe, L.J. Scinto. 2003. Decadal change in vegetation and soil phosphorus pattern across the Everglades landscape. *Journal of Environmental Quality* 32: 344-362.

DBHYDRO Browser, South Florida Water Management District, Accessed November 2011.http://my.sfwmd.gov/portal/page?_pageid=2235,4688582&_dad=portal&_schema=PORTAL

Gaiser, E.E., J.C. Trexler, J.H. Richards, D.L. Childers, D. Lee, A.L. Edwards, L.J. Scinto, K. Jayachanran, G.B. Noe, R.D. Jones. 2005. Cascading ecological effects of low-level phosphorus enrichment in the Florida Everglades. J. Environ. Qual. 34:717-723.

Gaiser, E.E., Childers D.L., Jones R.D., Scinto L.J., Trexler J.C. 2006. Periphyton responses to eutrophication in the Florida Everglades: cross-system patterns of structural and composition change. Limnology and Oceanography 51:617–630

Gann, G.D, K.A. Bradley, S.W. Woodmansee. 2011. Floristic Inventory of South Florida Database Online. The Institute for Regional Conservation, Miami, Florida. www.regionalconservation.org. Accessed June 30, 2011.

Hill, M.O. 1979. TWINSPAN – A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University, Ithaca, NY, US.

McCune, B., J.B. Grace. 2002. Analysis of Ecological Communities. Structural Equation Modeling 28(2).

Mo, C., V. Ciuca, and S. Van Horn. 2010. Settlement Agreement Report- Fourth Quarter October-December 2010: Prepared for the Technical Oversight Committee. South Florida Water Management District, West Palm Beach, FL, USA

Newman, S., J.B. Grace, J.W. Koebel. 1996. Effects of Nutrients and Hydroperiod on *Typha*, *Cladium*, and *Eleocharis*: Implications for Everglades Restoration. Ecological Applications, 6:774–83

Noe, G.B., D.L. Childers, and R.D. Jones. 2001. Phosphorus biogeochemistry and the impact of phosphorus enrichment: Why is the Everglades so unique? Ecosystems 4:603-624.

Olmsted I.C., L.L. Loope, R.E. Rintz. 1980. A Survey and Baseline Analysis of Aspects of the Vegetation of Taylor Slough. Report T-586. South Florida Research Center, Everglades National Park, Homestead, Florida, USA.

Reed, P.B., Jr. 1988. National List of Plant Species that Occur in Wetlands: Southeast (region 2). U.S. Department of the Interior, Fish and Wildlife Service, Biological Report 88(26.2) 124pp. Amended on USFWS 1996. http://www.fws.gov/nwi/bha/list96.html1996 National List of Vascular Plant Species that Occur in Wetlands.

Richardson, C.J., R.S. King, J. Vymazal, E.A. Romanowicz, J.W. Pah. 2008. Macrophyte Community Responses in the Everglades with an Emphasis on Cattail (*Typha domingensis*) and Sawgrass (*Cladium jamaicense*) Interactions along a Gradient of Long-Term Nutrient Additions, Altered Hydroperiod, and Fire. In Richardson, C.J. (ed.) Everglades Experiments Lessons for Ecosystem Restoration Ecological Studies Volume 201, II, pp 215-260

Right M.A., Iwaniec D.M., Childers D.L. 2004. Spatial and temporal patterns of periphyton in the Florida Everglades, down transects C-111 and Taylor Slough. Florida Coastal Everglades Long Term Ecosystem Research, conference poster presentation. http://fce.lternet.edu/about_us/meetings/asm2004/posters/Mike_Right_2004_ASM_poster.pdf.

Rutchey, K., T.N. Schall, R.F. Doren, A. Atkinson, M.S. Ross, D.T. Jones, M. Madden, L. Vilchek, K.A. Bradley, J.R. Snyder, J.N. Burch, T. Pernas, B. Witcher, M. Pyne, R. White, T.J. Smith III, J. Sadle, C.S. Smith, M.E. Patterson, and G.D. Gann. 2006. Vegetation Classification for South Florida Natural Areas. United States Geological Survey, Open-File Report 2006-1240. 142 pages. St. Petersburg, Florida.

Sadle, J. 2008. Summary of cattail encroachment in Taylor Slough. South Florida Natural Resource Center. Everglades National Park, Homestead.

SFWMD. 2012. Settlement Agreement Report. http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/sar_20120810.pdf.

Surratt, D., D. Shinde, N. Aumen. 2012. Recent cattail expansion and possible relationships to water management: Changes in upper Taylor Slough (Everglades National Park, Florida, USA). Environmental Management 49(3):720-733.

Taylor, D. 1981. Fire history and fire records for Everglades National Park 1948-1979. South Florida Research Center Report T-619. Homestead, Florida.

Ter Braak, C.J.F., I.C. Prentice. 1988. A Theory of Gradient Analysis. Advances in Ecological Research 18, 271–371

Trexler, J., Loftus W., Bruno C., Gaiser E., Jacobsen R., Kline J. 2003. Assessment of IOP/ISOP impacts on aquatic communities. In: Trexler J (ed) Monitoring fish and decapods crustaceans in the southern Everglades. Southeast Environmental Research Center and Department of Biological Sciences. Florida International University, Miami

USFWS. 2007. South Florida Multi-species Recovery Plan. http:/www.fws.gov/verobeach/images/pdflibrary/marshes%20wet%20prairies. pdf. Accessed December 10, 2010

Van Lent, T.R., J. Johnson, R. Fennema. 1993. Water Management in Taylor Slough and Effects on Florida Bay. Technical Report # SFNRC 93–03. South Florida Natural Resource Center, Everglades National Park, Homestead, Florida, USA.

Table 1: Transect elevation, soil depth, and water depth, February-March 2010.

Transect	Mean Ground Elevation ± SE (m, 1997)
1	1.135 ± 0.032
2	1.037± 0.233
3	0.81 ± 0.34
4	1.617 ± 0.672
5	1.32 ± 0.311
	Mean soil depth ± SE (cm, 2010)
1	40.81 ± 2.191
2	31.77 ± 2.179
3	50.82 ± 2.125
4	14.8 ± 2.168
5	25.05 ±2.146
6	80.81 ± 2.275
	Mean water depth ± (cm, March 2010)
1	8.10 ± 8.061
2	0.74 ± 3.953
3	2.01 ± 2.59
4	0.39 ± 0.282
5	0.005 ± 0.002

Table 2: Species and total vegetation cover across transects and years.

Statistically significant values are **bold.** CENTASIA = *Centella asiatica*; CLADJAMA = *Cladium jamaicense*; ELEOCELL = *Eleocharis cellulosa*; MUHLCAPI = *Muhlenbergia capillaris*; PANITENE = *Panicum tenerum*; PLUCROSE = *Pluchea rosea*; RHYNTRAC = *Rhynchospora tracyi*; TOTAL = total vegetation cover.

