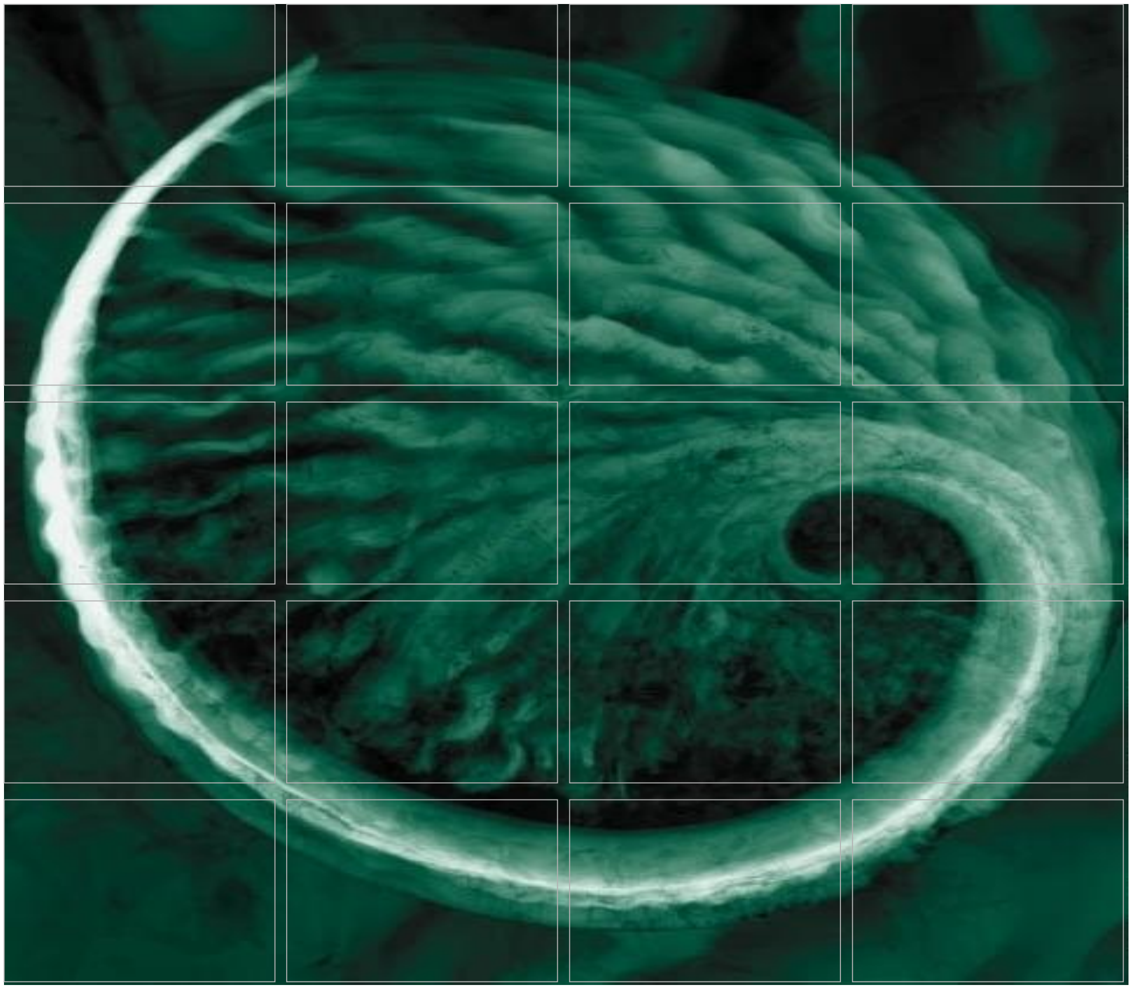

Year 4 Post-Restoration Vegetation Monitoring of Prairie Canal & Control Transects - Picayune Strand Restoration PSRP Vegetation Monitoring 2011

Prepared for:
South Florida Water Management District
Fort Myers Service Center
2301 McGregor Boulevard
Fort Myers, Florida 33901

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January 20, 2012

ENVIRONMENTAL RESOURCES MANAGEMENT
5805 Blue Lagoon Drive, Suite 350
Miami, Florida 33126
www.erm.com

South Florida Water Management District

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Work Order No. 4600001953-WO3

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Steven C. Hess, Ph.D.
Environmental Resources Management-Southeast, Inc. (ERM)
Principal Consultant

Keith Bradley
Institute for Regional Conservation (IRC)
Subcontractor Project Manager

Mike Barry
Institute for Regional Conservation (IRC)
Senior Scientist/Field Team Director

Maureen S. Bonness, Ph.D.
Institute for Regional Conservation (IRC)
Subcontractor Field Scientist

Environmental Resources Management
5805 Blue Lagoon Drive, Suite 350
Miami, Florida 33126
(305) 267-6667

and

The Institute for Regional Conservation
22601 SW 152 Avenue
Miami, Florida 33170
(305) 247-6547

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EXECUTIVE SUMMARY

As part of a long-term study to evaluate restoration effects on vegetation, sampling for the Year 4 Post Restoration Vegetation Monitoring of Prairie Canal & Control Transects was conducted between May and July 2011. Sampling was done on a total of 36 transects, including 11 control transects. Ten previously monitored transects were not sampled in 2011 because they burned in a wildfire on May 12. Sampling methods included belt transects, line-intercepts, and quadrats to identify and quantify plants within the canopy, sub-canopy, shrub, and groundcover strata. This report offers comparisons among data collected in 2011 and data collected during the dry seasons of 2008 and 2009, as well as incomplete data sets in the fall of 2005 and the spring of 2004.

Construction work to fill and plug the north-south portion of Prairie Canal began in 2004 at the northernmost portion and was completed by 2007. While the Prairie Canal has been mostly filled, it is important to note that none of these transects have been completely "restored" hydrologically because the lower east-west canal section remains as drainage, and because some flow drains westward into the Merritt Canal. Furthermore, drought conditions have dominated the site since 2007.

Comment [MJB1]: This paragraph was deleted from earlier version. This is a very important paragraph as it explains why we have not seen a whole lot of change. Also without it the next paragraph starts awkwardly with "despite drought".

Water level data from monitoring wells suggest a lengthening of the hydroperiod since restoration, despite drought conditions. For example, water levels above ground level have been recorded regularly since the filling of Prairie Canal at well SGT3W6 (South Florida Water Management District). Water levels above ground levels were never recorded at nearby piezometer 13 (National Resources Conservations Services) during the period of 1997-2004.

In order to analyze data for changes over time, as well as differences between control and restoration sites, transects were classified into three major pre-drainage habitat groupings: Cypress, Pineland, and Wet Prairie. An additional subset, labeled "less-drained", was created for four transects that are located in a transition zone between control and restoration conditions. Statistical analyses emphasized comparisons of 2011 data with data sets from 2008 and 2009 because the latter data are directly comparable, with no differences in seasonality or the timing of field monitoring activities.

Dominant tree species show minimal changes in basal area and density from 2008 to 2011 that are indicative of hydrologic alteration. Changes in this stratum are expected to be slow, with the exception of mortality of species sensitive to inundation. The dual effects of prolonged drought and incomplete restoration likely contribute to the lack of changes in this

stratum. Density and basal area of cypress (*Taxodium ascendens)* in cypress habitats remains lower at restoration sites than at control sites, which is thought to indicate increased mortality rates in the drained communities prior to restoration. Relative growth rates were lower for cypress (significantly) and pop ash (*Fraxinus caroliniana)* at restoration transects, while pine (*Pinus elliottii*) growth rates are significantly higher at restoration transects, which is consistent with known ecology of these species. With restoration, we expect these trends to reverse.