Transect 1			**Transect 2**			**Transect 3**			**Transect 4**			**Transect 5**		
Taxon Code	**Year**	**Mean Cover**	**Taxon Code**	**Year**	**Mean Cover**	**Taxon Code**	**Year**	**Mean Cover**	**Taxon Code**	**Year**	**Mean Cover**	**Taxon Code**	**Year**	**Mean Cover**
CENTASIA	1995	**0.72**	CENTASIA	1995	**1.7**	CENTASIA	1996	0.21	CENTASIA	1997	**1.31**	CENTASIA	1997	**2.74**
CENTASIA	1999	**0.82**	CENTASIA	1999	**1.92**	CENTASIA	1999	0.12	CENTASIA	1999	**1.45**	CENTASIA	1999	**2.5**
CENTASIA	2003	**7.3**	CENTASIA	2003	**4.2**	CENTASIA	2003	0.05	CENTASIA	2003	**1.12**	CENTASIA	2003	**0.78**
CENTASIA	2007	**5.46**	CENTASIA	2007	**6.09**	CENTASIA	2007	0.33	CENTASIA	2007	**2.2**	CENTASIA	2007	**3.89**
CENTASIA	2010	**3.53**	CENTASIA	2010	**2.62**	CENTASIA	2010	0.35	CENTASIA	2010	**0.24**	CENTASIA	2010	**1.27**
CLADJAMA	1995	**10.09**	CLADJAMA	1995	**10.51**	CLADJAMA	1996	**40.53**	CLADJAMA	1997	**18.73**	CLADJAMA	1997	**12.12**
CLADJAMA	1999	**10.24**	CLADJAMA	1999	**18.99**	CLADJAMA	1999	**29.95**	CLADJAMA	1999	**27.82**	CLADJAMA	1999	**17.43**
CLADJAMA	2003	**9**	CLADJAMA	2003	**22.66**	CLADJAMA	2003	**27.85**	CLADJAMA	2003	**37.83**	CLADJAMA	2003	**22.34**
CLADJAMA	2007	**20.99**	CLADJAMA	2007	**26.44**	CLADJAMA	2007	**55.83**	CLADJAMA	2007	**49.26**	CLADJAMA	2007	**29.7**
CLADJAMA	2010	**19.86**	CLADJAMA	2010	**30.81**	CLADJAMA	2010	**39.55**	CLADJAMA	2010	**33**	CLADJAMA	2010	**21.92**
ELEOCELL	1995	10.66	ELEOCELL	1995	**11.13**	ELEOCELL	1996	**4.89**	ELEOCELL	1996	0.05	ELEOCELL	1997	0.02
ELEOCELL	1999	16.94	ELEOCELL	1999	**24.53**	ELEOCELL	1999	**6.93**	ELEOCELL	1999	0.19	ELEOCELL	1999	0.18
ELEOCELL	2003	4.1	ELEOCELL	2003	**7.32**	ELEOCELL	2003	**0.24**	ELEOCELL	2003	0.03	ELEOCELL	2003	0.02
ELEOCELL	2007	22.78	ELEOCELL	2007	**8.31**	ELEOCELL	2007	**2.25**	ELEOCELL	2007	0.08	ELEOCELL	2007	0.17
ELEOCELL	2010	15.83	ELEOCELL	2010	**5.71**	ELEOCELL	2010	**1.29**	ELEOCELL	2010	0.1	ELEOCELL	2010	0.27
MUHLCAPI	1995	1.46	MUHLCAPI	1995	**4.68**	MUHLCAPI	1996	**3.72**	MUHLCAPI	1997	15.55	MUHLCAPI	1997	**15.91**
MUHLCAPI	1999	1.52	MUHLCAPI	1999	**2.64**	MUHLCAPI	1999	**2.81**	MUHLCAPI	1999	14	MUHLCAPI	1999	**25.14**

Transect 1			**Transect 2**			**Transect 3**			**Transect 4**			**Transect 5**		
MUHLCAPI	2003	3.5	MUHLCAPI	2003	**2.5**	MUHLCAPI	2003	**5.21**	MUHLCAPI	2003	14.89	MUHLCAPI	2003	**29.04**
MUHLCAPI	2007	6.57	MUHLCAPI	2007	**4.48**	MUHLCAPI	2007	**11.98**	MUHLCAPI	2007	15.59	MUHLCAPI	2007	**31.8**
MUHLCAPI	2010	5.88	MUHLCAPI	2010	**7.64**	MUHLCAPI	2010	**6.67**	MUHLCAPI	2010	11.4	MUHLCAPI	2010	**24.35**
PANITENE	**1995**	**0.56**	PANITENE	1995	**0.7**	PANITENE	1996	**0.58**	PANITENE	1997	**0.85**	PANITENE	1997	**1.15**
PANITENE	**1999**	**0.49**	PANITENE	1999	**0.89**	PANITENE	1999	**0.75**	PANITENE	1999	**1.17**	PANITENE	1999	**1.47**
PANITENE	**2003**	**1.72**	PANITENE	2003	**1.08**	PANITENE	2003	**0.61**	PANITENE	2003	**0.9**	PANITENE	2003	**1.3**
PANITENE	**2007**	**4.17**	PANITENE	2007	**2.63**	PANITENE	2007	**1.83**	PANITENE	2007	**2.04**	PANITENE	2007	**2.62**
PANITENE	**2010**	**6.02**	PANITENE	2010	**2.68**	PANITENE	2010	**2.49**	PANITENE	2010	**2.07**	PANITENE	2010	**2.51**
PLUCROSE	1995	0.28	PLUCROSE	1995	0.63	PLUCROSE	1996	0.37	PLUCROSE	1997	**0.44**	PLUCROSE	1997	**0.69**
PLUCROSE	1999	0.3	PLUCROSE	1999	0.75	PLUCROSE	1999	0.88	PLUCROSE	1999	**0.86**	PLUCROSE	1999	**0.04**
PLUCROSE	2003	0.44	PLUCROSE	2003	0.92	PLUCROSE	2003	0.92	PLUCROSE	2003	**0.34**	PLUCROSE	2003	**0.5**
PLUCROSE	2007	0.18	PLUCROSE	2007	0.88	PLUCROSE	2007	1.04	PLUCROSE	2007	**1.62**	PLUCROSE	2007	**1.32**
PLUCROSE	2010	0.22	PLUCROSE	2010	0.89	PLUCROSE	2010	0.72	PLUCROSE	2010	**1.29**	PLUCROSE	2010	**1.11**
RHYNTRAC	1995	1.93	RHYNTRAC	1995	**2.52**	RHYNTRAC	1996	0.07	RHYNTRAC	1997	**0.63**	RHYNTRAC	1997	**0.17**
RHYNTRAC	1999	1.31	RHYNTRAC	1999	**1.21**	RHYNTRAC	1999	1.18	RHYNTRAC	1999	**0.12**	RHYNTRAC	1999	**1.07**
RHYNTRAC	2003	1.35	RHYNTRAC	2003	**0.71**	RHYNTRAC	2003	0.63	RHYNTRAC	2003	**0.25**	RHYNTRAC	2003	**0.08**
RHYNTRAC	2007	1.68	RHYNTRAC	2007	**1.26**	RHYNTRAC	2007	1.12	RHYNTRAC	2007	**0.24**	RHYNTRAC	2007	**0.42**
RHYNTRAC	2010	1.36	RHYNTRAC	2010	**2.16**	RHYNTRAC	2010	0.95	RHYNTRAC	2010	**0.78**	RHYNTRAC	2010	**0.8**
TOTAL	**1995**	**38.97**	TOTAL	1995	**45.54**	TOTAL	1996	**53.17**	TOTAL	1997	**43.8**	TOTAL	1997	**42.83**
TOTAL	**1999**	**48.73**	TOTAL	1999	**65.5**	TOTAL	1999	**48.67**	TOTAL	1999	**53.41**	TOTAL	1999	**54.37**
TOTAL	**2003**	**47.69**	TOTAL	2003	**44.94**	TOTAL	2003	**35.18**	TOTAL	2003	**57.95**	TOTAL	2003	**60.9**
TOTAL	**2007**	**78.14**	TOTAL	2007	**53.54**	TOTAL	2007	**66.45**	TOTAL	2007	**64.41**	TOTAL	2007	**65.08**
TOTAL	**2010**	**71.48**	TOTAL	2010	**53.23**	TOTAL	2010	**54.1**	TOTAL	2010	**56.9**	TOTAL	2010	**62.91**

Table 3: ANOVA results (F statistic, P value, (degrees of freedom for all these tests are 4 (years), 19 (plots) species and transect combinations across sampling years.

Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5
Centella asiatica	4.90, 0.001[1]	4.69, 0.001	1.17, 0.325	9.81, 0.001	10.59, 0.0001
Cladium jamaicense	4.21, 0.001	8.42, 0.0001	8.36, 0.0001	10.33, 0.0001	10.37, 0.0001
Eleocharis cellulosa	2.48, 0.051	5.49, 0.001	3.66, 0.008	0.36, 0.834	0.445, 0.773
Muhlenbergia capillaris	0.93, 0.453	2.84, 0.019	4.47, 0.002	0.35, 0.845	3.70, 0.008
Panicum tenerum	3.61, 0.009	3.09, 0.012	4.3, 0.011	3.52, 0.01	2.71, 0.035
Pluchea rosea	1.13, 0.349	0.31, 0.91	1.003, 0.41	4.26, 0.003	3.47, 0.011
Rhynchospora tracyi	0.34, 0.85	2.88, 0.02	1.70, 0.15	3.37, 0.013	6.66, $P < 0.001$
Total cover	16.39, 0.0001	4.41, 0.002	11.00, 0.0001	48.46, 0.0001	20.01, 0.0001

---

[1] F, P. Cover value for each plot per sampling year are pooled as independent replicates. F statistic and P value indicating that random sampling from identical populations would lead to a difference smaller than observed in 95% or greater of experiments.