To date, restoration has not altered cabbage palm (*Sabal palmetto*) densities, with the exception of some mortality in seedlings and young cabbage palm in cypress transects close to the Prairie Canal footprint. The overall trend for cabbage palm density at both control and restoration transects, since 2004, has been a slow and steady increase in cabbage palm density (this may be in part influenced by drought), although the densities and rates of change vary considerably by habitat and land management regime. High cabbage palm densities and rates of increase were recorded in pinelands within both restoration and control transects. Cypress habitats in restoration transects had high cabbage palm densities, but not in control transects. All wet prairie transects remain low in cabbage palm densities. Variability in cabbage palm densities from year to year is greatest in the younger strata (seedlings and pre-trunk palms) in cypress habitats, suggesting that fluctuating water levels and varying hydroperiods cause some mortality. Mortality of middle-stratum cabbage palm (with trunks <4.5') caused by Florida black bear depredation was observed frequently.

Differences in overall shrub cover, as measured using the line intercept method, primarily reflected recent fire history. A notable exception is mortality of invasive Brazilian-pepper (*Schinus terebinthifolius*) due to flooding in transect PC26, which is adjacent to the canal footprint and thus hydrologically more affected by restoration. We expect changes in shrub cover to be slow, but eventually species sensitive to flooding should be eliminated from transects of relatively lower elevations.

Quadrat sampling (groundcover) resulted in the identification of 2,340 records, with identification to species or variety level at 97-98%. When weighted by percent cover, identification level exceeded 99%. Evaluation of percent cover and frequency included various statistical analyses, including species richness. The Wetland Affinity Index (WAI), calculated using 1996 US Fish & Wildlife Service wetland indicator values, proved most relevant for evaluating changes due to hydrological restoration.

In both cypress and wet prairie transects, WAI values in restoration transects are converging with WAI values in control transects. A discernible increase in WAI values in restoration transects is apparent, while WAI values in control and less-drained transects show a slight decrease (perhaps due to drought conditions). WAI values for pineland transects show greater variability (likely due to transects covering a range from mesic to hydric pinelands), with control transect WAI mean values decreasing. Restoration transect WAI mean values are increasing and surpassing control values. Considering drought conditions, it is especially encouraging that restoration transects have exhibited increases in WAI, suggesting hydrological restoration is having a positive effect on groundcover vegetation. Transects closest to the canal footprint exhibited the greatest increases.

Classification and ordination analyses for most transects show no discernible trend relating to hydrological restoration. However, data reveal that groundcover strata in restoration transects adjacent to the Prairie Canal footprint are becoming more similar to control transects. These transects, being closest to the canal, were more severely drained. As analyzed separately by habitat groupings, transects in cypress and wet prairie showed greatest similarity to transects within the same management regime (control versus restoration). Pineland transects showed greatest similarity according to fire history, rather than hydrology.

1.0 INTRODUCTION

The Picayune Strand Restoration Project (PSRP) area, formerly known as Southern Golden Gate Estates (SGGE), is a large, former development, located east of Naples in southern Collier County. It is located within the southeastern portion of Picayune Strand and is part of a larger development, the Golden Gate Estates (GGE), the northern portion of which is a residential community. The entire GGE area has undergone hydrologic and environmental alteration due to construction of a network of canals, levees, and roads built in the 1960s. Four major, north-to-south canals drain the PSRP. These four canals interconnect at the southern end of the area and, together, drain into the Ten Thousand Islands, the marine ecosystem downstream and outside the PSRP.

Prior to development, the PSRP was characterized by seasonal flooding and slow-moving overland sheet flow that supported a variety of plant and animal communities in uplands and freshwater wetlands and, in downstream areas, brackish wetlands and estuaries. Channelization of water flows has resulted in the elimination of sheet flow across the PSRP and into the estuaries, lowered water tables within the PSRP, and a fluctuating freshwater point discharge to the estuarine ecosystem in the Ten Thousand Islands. As a result, upland, wetland, and estuarine plant communities have been degraded, the abundance of native fish, wildlife, and estuarine shellfish populations has declined, recharge of the surficial aquifer has been reduced, and non-native species have increased in abundance. The drained conditions have resulted in widespread and more intense wildfires than occurred under pre-drainage conditions. These fires are accelerating the change in vegetation from wetlands to upland communities dominated by fire tolerant species, such as cabbage palm (*Sabal palmetto*) and exotics, such as Brazilian-pepper (*Schinus terebinthifolius*). In addition, these impacts extend a mile or more into other conservation areas, including the Fakahatchee Strand Preserve State Park.

The PSRP currently has a network of east-west roads, at quarter-mile intervals, connected by north-south roads at approximate one mile intervals. These roads formerly had paved surfaces overlying emplaced fill. This network of roadways resulted in several environmental impacts: the impeded the natural sheet flow of surface water, and their construction resulting in altered habitat that allowed the invasion of a wide diversity of exotic plants. Additionally, the roads also provide access to all parts of the project area where there are impacts from off-road vehicles, poaching of animals and plants, vandalism, and the illegal dumping of solid waste. This has resulted in the fragmentation of an extensive block of contiguous natural lands that compromises the value of the area for a variety of wide-ranging wildlife, such as the Florida panther and other threatened and endangered species.

In 2007, the removal of 65 miles of road east of the Merritt Canal and the filling of the north-south portion of Prairie Canal was completed. Construction work began in 2004 at the northernmost portion (north of 79th Avenue SE) and progress of the filling of the canal continued southward until 2007.

The plugging and filling of long sections of the Prairie Canal, the eastern-most canal in the PSRP, has eliminated the rapid loss of water along most of its seven-mile length by stopping quick flows and re-establishing sheet flow in the area during high rainfall periods. It has also greatly slowed drainage after the water table falls below ground during drier periods, although slightly increased flows probably remain through the less consolidated fill material in the restored canal and adjacent substrates that were fractured during construction. Over time, these slightly higher groundwater flows should steadily diminish as organics accumulate in the pools remaining along the canal and seal the pool bottoms.

The area benefited hydrologically by the plugging and filling of the Prairie Canal, including virtually all of SGGE to the east of Patterson Boulevard. Based on 20 years of monitoring water levels in the adjacent Fakahatchee Strand (a reference site), the effects from the Prairie Canal plugging have extended from one to three miles into Fakahatchee Strand during the wet and dry periods. These beneficial effects are increasingly apparent proximal to the canal.

Assuming a similar extent of impacts from the other SGGE canals, the portion of SGGE to the west of Patterson Boulevard will probably continue to be severely impacted until the Merritt Canal is restored. Also, since the southern-most, east-west portion of Prairie Canal (below the restored upper seven miles) is still open and draining into Merritt Canal, it is likely that the water table in the lower one-to-three miles of the area between Patterson Boulevard and the north-south portion of the filled Prairie Canal is still being negatively impacted hydrologically.

An additional influence on water levels to the west of Prairie Canal is the major cypress strand that crosses I-75 and enters SGGE in the vicinity of the Merritt Canal. This large strand swamp is the actual Picayune Strand and the namesake of the entire state forest and project area. This large flow-way turns to the east and approaches Prairie Canal above Stewart Boulevard, before turning back to the west and leaving SGGE in the vicinity of the Faka Union Canal at US 41. Historically, during and for some time following wetter periods, flows in this strand would have increased water levels along and to the west of the Prairie Canal, prior to the construction of the SGGE canal system. These water levels cannot be completely restored until Merritt Canal is restored.