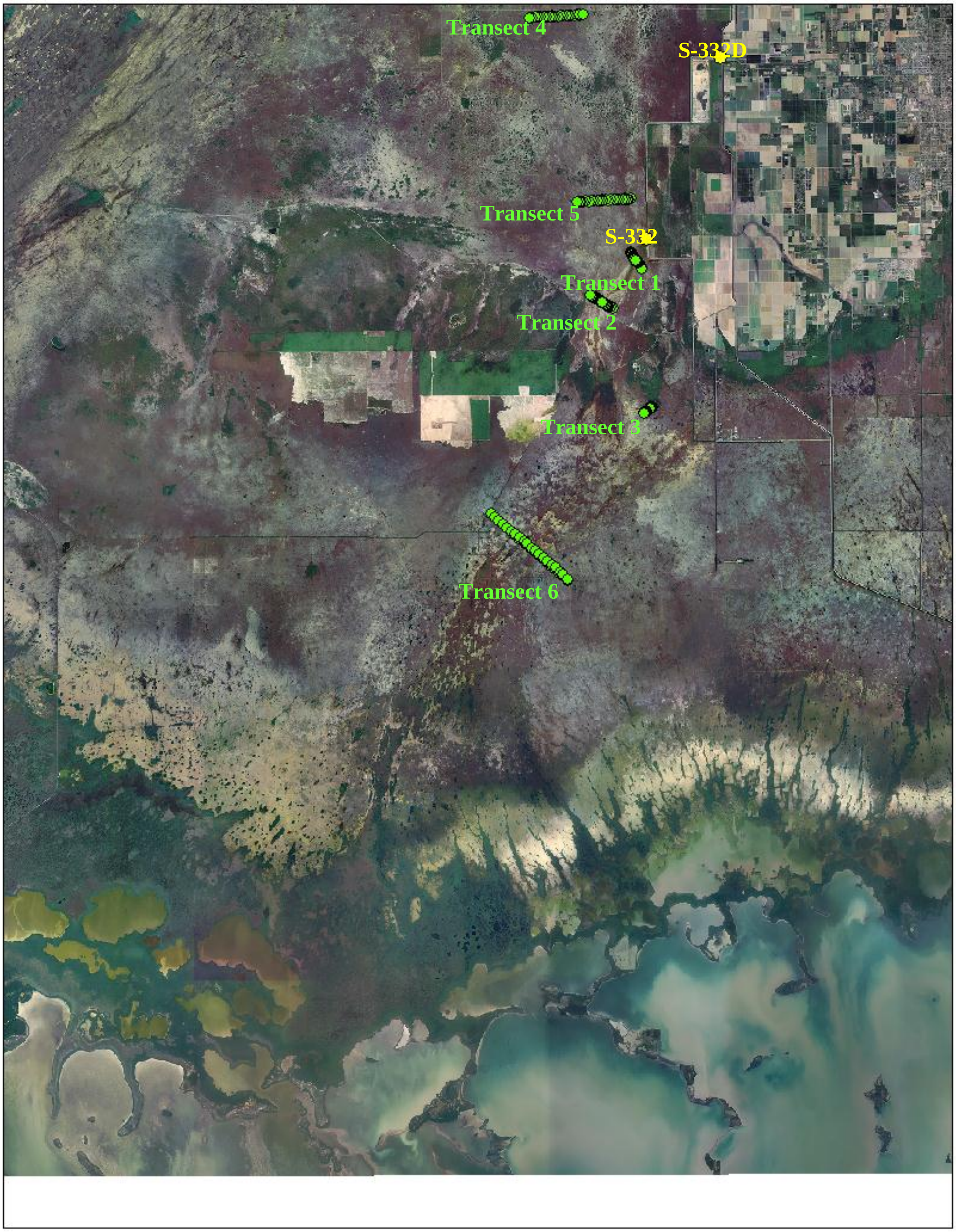

Figure 1. Location of transects in Taylor Slough

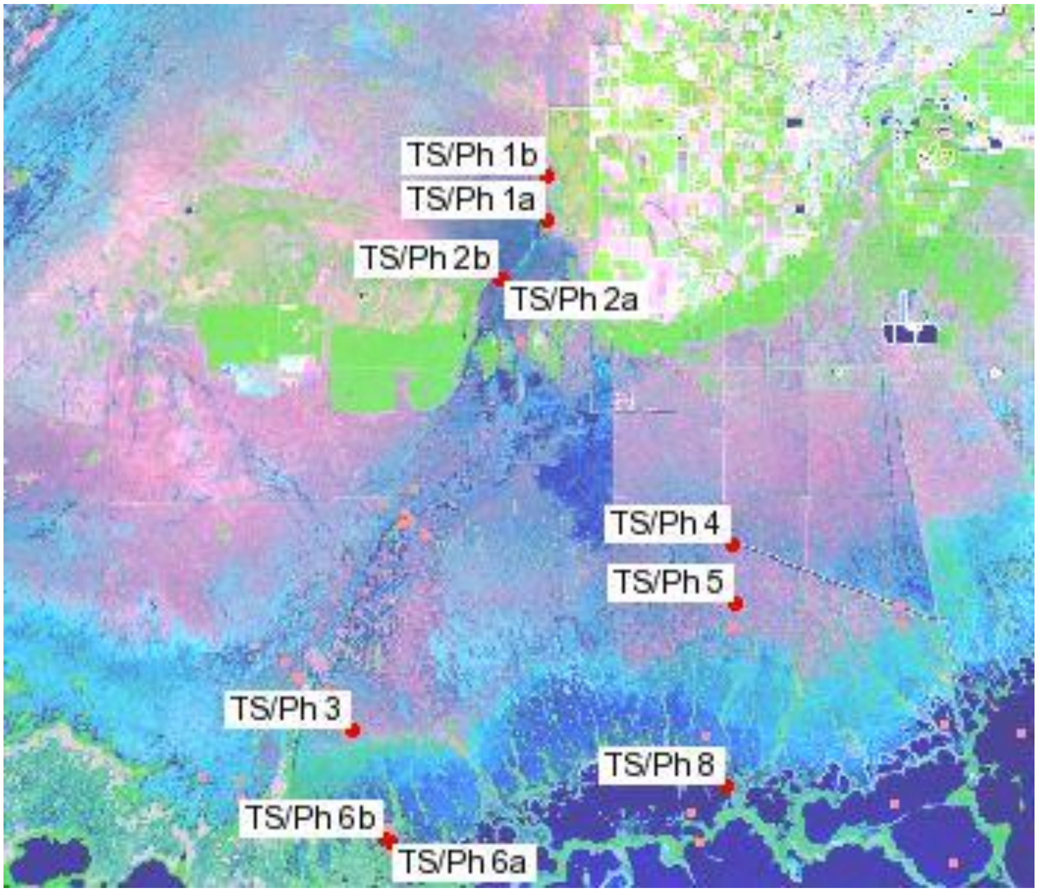

Figure 2. Locations of sample stations for total phosphorous data

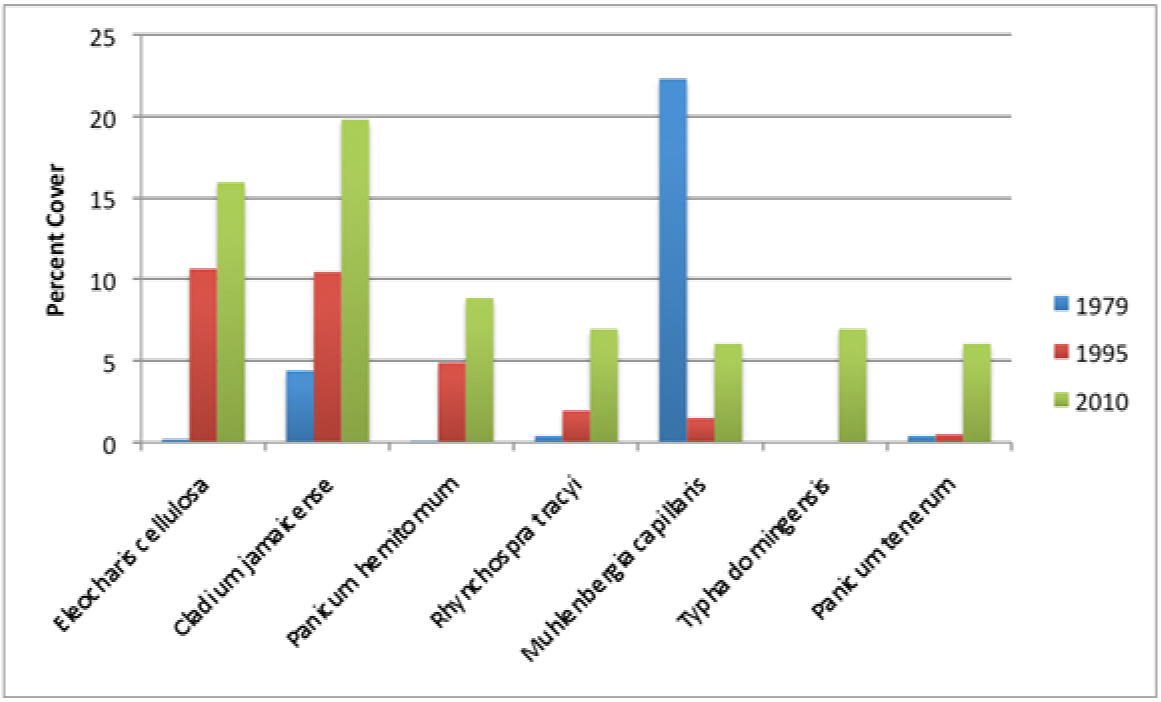

Figure 3: Changes in composition of dominant species in Transects

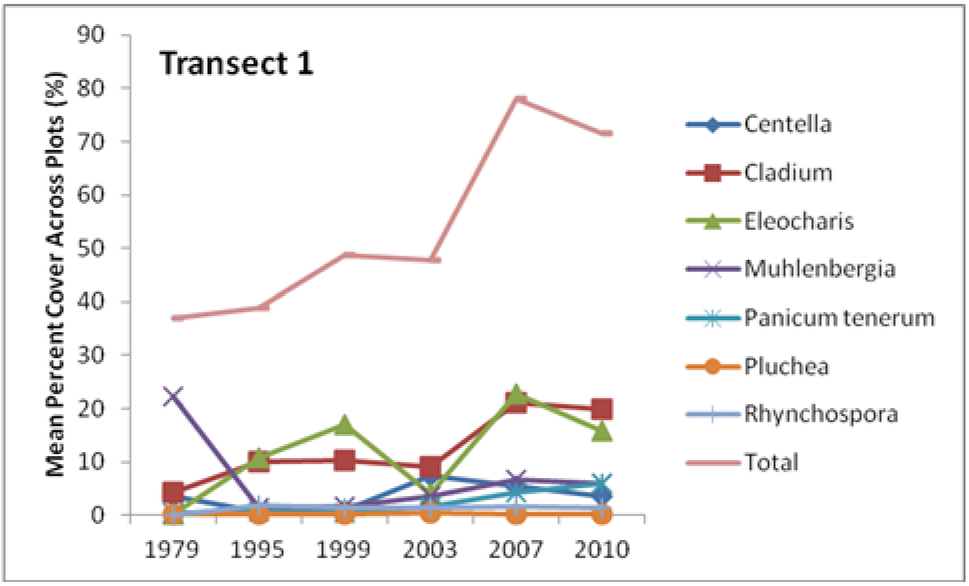

Figure 4: Species composition on Transect 1

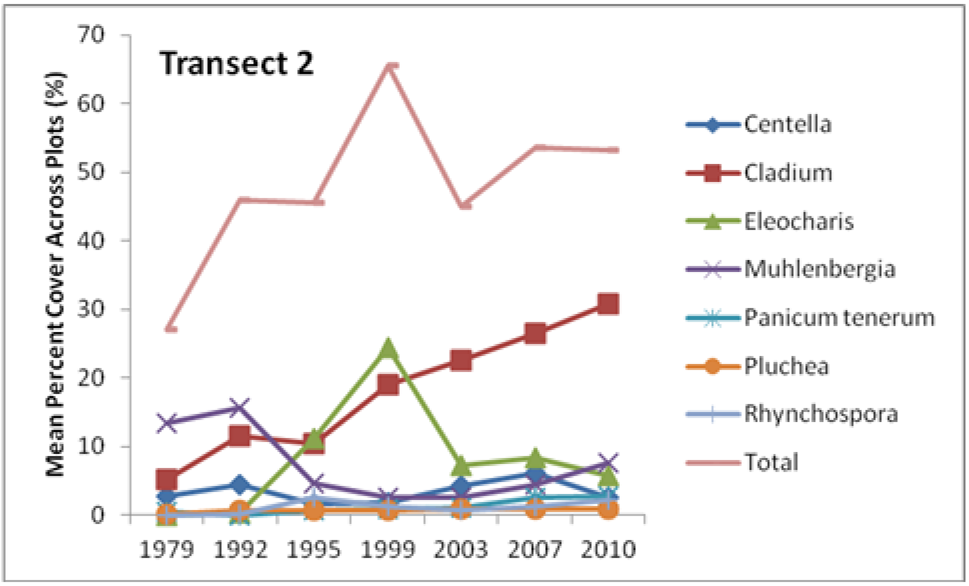

Figure 5: Species composition on Transect 2

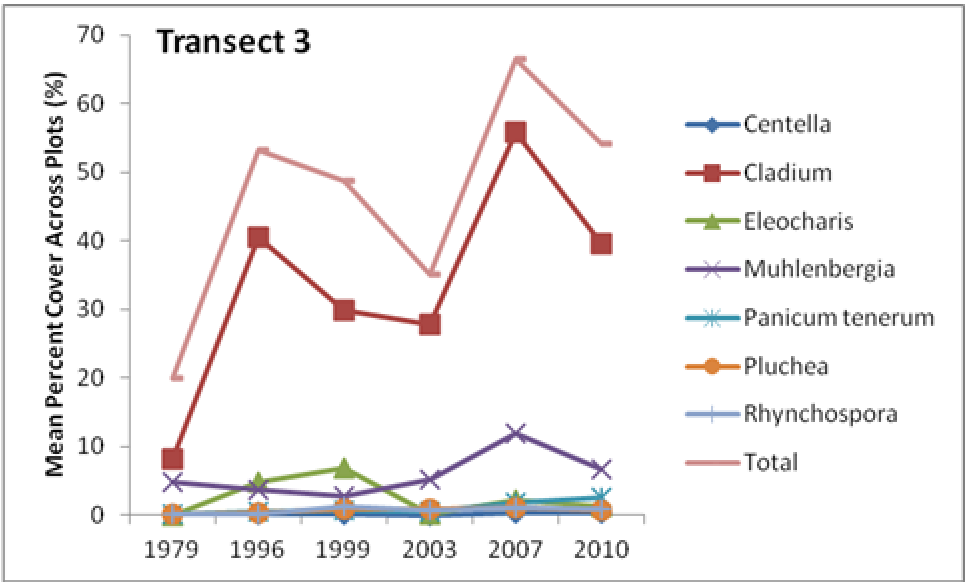

Figure 6: Species composition on Transect 3

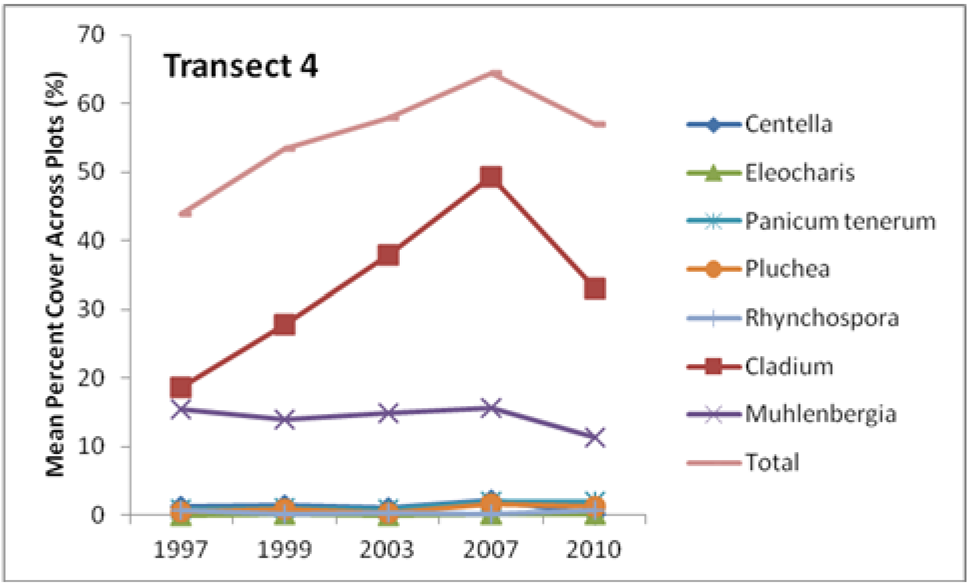

Figure 7: Species composition on Transect 4

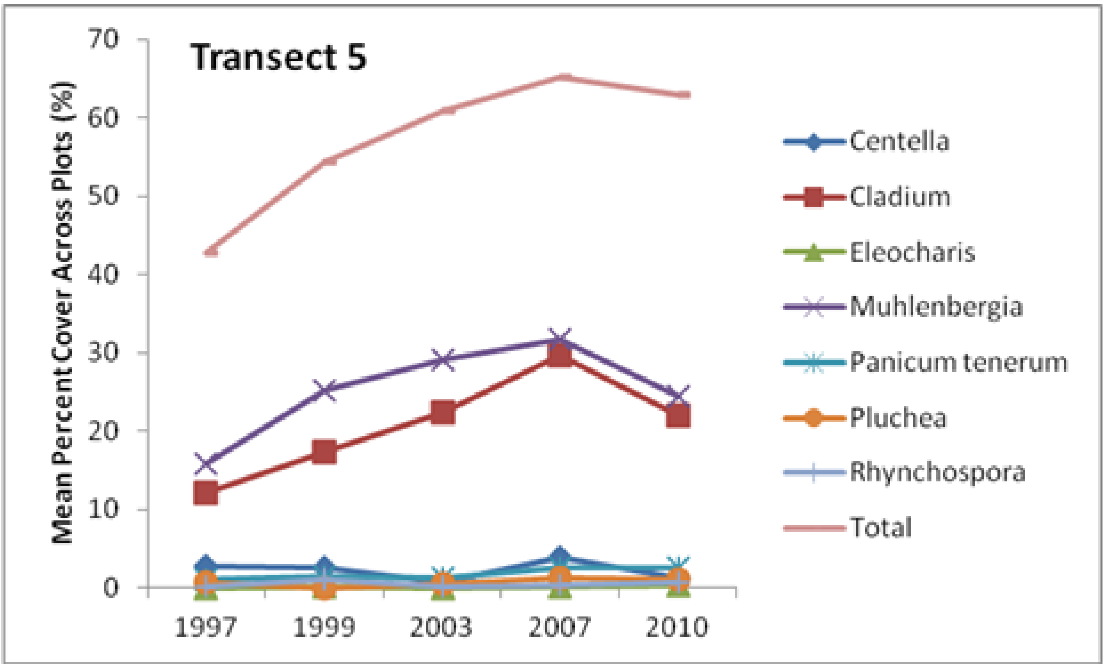