Based on the above observations, hydrologic restoration resulting from plugging and filling Prairie Canal should be close to complete east of the canal, but benefits should diminish moving west from the canal and approaching the unfilled east-west (southernmost) section between the Merritt and Prairie Canals.

In the spring of 2004, prior to plugging and filling the Prairie Canal, three series of east-west vegetation transects were established, with 10 transects in each of the upper, middle, and lower portions of the seven-mile long north-south portion of the canal. These transects were sampled once to establish baseline conditions to form a basis for comparison when subsequently documenting the restoration of plant communities along the canal. Vegetation monitoring was scheduled to commence along these transects after one full growing season, following the completion of construction, and then annually for some additional years. Depending on the observed restoration response, less frequent sampling might occur thereafter, until a trend toward pre-development conditions was established.

The original baseline monitoring was conducted during spring 2004, and all post-construction monitoring began in spring 2008. Therefore, the data collected in the northern-most areas have potentially been affected by a lengthened hydroperiod since the rainy seasons of 2005, while the rest of the area would have only experienced post-restoration rainy seasons since 2007.

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The purpose of this report is to analyze vegetative changes observed in re-sampling of these transects along the Prairie Canal, from pre-restoration to post-restoration, to evaluate if restoration is indeed having an impact on vegetation composition and structure, and if the vegetation is converging towards the baseline composition. This report specifically addresses the monitoring activities completed in FY2011.

2.0 METHODS

Permanently marked, 50-meter (m) transects were previously established along the Prairie Canal, and control transects were established in the Florida Panther National Wildlife Refuge (FPNWR) and Fakahatchee Strand Preserve State Park (FSPSP), as depicted in Figure 1. A field guide for transect methods is included as Appendix 1.

In 2011, re-sampling was conducted on 36 transects, including 11 control transects. The Prairie Canal area includes 30 transects (PC01-PC30), located along three east-west lines (Northern Series, Middle Series, Southern Series), which extend 1 kilometer (km) to the east and 1 km to the west of Prairie Canal. These transects were established in 2004. Transects to the east of the Prairie Canal are within Picayune Strand State Forest (PSSF), while those to the west are within the FSPSP. Five additional Prairie Canal transects (42, 53, 55, 56, and 57) were established at the original Natural Resources Conservation Service (NRCS) monitoring sites within the PSSF at that same time. Additional control transects in FPNWR and FSPSP were re-sampled as they were in 2005, 2008 and 2009. Most of these were established in 2005 (32, 45, 37, 39, 51, 64, and 67), but in some cases, we utilized transects established as early as 1996 (07PI11, 07WP11, 32PI33, 32WP33), which include several sampling events prior to 2005.

Each transect was relocated using a Global Positioning System (GPS) and marked with rebar at each end. Each rebar position was recorded in UTMs (NAD83 17N), using a GPS device with sub-meter accuracy. Trees near each rebar were flagged using orange tape. A 50-meter transect tape was then strung tightly between the two rebar locations to provide a taught, straight transect line. In all cases, transects were positioned North/South and East/West, with the origins occurring at the East or North, with the exception of those transects established prior to 2004. These older transects, established on FPNWR, had start ends closest to buggy trails; and most have the start marked on aluminum foil tags attached to the rebar. Start ends also are recorded accordingly in the geo-database. Although not required, for each transect, at least one photo was taken at each rebar position in the direction of the other rebar stake.

Vegetation sampling methods similar to those used during the pre-construction sampling were utilized during the post-construction sampling (Woodmansee & Barry 2005). These methods were derived from those utilized at FPNWR, with some modification to include the canopy stratum (Main et al. 2000). Restoration targets for the Prairie Canal monitoring sites are a function of the new hydrologic regime and should be comparable to the composition and structure of hydrologically similar reference sites in the FPNWR and FSPSP sampled during the baseline PSRP vegetation monitoring effort. This included a total of 13 transects placed as control plots (see Figure 1).

The vegetation along the transects was divided into four strata, based on Chapter 62-340.200, Florida Administrative Code (F.A.C.) (1996) of the Florida Wetlands Delineation Manual, *Delineation of the Landward Extent of Wetlands and Surface Waters*.

- Canopy trees, consisting of those woody plants with a diameter at breast height (dbh) greater than 10 centimeters (cm) or 4 inches (in);

- Sub-canopy trees, consisting of tree species with a dbh between 2.5 and 10 cm (1-4 in), excluding woody shrubs;

- Shrub layer, consisting of trees with a dbh less than 2.5 cm (1 in) and any-sized individuals of shrub species (see "shrub notes" in Appendix 1); and

- Ground cover, consisting of all plants not found in the other strata and primarily herbaceous species.

Extra emphasis was placed on cabbage palm densities due to the current high densities observed in the drained areas of PSRP relative to historical accounts of the area, prior to drainage. Cabbage palms were separated into 5 strata described below.

- Canopy palms with apical meristems above 2.4 m (8 feet (ft)). Sub-stratum below 1.5 m was noted for "old growth", or pre-disturbance cabbage palms (or pre-disturbance overstory slash pine (*Pinus elliottii*), as well), based on morphological characters such as bootless trunks lacking boot-scars, and the presence of adventitious roots. For slash pine, this determination was based on characters such as crown form and swollen base. A detailed explanation of old-growth cabbage palm can be found in the 2006 FPNWR report (Barry 2006);

- Sub-canopy palms with apical meristems greater than breast height of 1.4 m (4.5 ft), but less than 2.4 m (8 ft);

- Shrub layer palms with apical meristems just above ground level to a breast height of 1.4 m (4.5 ft);

- Groundcover palms, including individuals with apical meristems still at ground level (*i.e.,* no trunk), and with palmate leaves or with at least four (or evidence of having produced four) simple leaves. According to McPherson and Williams (1996), this stratum would include pre-trunk plants with palmate leaves to plants with simple leaves, but with leaf widths>8 mm. In 2011, stratum 4 was additionally segregated into sub-stratum 4-palmate and sub-stratum 4-simple; and

- Palm seedlings, defined as individuals without palmate leaves and only two to three leaves (including remnant petioles at the base, if present). McPherson and Williams (1996) defined new recruits to be the smallest plants with leaves of three or fewer, accordion, V-shaped folds and leaf widths less than or equal to 8 millimeters (mm).

For cabbage palms with trunks conforming to strata 1-3, the presence or absence of adventitious roots was recorded

Canopy trees, sub-canopy trees, and all strata of cabbage palms were sampled along 5-m wide, belt transects (Mueller-Dombois & Ellenberg 1974). Diameters of all canopy trees were measured and tagged to facilitate re-sampling and to document mortality and recruitment. Sub-canopy trees were counted by species to estimate density, but not measured or tagged. The number of cabbage palms was recorded in each of the five strata.

The composition and cover of the shrub stratum, as defined above, was quantified using the line-intercept method, along each transect (Canfield 1941, Lindsey 1955, Mueller-Dombois & Ellenberg 1974). Line-intercept data included all overhanging or underlying species in the shrub stratum. Saw palmetto (*Serenoa repens*) was consistently considered a shrub. Cabbage palms in strata 3–5 were also recorded. These data were used to calculate percent coverage.