Figure 8: Species composition on Transect 5

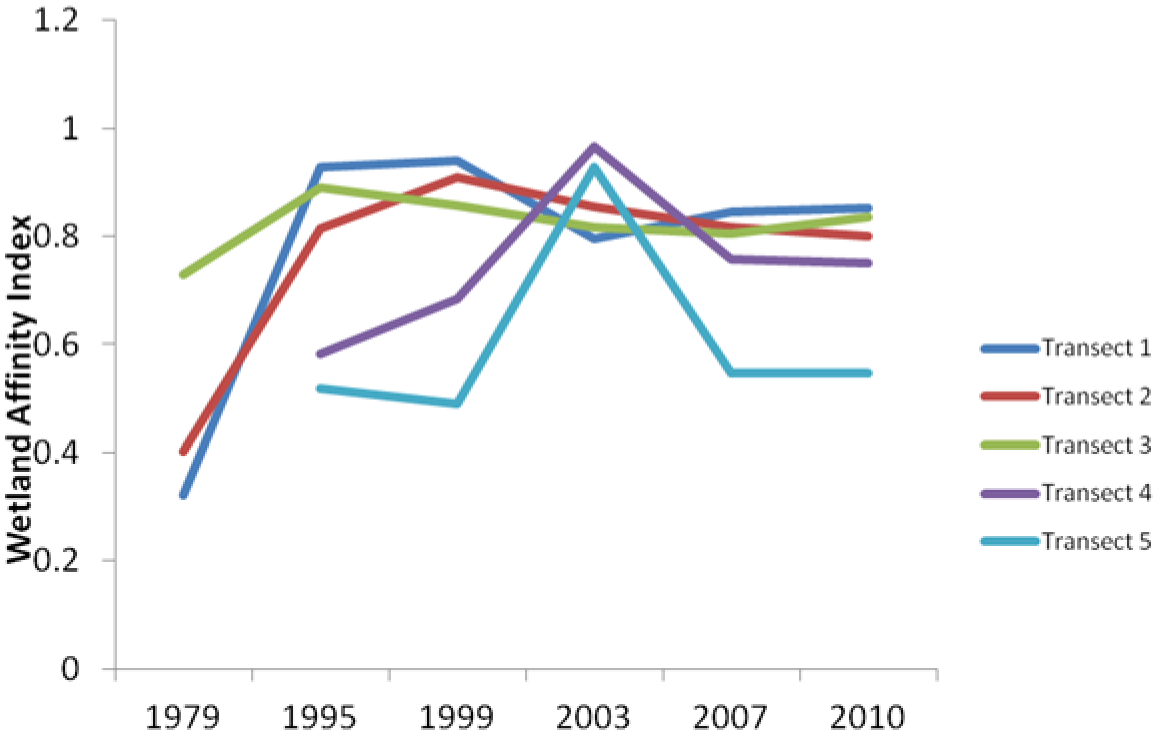

Figure 9: Wetland Affinity Index

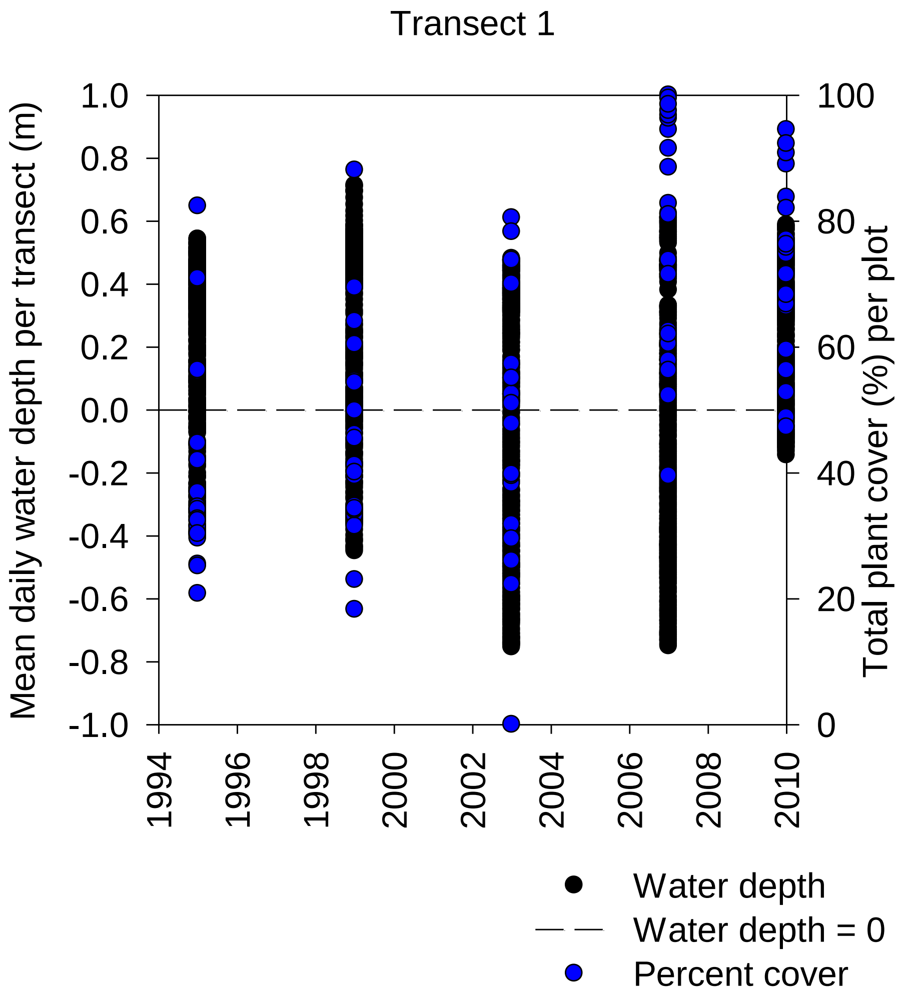

Figure 10: Temporal trend in water depth and total cover on Transect 1.

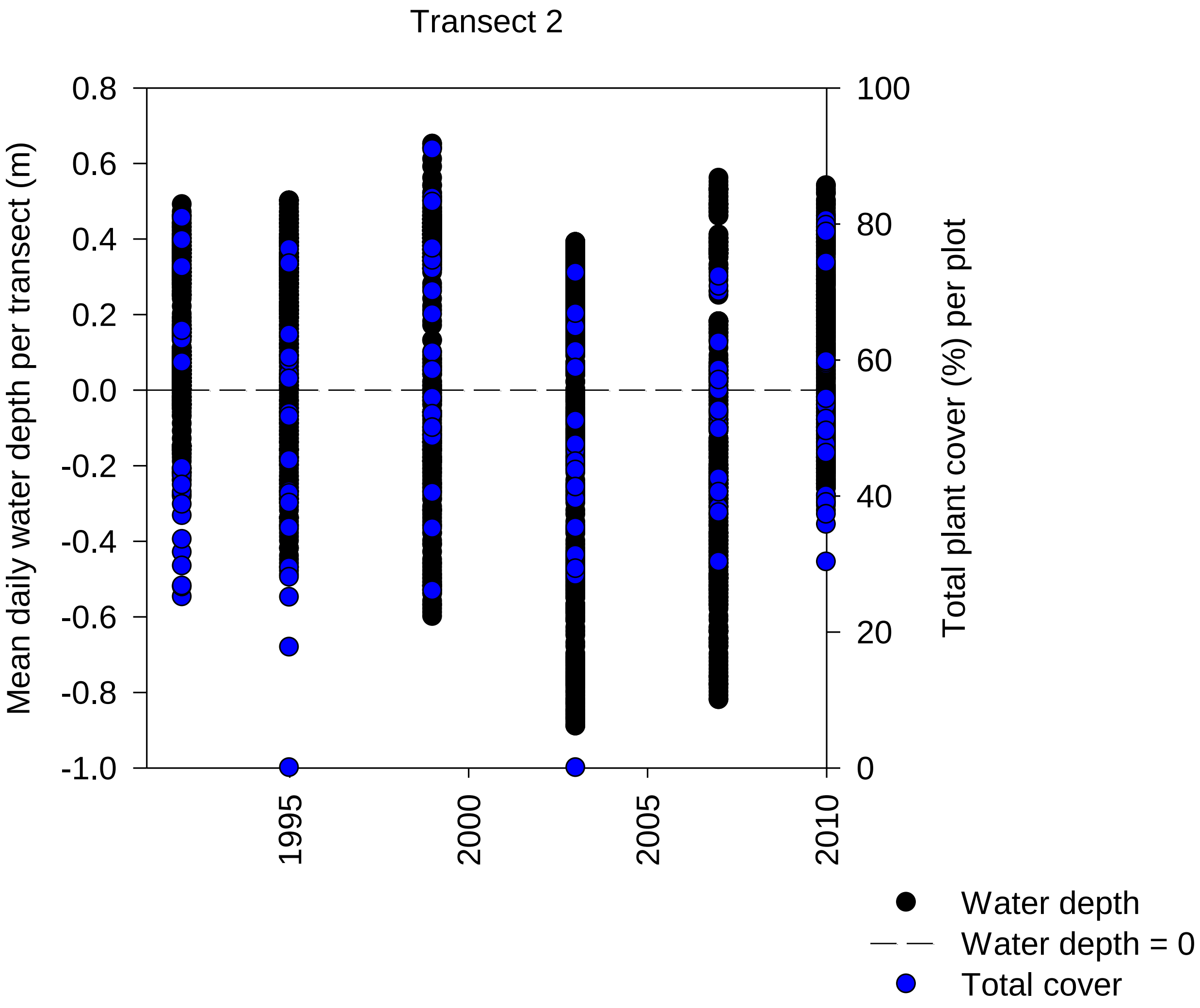

Figure 11: Temporal trend in water depth and total cover on Transect 2.

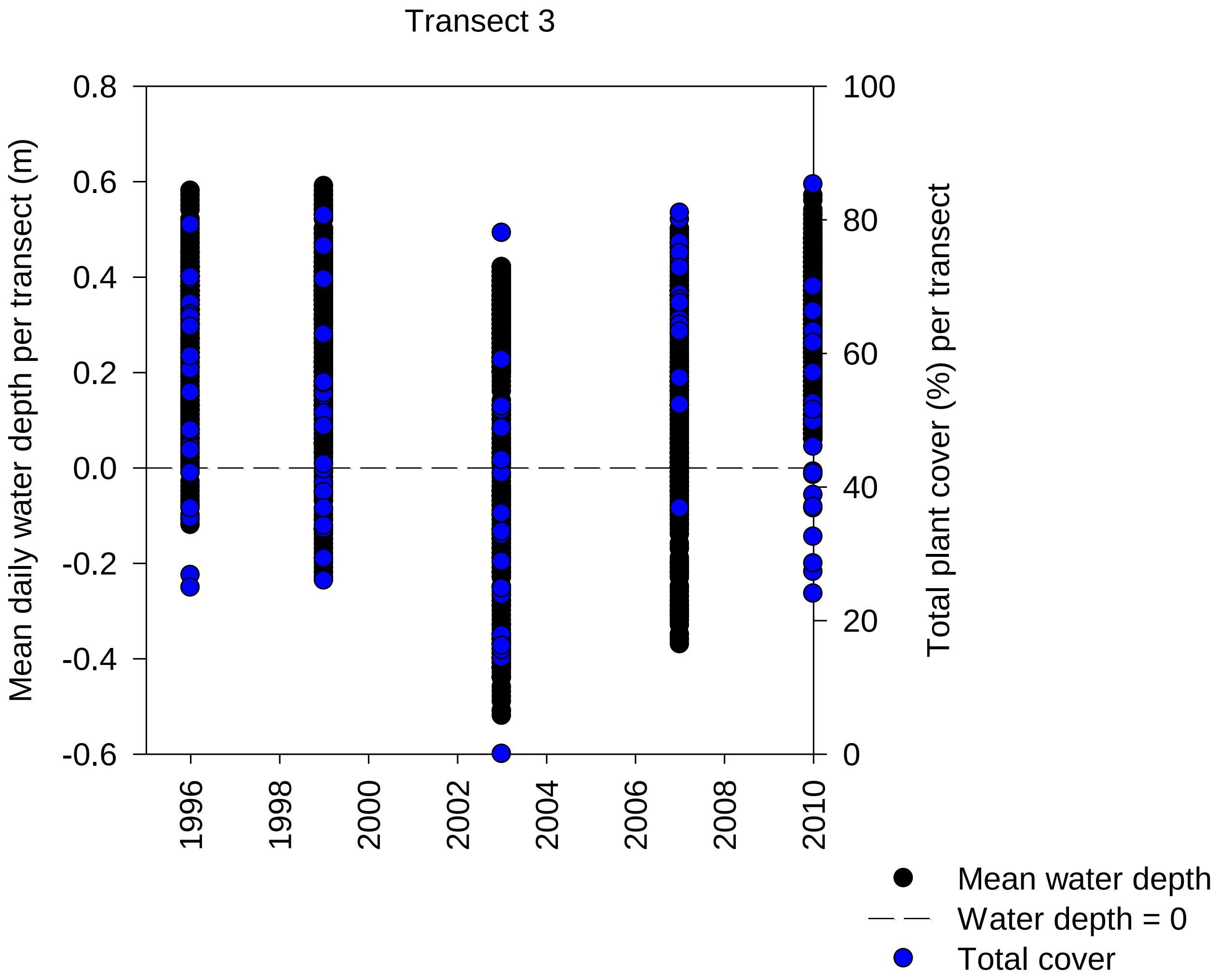

Figure 12. Temporal trend in water depth and total cover on Transect 3.

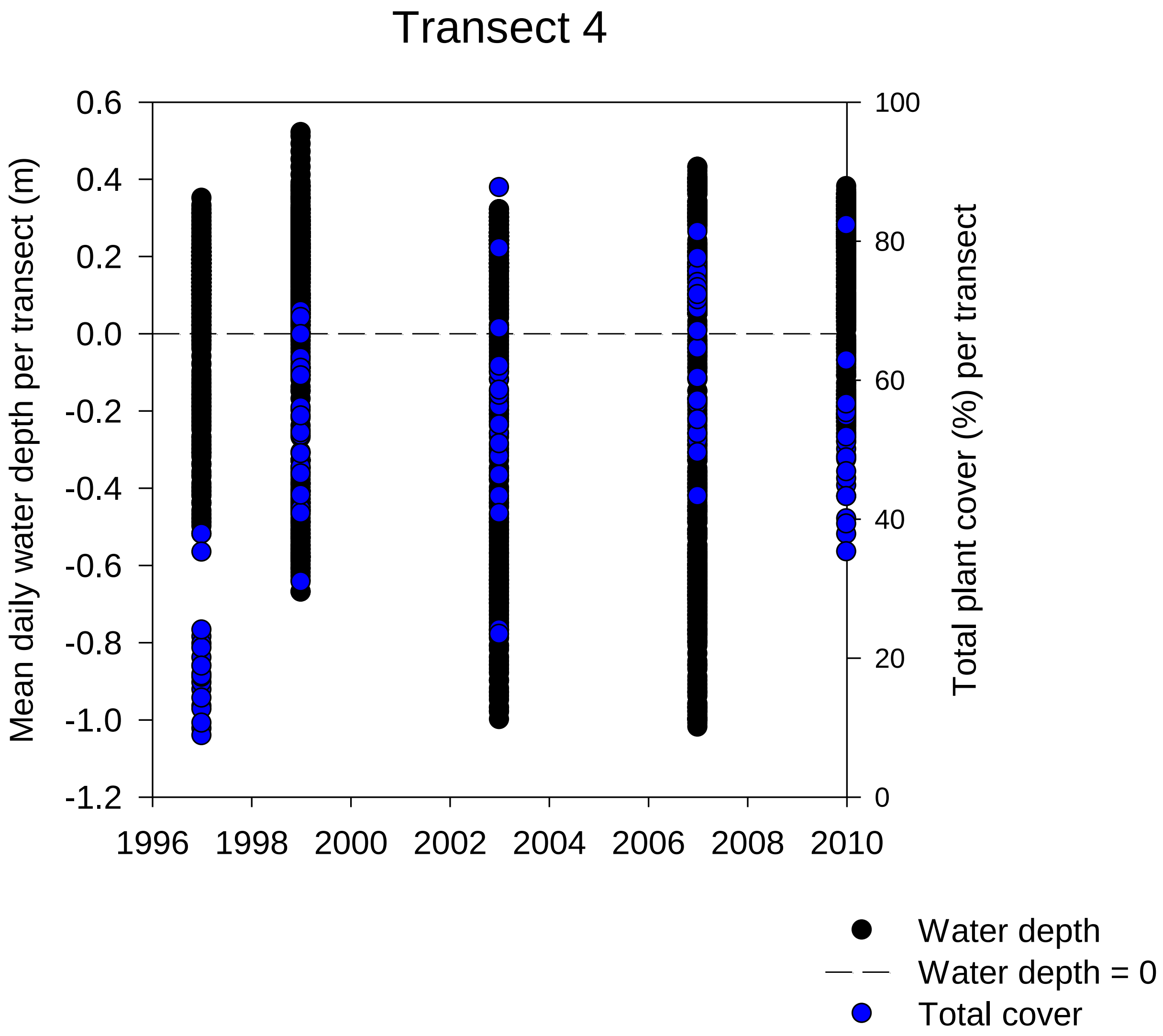

Figure 13. Temporal trend in water depth and total cover on Transect 4.