Ground cover species were sampled using rectangular quadrats (40.5 in x 20.75 in) with an area of 0.5-square meter (m^2), placed at 0-0.5 m, 10-10.5 m, 20-20.5 m, 30-30.5 m, 40-40.5 m, and 50-50.5 m, with the short edge of the rectangle on the intercept, and the long edge extending to the west (for transects starting on the north end) or north (for transects starting on the east end). Species composition and cover were quantified using Daubenmire (1959) cover classes: 1) 0-5%, 2) 5-25%, 3) 25-50%, 4) 50-75%, 5) 75-95%, and 6) 95-100%.

Comment [KB2]: It's a 40.5 x 20.75 inch rectangle

All plant species whose stems originated from within the quadrat were assigned cover class values. Shrub stratum species, epiphytes, and vines were assigned cover class values, if any part of the plant overhung the quadrat, regardless of where the stems originated. Cabbage palm strata 3–5 were lumped into one cover class, with additional notation made for the number of seedlings within the quadrat. Records were kept of all plant species observed within the quadrat that were flowering, fruiting, at seedling stage, or deer-browsed. Records of other species observed in or near the transect were made and incorporated into the site species lists.

Because fire is so important to the re-establishment of natural vegetation on the PSRP, records of wildfires and prescribed burns that affect portions of the PSRP vegetation monitoring sites were requested from appropriate agencies in the course of sampling. For each transect, fire interval was recorded. Fire intervals were placed into three categories: 1 = <1 year; 2 = 1-7 years; and 3 = > 7 years. Intervals were determined using these recorded burn history data or field observations when actual burn dates were not available.

Plant nomenclature followed Wunderlin & Hansen (2003), with certain exceptions, including any generally accepted taxonomic changes, since the date of this publication. Important departures include South Florida bluestem (*Schizachyrium rhizomatum*), which in Wunderlin & Hansen (2003) is treated as a synonym of little bluestem (*S. scoparium)*. To avoid confusion, the synonyms are provided in the species list included in the database.

In accordance with our work order requirements, the weighted (by total percent cover) percentage of species not identified to species level must be less than 1% of the total species recorded. Taxa not identified to species level were identified to the lowest taxonomic level possible, and a specimen was collected from outside the transect as a voucher, where possible.

Comment [KB3]: Scope of work says 98% of individuals to species, then 99% weighted by cover (page 7). I think it should really just be deleted here though.

2.1 DATA ENTRY

Data were entered into a Microsoft Access database. A single table was used for each study type: belt transect data, line intercept data, and quadrat data. In addition, tables were created for descriptions of each transect, including well number, location, rebar number, transect number, fire history, habitat, former habitat, and any notes. A table was also created for sampling events containing dates, surveyors, and "time since fire data". Comment fields were included in all tables. Additional tables were provided, including a GPS table linking geographic coordinates of each rebar belonging to each transect, an Accepted Names table (linking taxonomic code with genus species, higher taxonomic data, plant authority code, nativity, rare plant status, and Florida Exotic Pest Plant Council status), an Authority table (linking authority code with the appropriate literature reference), and Lookup tables for each of the data tables. After initial data entry, data were cross-checked for errors and corrected accordingly.

Previous data collection events utilizing the same field study methods were incorporated into the Access database and were included in some of the analyses documented in this report. These sampling events, listed in Table 1, were conducted as early as 1996. This was done to allow discussion of preliminary findings and to summarize pre-restoration habitats.

A total of 309 transects have been established and sampled multiple times (totaling 1,006 samples) through multiple funding sources. Pertinent data associated with all of these samples were included in the current database. A summary of all data set events is provided in Table 1. For a complete discussion of these events refer to Barry (2006).

2.2 *DATA ANALYSES*

For the purposes of this report, data analysis was performed utilizing a subset of the overall database described above. This data subset is presented in Table 2. Basic statistics were calculated and presented for each of the field methods, including standard forestry parameters, such as density, basal area, and stand basal area for belt transect data, percent cover for line intercept data, and percent cover, percent frequency of occurrence in quadrats, and percent dominance using quadrat data. Additional analysis was carried out using wetland indicator values (Reed 1988). Wetland Affinity Indices (WAI) were computed and utilized when evaluating the effects of hydrological conditions on the plant communities.

All analyses were conducted using SPSS 11.5 and graphs were made with Sigma Plot 10. PCORD5 was used to determine community traits such as species richness and species diversity. Classification and ordination analyses were conducted using PRIMER V.6 (Clarke and Gorley 2006).

Parametric tests were used on either the raw data or transformed data to meet normality criteria. Univariate ANOVA was conducted to examine the effects of restoration on species richness, Wetland Affinity Index (WAI), and on relative diameter growth rates (RGR), using habitats (cypress, pineland, and wet prairie), management regimes (control and restoration), year of data collection (2008, 2009, 2011), and species (cypress, pop ash, pines, etc.) as the predictor variables when applicable. Data from 2004-2005 sampling event were not included in the statistical analyses database, with the exception of RGR, where the 2004-2005 data were because RGR is a rate expressed on per year basis. RGR was calculated as:

$$\mathrm{RGR}_{diameter} = \frac{(\ln diameter\ t_2) - (\ln diameter\ t_1)}{t_2 - t_1}$$

Field Code Changed

In addition, data were evaluated to discern patterns of species composition across habitats to examine the role of fire, hydroperiod, and restoration in cypress dominated habitats in distinguishing areas of similar species composition and abundances. Results are organized as follows: p-values, data means, and standard errors are included in the text. Were significant effects were noted, the results were graphed to further evaluate and depict the affects of management regimes on response variables. Statistical tests were considered to be significant at a significance level of α <0.05%.

2.2.1 *Percent Cover and Species Richness*

Species richness (*S*) was defined as total number of all species occurring per transect. Species diversity is a non-biased measure of species composition, which takes into consideration *S* and the relative abundance (n/N) of each species in a transect. Where n is the frequency, percent cover, or count of individuals of a species and N is the total sum of occurrences of all species in a transect. For this study, frequency was utilized. Shannon Weaver's index *H'* was used to estimate diversity and was computed as:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where p_i is the relative abundance measured by percent frequency of a constituent species, *i,* in the transect.

Transect means are provided for each sampling type in the appendices.

2.2.2 *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, but not yet published, though the list is due for publication soon (Steve Mortellaro, USFWS, personal communication). The calculations used herein follow the revised 1996 classification method. This classification assigns a probability for each plant species in the region to occur in a wetland (P_{usfws}). The 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 = P_{USFWS} for indicator category, i, based on the above-noted 1996 classification; P_{usfws} = 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 inundation-tolerant species.

Comment [KB4]: This whole thing tuned out to be more confusing than that. The values were not for WAI, they were the USFWS values (Xi). I think deleting them is better since they didn't relate well to the sentence to begin with.

2.2.3 *Classification and Ordination*

Testing was performed to assess if significant clustering of transects occurred to examine if control and restored transects cluster together, or if they have different species composition. Bray-Curtis similarity matrices (Bray and Curtis 1957) were employed for the hierarchical cluster analysis using the group average method. Although the statistical routines used were non-parametric, all abundance data, as measured by percent cover per quadrat, were square-root transformed prior to the analysis to down-weight the influence of extremely abundant species (Clarke and Warwick 2001).

Standardization is appropriate for comparing data sets with varying levels of effort to obtain percent composition values for individual taxa within a community (by samples) or percent composition of individual taxa between communities (by variable). This was undertaken to identify relative distribution among habitat types and endemism where an individual species or taxa is found only at one site or habitat type. Standardization of sample results was not considered to be appropriate for the multivariate analysis, since the level of effort was consistent (or standardized) between sampling events and sites (Clarke, personal communication 2007), and individual species were already ranked by percent cover at each quadrat.

Non-metric multi-dimensional scaling (MDS) was used, in addition to classification as an ordination technique, to display in 2-dimensions the relative distances (dissimilarity) between points (communities at different sites or different sampling events). The relative position of each point in proximity to all other points (sites or events) is maintained. The plot is a visual representation of the Bray-Curtis similarity matrix in multi-dimensional space. The multi-dimensions represent species presence/absence and abundance values of all plant species at all sites.

3.0 RESULTS & DISCUSSION

Vegetation sampling was conducted for the Prairie Canal vegetation transects and control/reference sites beginning on May 16, 2011 and ending July 9, 2011, capturing the peak and end of the dry season. Sampling was completed on 11 control transects and 25 restoration area transects. These data were compared to data collected during dry seasons of 2008 and 2009. The data also were compared to control sites sampled in the fall of 2005 (wet season) and restoration sites sampled in the spring (dry season) of 2004.

Because of a lightning-ignited wildfire, the Cobalt Fire (May 12, 2011), a total of 10 transects burned, and these transects were not sampled during this monitoring period. These burned transects included all of the western half of the northern Prairie Canal transects (PC01-PC05), 4 transects from the eastern half (FSPSP) of the middle transect (PC16-PC19), and one transect near monitoring well SGT off 79th Avenue SE, east of Patterson (55). With the exception of one transect (PC02), all of these transects were either wet prairie, or pineland transects. It is expected the groundcover strata in these areas will benefit greatly from the fire. Photos at the ends of each of these transects (matching photos taken normally while sampling) were taken on May 23, 2011 to generally capture pine canopy scorch percent, char height, percent consumption of fuels, and overall severity of the fire.

Due to the lack of data for these burned transects, this report addresses data for transects actually sampled during this reporting period. To evaluate restoration, available data were compared to conditions noted in 2004, 2005, 2008, 2009 to 2011 (see Table 2). Analyses of data for the transects burned in the Cobalt Fire was presented in the Year 2 Monitoring Report (Barry et al. 2009).

For the statistical analysis of trends over time the data set was further reduced. Comparisons with the control sites sampled in the fall of 2005 (wet season) were not considered valid for groundcover analysis because the wet season sampling typically consists of greater species richness and abundance of wetland plants compared to the dry season in pinelands and prairies and lower species richness in cypress wetlands. Nevertheless, these data are presented for discussion purposes. Assessment of woody vegetation is not influenced by seasonality of sampling, but because 2004 and 2005 sampling events are more than a year apart they were also excluded from most analyses in this report. The 2004 and 2005 data are included in the transect mean tables (Appendices) and cluster analyses for reference.

In comparing control/reference sites to restoration transects, it has become apparent that 4 transects considered "restoration" transects are more similar to control transects. As a result, these transects were excluded from the analyses to bring to light the differences between management regimes.

These "less drained" transects include transect PC20, which is a burned over cypress strand on the far eastern end of the middle transect perpendicular to the Prairie Canal footprint, and PC28-PC30, at the far eastern end of the southern transect (Figure 1). These transects were included in mean tables (Appendices) and the cluster analysis for reference.

Also, it should be noted that transects 51 and 64, located off Janes Scenic Drive, in FSPSP, near South Florida Water Management District (SFWMD) monitoring well SGT3W7, were originally intended to be analyzed as "restoration" transects when they were installed because of their proximity to the Prairie Canal footprint (Mike Duever, personal communication). However, after initial vegetation sampling the data indicated a greater similarity to control sites with which they have been combined since initial sampling. These transects, which are upstream of PC28-30 (Figure 1), could be considered a part of the "less drained" category in the future. For this report, transects 51 and 64 remain a part of the control category.

3.1 HYDROLOGY

In 2007, the removal of 65 miles of road east of Merritt Canal and the filling of the north-south portion of Prairie Canal was completed. Construction work began in 2004 at the northernmost portion (north of 79^{th}), and progress of the filling of the canal continued southward until 2007. Therefore, the data collected in the northernmost areas have potentially been affected by a lengthened hydroperiod, starting during the rainy seasons of 2005, experiencing restoration for six years. The southern portion would have only experienced a shorter timeframe of four "restored" rainy seasons, starting in 2007. While the Prairie Canal has been mostly filled, it is important to note that none of these transects have been completely "restored" hydrologically because the lower east-west section remains as drainage and because some of the overland flow in this area still drains off to the west into the Merritt Canal.

Rainfall data have been recorded at SFWMD's SGGEWX weather station (located in PSSF), since its establishment in September of 2002. These data are presented in Figure 2.

Water levels were manually recorded in the PSRP area between 1997 and 2004, using piezometers installed by NRCS. Deeper monitoring wells with automated data recorders were installed by SFWMD in 2003. The locations of these monitoring wells can be found in Figure 1.

Hydrographs were prepared for select NRCS wells, while charts for SFWMD wells were provided by Dr. M. Duever and the SFWMD. A hydrograph for SFWMD well SGT3W7 is presented in Figure 3, as a control data comparison, though it is near the eastern edge of the expected zone of influence for the former Prairie Canal. Hydrographs for NRCS piezometer 14 and SFWMD well SGT2W6 at the same location are presented in Figures 4 and 5 to represent the middle to northern section of the Prairie Canal study area. Data for NRCS piezometer 13 and SFWMD well SGT3W6 are presented in Figures 6 and 7 to represent the middle to southern area. Data for NRCS piezometer 21 and SFWMD well SGT4W6 are presented in Figures 8 and 9 to show additional data from the southernmost area.

These hydrographs begin to suggest a lengthening of the hydroperiod since restoration, as water levels above ground level are recorded at the restoration sites by SFWMD wells. Water levels were rarely above ground level in the data collected in the NRCS piezometers. NRCS piezometer 13 and SFWMD well SGT3W6 most strongly suggest the effect of restoration at this early stage of restoration, with the evidence of a brief period of standing water during a close to average year of rainfall in the wet season of 2006 and again in 2008. This is significant in light of the lack of recorded standing water in the period from 1997 to 2004.

The weather influence on water levels, especially since 2009, is best explained by looking at timing and duration of flooding, as well as total rainfall. Drought from below average rainfall during the wet season, especially in June and October, along with above average temperatures, has been fairly common since 2007, although, in general, rainfall data indicate patterns roughly consistent with long-term averages posted by the SFWMD.

Total rainfall in 2005, the year that hurricanes Katrina, Rita, and Wilma passed nearby or over the study site, was 74 inches, which is above average for the Naples area average (52-55 inches/year). This resulted in a more extended hydroperiod, even at the control well site (SGT3W7).

In 2007, rainfall totaled 50 inches, slightly below average. Notably, however, monthly totals were especially low during July through October (wet season). Following this rain pattern, all wells showed a shortened hydroperiod in 2007.

The spring 2008 rains, which appear in the hydrograph, helped ease effects of drought conditions. The dry season was very hot and dry in May and was made somewhat more severe due to the presence of very dry air masses throughout winter. Steady rains from June through September resulted in a good period of high water roughly from July through September. Rainfall for 2008 was 61 inches.