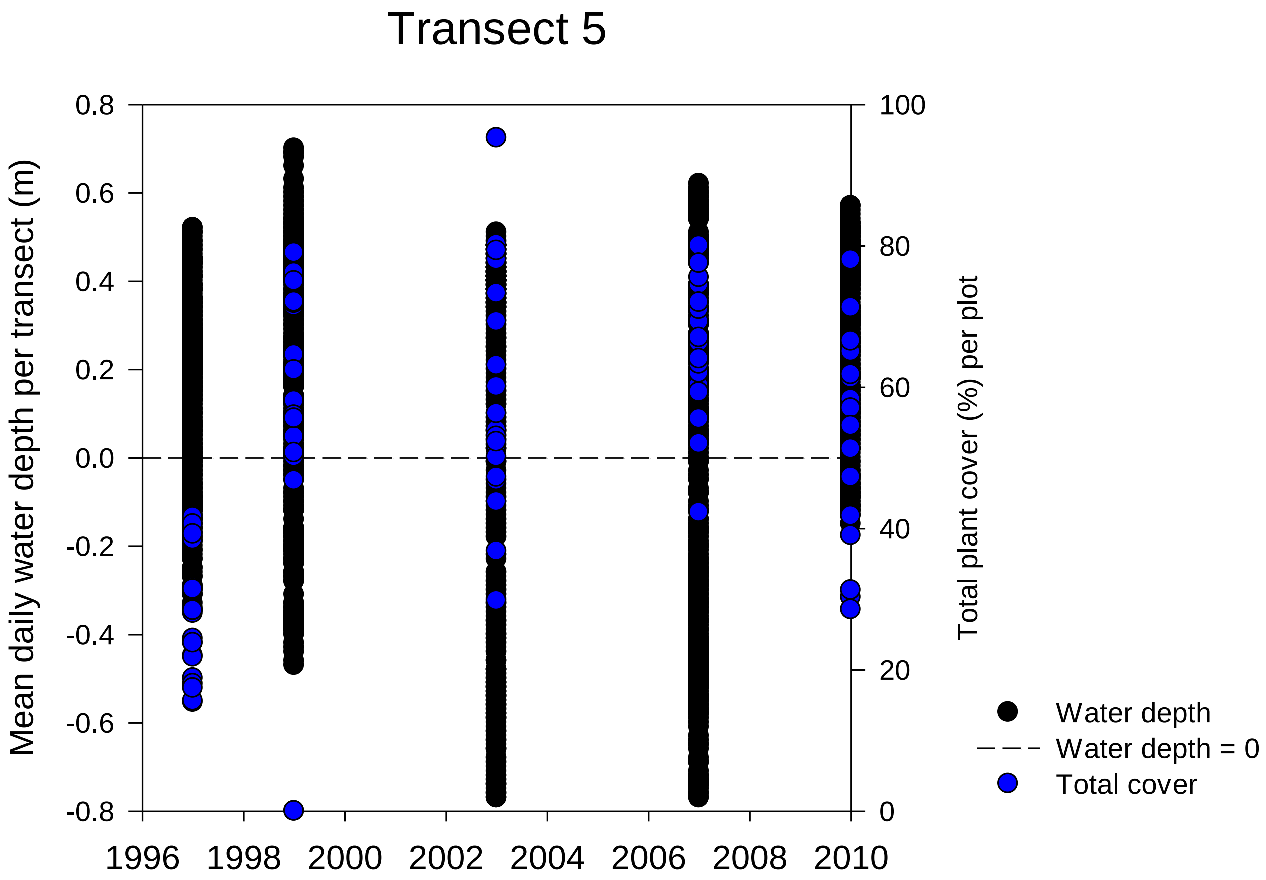

Figure 14. Temporal trend in water depth and total cover on Transect 5.

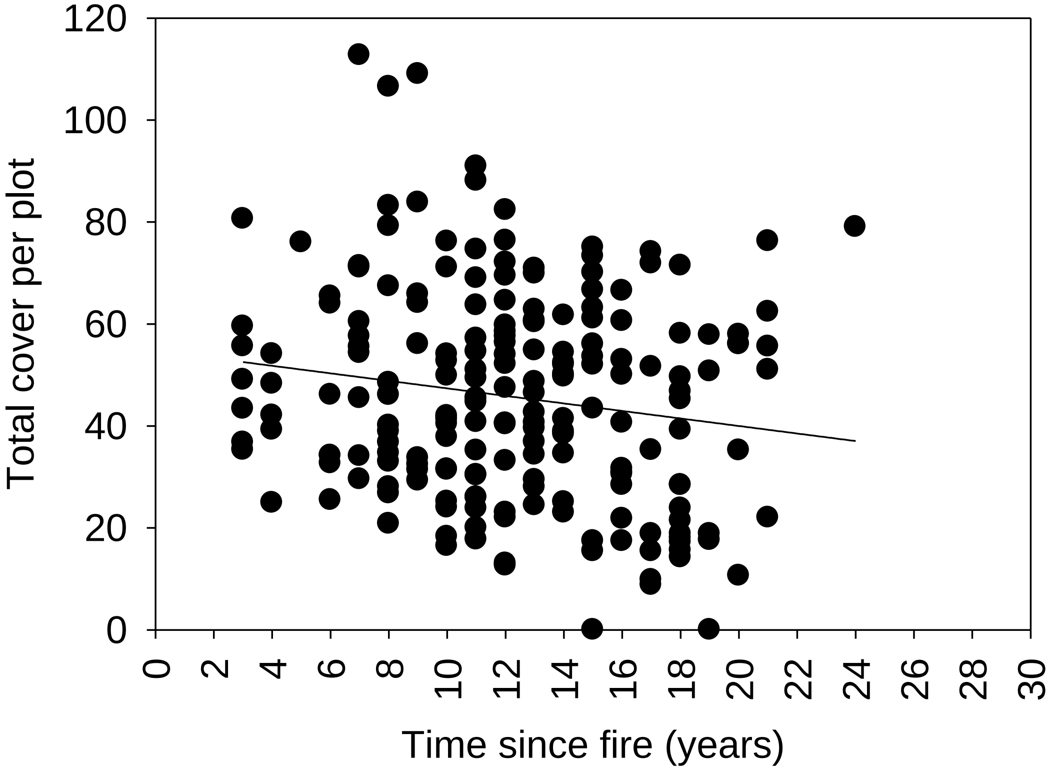

Figure 15: Global data set of total cover and time since fire.

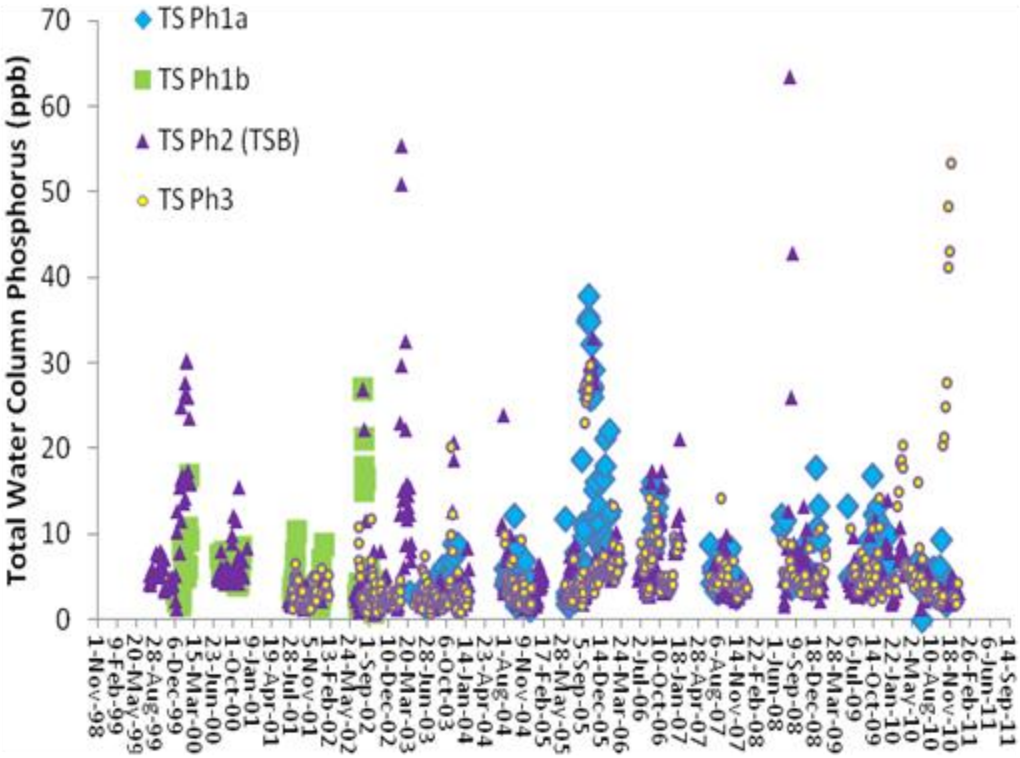

Figure 3: Total phosphorous at recording stations