The dry season started in October 2008 and was below average rainfall, until sampling in 2009. After a brief period of high water in the summer of 2009, the dry season began with a hot and dry October.

The winter of 2009-2010 proved to be a substantial departure from average, with rains occurring through mid-May, which maintained higher than expected water levels, although not flooding the majority of transects.

In June 2010, conditions changed dramatically with below average rainfall, above average temperatures, and dry air masses contributing to a quick dry-down before the rainy season commenced. The hot June of 2010 lowered water levels substantially. The summer water levels followed with a brief period of high water.

The dry season of 2010-2011 began abruptly in October, coupled with above average temperatures. Dry-down through the entire spring and early summer resulted in extreme low water levels well into July. In fact, June 2011 was the lowest recorded water levels (20 years of data) for Bridge 105 Tamiami in the Big Cypress (http://www.gohydrology.org). Since June, summer precipitation has been near normal levels, but water levels had not recovered by August.

In short, weather and water levels since time zero restoration (2007) have resulted in more drought than flood, and hydroperiods have been relatively short. Specifically, the beginning and the ends (May/June and October, respectively) of a few of the rainy seasons have been characterized by above average temperatures and below average rainfall. Longer-term data, however, suggest that prior to the last two decades such droughts definitely were more prevalent (http://www.gohydrology.org).

This recent drought, coupled with high temperatures, could also potentially be indicative of long-term trends predicted by climatologists. IPPC models based on mid-range scenarios of CO_2 loading until the end of this century predict slight decreases in precipitation for December-February and a 10-15 percent decrease in the wet season from June-August (ENP 2009). In the literature synthesis, it goes on to say that “the combined effect of even modest increases in temperature, along with modest reductions in rainfall during the historic wet season, would be extended droughts with increased evaporation and uncertain recharge of Everglades’ wetland ecosystems and surface aquifers during the wet season.”

If warmer and drier conditions become more prevalent, effects of hydrological restoration on vegetation will be less obvious than anticipated. Conversely, if canals are not filled, we would see more severe effects on vegetation than what observed over the past 30-40 years. For example, cypress throughout study area began turning yellow in late July which is the earliest that authors have observed. While uncertain, this occurrence may well be a manifestation of heat and drought stress. The early leaf drop was more substantial in the more severely drained areas to the west of Merritt Canal (personal observation), while leaves dropped and re-flushed on FPNWR (Refuge staff, personal communication). Early leaf drop was also observed on a variety of tree species in Texas this summer, which has experienced its worst drought on record, as reported at http://txforestservice.tamu.edu/main/article.aspx?id=13768.

3.2 HABITATS

Habitat designations followed the Burch et al. (1998) definitions with some modifications. This habitat classification system was chosen for analyses because previous work for PSRP utilized these habitat types, including pre- and post-drainage vegetation maps. The database also includes the vegetation classification system for south Florida (Rutchey et al. 2006) and more detailed mapping of PSRP using this more precise classifications system (Barry et al. 2009). However, for analytical purposes, we have found it necessary to reduce precision below even the NRCS codes due to small sample size.

A total of eight distinct habitats (including altered habitat types) were studied under this project at control and reference sites (see Table 3). For most statistical analyses, we found it helpful to combine all cypress habitats (Ch, Cg, and C) and combine both mesic and hydric pinelands for comparisons between control and restoration sites, thus increasing sample size by habitat. This results in 4 control and 12 restoration cypress transects along with 3 control and 12 restoration pinelands transects in total. As noted earlier, only 11 restoration cypress transects and 5 pineland transects were sampled during current sampling due to fire impacts.

The general location of all transects at control and restoration sites were described above in the Methods section and in Figure 1. Each transect is presented below with both pre-drainage and current (baseline) habitat type in Table 4. Soil types, following the mapping data from the Soil Survey for Collier County (Liudahl et al. 1998) also are tabulated. The restoration sites are shown over 1940 and 2009 aerial photography separated by Northern, Middle, and Southern transects in Figures 10-15. Existing conditions or baseline habitat types were based on general assessment of the site in the field and utilizing transect data. Historic or pre-drainage habitat types were determined using a combination of factors, including evaluation of 1940's aerial photography and field evidence, such as the presence or absence of old-growth trees, dead stumps or trunks, and species composition.

Dominant soil types generally follow habitat types. Half of the transects (23 of 46) consist of Ochopee fine sandy loam and Ochopee fine sandy loam, low. These conditions are prevalent in the wet prairies (G), graminoid-dominated hydric pinelands (Ph), and some of the more open cypress with graminoid (Cg) transects. Pinelands also consisted of Hallandale and Boca fine sands. Cypress areas included Boca, Riviera, limestone substratum, and Copeland fine sands, digressional. The wet prairie with this soil type is a narrow area around a cypress dome, thus the soil type is probably different, likely just reflecting the lack of precision in the soils mapping. To analyze effects of soils specifically it would be advisable to first have a soil scientist evaluate each transect in the field.

Historic aerial photograph interpretation was also utilized for indications of past site conditions. Interpretation of the 1940's aerial photography of the PSRP suggests that, in areas not directly cleared or disturbed since 1940, the woody vegetation has increased and has encroached on graminoid-dominated areas, or has reduced graminoid coverage within pineland and transitional cypress (Cg) habitats. This same trend of reduced openness in pinelands was also observed in aerial photography in Rookery Bay National Estuarine Research Reserve and in TTINWR (Mike Barry, personal observation).

While, in general, the 1940's aerial photography is a good indication of pre-drainage conditions, when examining these photos it is important to recognized that logging of slash pine may have occurred here in the 1920's and 1930's, as saw mills were operating during these years along S.R. 29 (Duever et al. 1986). This may contribute to the observed changes in canopy of the pinelands. Several disturbed areas and trails evident in the 1940's aerial photography may have been utilized for timber extraction. Also, geo-referencing of the 1940's aerials was less precise than the 2008 aerials, so transect placement over the photography is less accurate.

The Northern Series transects include PC01-PC10, which historically were predominantly open and assumed to be fire-maintained habitats, with the possible exception of PC02. It is also possible that the very open-canopy nature of this general area evident in the 1940's aerial may be, in part, artificial due to logging, as evidenced by the visible trail running through the middle of the most open area. PC02 consists of more visible canopy (less open) in the 1940 aerial and is currently considered to be cypress with hardwoods (Ch) because of abundant swamp bay (*Persea palustris*) and old growth cabbage palms. The canopy appears more closed in the current aerial photography. The Cobalt Fire (May 12, 2011) burned PC01 to PC05. Incidentally, PC02 had already changed dramatically after the "Pretty Island" Fire in June of 2004, which substantially opened the canopy by killing much of the swamp bay and promoting growth of sawgrass (*Cladium jamaicense*) underneath. Now, following the Cobalt Fire, the transect is even more open and is basically scattered mature cabbage palm with a graminoid understory on the east half, while shrubs still dominate the west half. Two additional transects in the area include one pineland (53) and one cypress (42) transect, which were closer to the actual Picayune Strand Swamp that extends from north to south along the western side of the Northern Transect area.

The Middle Series transects include PC11-PC20. Transects which were predominantly cypress-dominated communities are located to the west of the Prairie Canal (the main Picayune Strand jogs to the east just north of this location), as well as the eastern-most transect. Wet prairies occur just to the west of the former Prairie Canal in transect PC14 and to the east in transects PC16 and PC17. To the east, a slightly higher, fire-maintained area of pineland is present (PC18 and PC19), which grades back into another cypress dominated area (PC20). This area has since burned (2001) killing overstory cypress trees. One additional transect sampled (55) occurs about a mile to the north, on the Picayune Strand side of the former Prairie Canal. This area represents a stretch of former cypress with a graminoid understory (Cg) that has become colonized by slash pine and shrubs.

Another important change that is evident in the cypress with graminoid (Cg) transects (PC11 and PC13) in the Middle Series area is that they have become much more closed-canopy since the 1940's aerial photography. This suggests that shrubs, palms, and vines dominating these transects may have increased since that time. Also, young pines in eastern PC11 may be recent colonization, since it appears there was a prairie-like open area extending from the edge of that transect in the 1940's aerials.

The Southern Series transects (PC21-PC30) are open, fire-maintained wet prairie and pineland to the west of the former Prairie Canal. Areas around the canal (PC26) and to the east generally are cypress-dominated ecosystems. Changes since 1940 are less obvious in the aerial photography compared to conditions observed in the field. Most of the wet prairies have changed little in overall structure, although scattered dead trunks of small cypress trees indicate cypress was more abundant previously, but not dominant. The cypress areas appear to have a closed canopy in both the 1940 and 2009 aerial photography. However, based on the abundant, large, cypress stumps and logs found in these areas, overall canopy height is currently lower, likely due to cypress logging post-1940, drainage, and fire. PC28 is a good example of a logged, old-growth stand with large stumps.

PC27 was considered to be cabbage palm hammock (Hp) in both historic and current conditions because it occurs on an isolated slightly higher, rocky area. PC27 is currently dominated by old growth cabbage palms, a variety of shrubs typical of hammock areas, and the absence of dead cypress trunks or stumps. The transect also appears more open in 1940, suggesting that historically it was more of a woodland with scattered palms, which is typical along the edges of less disturbed areas of the Fakahatchee Strand. The designation of hammock (Hp) is the closest fit in the NRCS habitat classification system.

Large areas of this habitat type likely occurred along the edges of the actual Picayune Strand flow-way, which is evidenced by persisting old palms in the field and large areas mapped by NRCS in the 1940's vegetation map called "cabbage palm flatwoods". It is important to take notice of these historic palm hammock areas when considering control of cabbage palm as a nuisance species (in other habitats a substantial increase in palms has affected species composition and the ecology of the area negatively).

3.3 FIRE HISTORY

In the short term, fire may have a much more immediate and substantial effect on vegetation transect data than hydrological restoration. To address this, a geodatabase of wildfire and prescribed (Rx) burns was compiled using existing GIS data from PSSF, FSPSP, and FPNWR. These data, however, are still incomplete. The three fire-interval categories described in the Methods section were, at times, determined based on estimates of time of year or, in a few cases, fire category was determined in the field based on professional judgment, using signs of char and woody growth. Unfortunately, since the previous event in 2009, it has become more difficult to incorporate GIS data into our analysis of fire, with FPNWR being the only agency at this time to record and provide these data for our geodatabase.

Maps of fires occurring prior to the 2004 sampling and between sampling events in 2004, 2008 and 2009 were presented in the Year 2 monitoring report (Barry et al. 2009). Wildfires in PSSF affecting transects in the Northern Series transects (PC01-PC05) occurred under drought conditions (after periods of fire suppression in June of 2004, immediately following sampling). Photographs of the transects were taken immediately following this fire. The Middle Series transects (PC11-PC15) are long fire-suppressed, while the Southern Series transects (PC21-PC25, 57) in PSSF have been burned more than once in prescribed burns. Fakahatchee fires along Prairie Canal are the least mapped, therefore, the fire histories of some of the transects may be in error. These are largely wildfires prior to 2004 and more recently in June 2007 (PC08-PC10, PC18-PC20), with the exception of the wet prairie transects (PC06-PC07, PC16-PC17), which were prescribed burns in early 2007. Fakahatchee control transects in the isolated prairies and areas of Janes Scenic Drive (39, 64, and 67) have been burned during both Rx burns and wildfires, but the exact data have not yet been acquired. No fires along Prairie Canal occurred between sampling events in 2008 and 2009. Transect (64), along Janes Scenic Drive was burned again between the 2008 and 2009 sampling event, although the exact date is not known.

At least 3 fires have affected Prairie Canal vegetation transects since 2009. On the FPNWR, a controlled burn on July 9, 2010 affected transects 07PI11 and 07WP11, but did not penetrate the cypress in transect 32, all of which were sampled on May 26, 2011. In FSPSP, a prescribed burn conducted on March 9, 2011 (Mike Owen, personal communication) affected transects 39 and 67, which were sampled on June 1 and June 4, 2011, respectively. Finally, the Cobalt Fire consumed fuels in transects PC01-05, PC16-PC19, and 55 on May 12, 2011. As a result, these transects were not sampled.

Within the study area, one transect in 2004 and 8 transects in 2008 were sampled less than one year following fire (Category 1) in hydric flatwoods (Ph), mesic flatwoods (Pm) and prairie (G) habitats (see Table 5). Twenty-six transects in 2004 and 2005 and nineteen transects in 2008 were sampled from 1-7 years since fire (Category 2) in various habitats. Nineteen transects in 2004 and 2005 and sixteen transects in 2008 were sampled greater than 7 years since fire (Category 3). The majority of these transects were cypress or former cypress (C, Cg, Ch, Hh) habitats, which rarely burn. Additionally, these transects included some hydric and mesic flatwoods (Ph, Pm) and wet prairie (G) sites in PSSF, which are long fire-suppressed. Only one wet prairie site (G) and one cypress with graminoid understory (Cg) transect burned between the 2008 and 2009 sampling events, totaling 2 transects of less than 1 year since fire in 2009. A total of 28 transects were from 1-7 years since fire (Category 2) in 2009. A total of 16 transects were long fire-suppressed (Category 3) in 2009.

One difference to note in the data since the Year 2 Report regards transect 56. This area was considered hydric hammock (Hh) and historically was cypress (C). After reviewing the data, the area has been re-categorized to long fire-suppressed (Category 3) because a controlled burn on August 2, 2006 apparently did not penetrate the area.

A total of 4 Category 1 transects were sampled in 2011, all of which were control sites (see Table 5). A total of 15 Category 2 transects were sampled in 2011. A total of 17 Category 3 transects were sampled in 2011. A total of 10 transects, all in the restored areas of PSSF and FSPSP, burned in the Cobalt Fire in May 2011 and were not sampled during 2011.

3.4 EFFECTS OF WIND DAMAGE & HURRICANE WILMA ON BELT TRANSECTS

Several hurricanes hit the monitoring area between the 2004/2005 sampling events and the 2008/2009 sampling events, with Hurricane Wilma having the most impact. The 75-mile wide eye of Hurricane Wilma passed directly over the study area with 120 mph sustained winds on October 24, 2005. Other storms, such as hurricanes Charley, Frances, Jeanne, Katrina, and Rita may also have effected some of the transects to a lesser degree, since the initial sampling in the spring of 2004/2005.

Based on sampling results immediately after Wilma on FPNWR, the most substantial effect of the storm on pine flatwoods was an approximate 9% reduction in slash pine overstory density. Secondarily, there was an approximate 3.5% reduction in old (tall bootless) cabbage palms and a 14% reduction in the density of the fairly uncommon live oak, as discussed in more detail in the Year 1 monitoring report (Barry 2006). Effects on cypress habitats differed greatly, with no measurable effect on pop ash (*Fraxinus caroliniana*) or pond cypress in control sites and up to 50% mortality observed in restoration transects (Barry and Saha 2008). No major widespread windstorms hit the study area since the 2008 sampling event.

3.5 BELT TRANSECT EVALUATION

Data for each transect sampled in 2011 are presented in Appendix 2, and they include overstory basal area, overstory density, understory density and density of cabbage palm in all strata. Sampling data for prior years for these same transects was provided to SFWMD electronically.

3.5.1 *Overstory and Understory Density and Basal Area Excluding Cabbage Palm*

In general, the changes since sampling in 2009 have been subtle and similar to changes from 2004 and 2005 to 2009, as reported in the 2-year monitoring report (Barry et al. 2009). At this time, none of the changes suggest effects of restoration. Changes in the overstory are expected to be slower than other strata, unless mortality occurs for species more sensitive to inundation. Because we have had drought years since 2005, and because restoration is incomplete, the lack of observed changes is not unexpected.

For cypress habitats, overall density and basal area of cypress remained lower at restoration sites than at control sites, which, as discussed in previous reports, is indicative of higher mortality of cypress in drained sites over time. Pop ash overstory density continues to increase steadily at all sites where present, as observed in 2009 (Barry et al. 2009). This is also reflected in the data by decreases in density in the understory strata; however, in some transects the decrease in the density in the understory exceeds the increase, suggesting some mortality of stems as the larger stems achieve dominance. Other species such as swamp bay and laurel oak (*Quercus laurifolia*) remain in greater densities and basal area at the restoration sites, which is indicative of shorter hydroperiods, as suggested in the last report.

Cabbage palm hammock (Hp) was represented solely by transect PC27 in the restoration transects of Fakahatchee Strand, between two north to south flowing sloughs. In this transect, the relative composition of laurel oak, which has an affinity for wet conditions, and live oak (*Quercus virginiana*), which prefers drier conditions, is being monitored. At this time, laurel oak in the understory has increased more substantially than live oak since 2009; however, this may simply be indicative of the faster growth rates of young laurel oak. It is important to note that no live oak mortality (which could be caused by wetter conditions) has occurred.

Woody plant dominance remains low in wet prairie transects, as discussed in the 2-year monitoring report. No substantial changes were observed this event (Appendix 2).

Slash pine densities in all habitats remained nearly the same in the overstory with some reduction overall in the understory (Appendix 2). In general, mortality has been associated with either fire or Hurricane Wilma in the past, and not necessarily related to hydrological restoration (Barry et al. 2009). It is anticipated that some mortality will have occurred when transects that burned just prior to this sampling event (which were not sampled) are sampled after recovering from burning. Also, slash pine in some of the restoration cypress transects, such as PC11 and PC13, has not changed; although, with increasing hydroperiod one might expect some mortality.

3.5.2 *Analysis of Relative Growth Rates of Dominant Overstory Tree Species*

Diameter growth was determined as relative growth rate measured in centimeters at two points in time to assess differences between control and restoration transects. Comparisons of RGR in future events will focus on changes over time within management regimes to see if hydrological restoration is altering the growth rates; however, a longer time since restoration will be necessary to draw any conclusions. For this report, measurements were analyzed between 2004 or 2005 (t1) and 2011(t2). Relative growth rate normalizes for the initial differences in size across individuals and also for the elapsed time over which the growth is assessed, so that growth rates can be compared (see Analysis section 2.2).

Since all species do not occur at all sites, for growth rates, we compared a) slash pine growth across management regimes for pineland habitats, b) cypress growth across management regimes for cypress-dominated habitats, and c) pop ash growth across management regimes for cypress habitats.

The trends of faster growth of slash pine and slower growth of cypress at restoration sites discussed in the 2-year monitoring report (Barry et al. 2009) were also observed this sampling event; however, the differences are more obvious with the "less drained" transects removed from analysis, especially PC28, which is somewhat anomalous.

With 2011 data analyzed, slash pine growth was significantly higher ($p = .01$) in the restoration pineland transects (0.022 ±0.003) than the control transects (0.008 ±0.0063) (Tables 6 and 7, Figure 16). Slash pine growth is known to be slower in more hydric conditions, suggesting the hydroperiods in the pinelands of the restoration transects remain too short to affect growth.

Cypress and pop ash growth rates were both found to be higher in control transects (0.007 ±0.001, 0.012 ±0.002) compared to restoration transects (0.000 ±0.001, 0.005 ±0.005) (Tables 8-10, Figure 16); however, the growth rates were significant in control transects for cypress only ($p < 0.01$). Both species appear to continue to grow slowly at the restoration transects, which is more typical of a drained condition rather than restored condition. The "less drained" transect PC28 is included for reference and has one of the highest growth rates of all transects (0.025 ±0.002, 0.032 ±0.007, for cypress and pop ash, respectively).

3.5.3 *Cabbage Palm Densities*

Thus far, restoration does not appear to have had an effect on cabbage palm density, with the exception of causing some mortality in lower strata in a few cypress transects close to the Prairie Canal footprint. The overall trend at both control and restoration transects over time, since sampling began in 2004, has been a slow and steady increase in cabbage palm density, although the densities and rate of change varies considerably by habitat and management regime (Tables 11-22, Figures 17-19, Appendix 2).

Restoration transects in both cypress and pineland habitats had significantly higher ($p < 0.05$ for cypress and $p < 0.01$ for pine) densities of established (upper strata) palms (147.654 ±48.309, 203.88 ±54.30) than control (26.969 ±19.087, 80.33 ±23.51) transects (Tables 11, 12, 15, and 16, Figures 17 and 18). Densities were higher in restoration wet prairie transects (though not significant (p = 0.89)), as overall densities remain low in this habitat type in general (Table 20, Figure 19). Control sites had the highest densities and rates of increase in the pineland habitats with low densities in other habitats, while restoration sites had highest densities in both pinelands and cypress habitats, as reported in the past (Barry 2006, Barry and Woodmansee 2006). This is likely related to hydroperiod, since the restoration cypress sites have had over 30 years of hydroperiods that resemble control pineland hydroperiods.

The upper strata (strata 1 and 2 combined or all individuals with meristems >4.5′) for both control and restoration transects shows an increase trend over time, as shown in Tables 11, 15, and 19, with the exception of the pineland control transects; although the difference between sampling years is not significant (p = 0.98, p = 0.66, p = 1.0 for cypress, pineland, and wet prairie, respectively). Some strata 2 palms were observed to be depredated by Florida black bear at these 3 control transects.

Intermediate strata 3 palms, or those with meristems above ground up to 4.5′, seems to be variable, showing no patterns between control and restoration transects, except in cypress habitats where density is higher in restoration transects (127.427 ±42.446 vs. 43.150 ±28.103) (Table 13, Figures 17-19); although, the difference is not significant (p=.091). Predation by Florida black bear was most often observed in this strata (Barry et al. 2009). Also, cabbage palms grow more quickly in this strata, so palms move in and out of this strata frequently (Barry et al. 2009, McPherson and Williams 1996).

The lower strata, strata 4 plus 5, includes seedlings through pre-trunk palms, is the most variable in terms of density between habitats and over time (Tables 11, 15, 19, Figures 17-19, and Appendix 2). The lower strata are arguably the most important for understanding the effects of restoration and the future of dominance by cabbage palm, especially in light of this variability. The variability from year to year is highest in cypress habitats, suggesting that fluctuating water levels and varying hydroperiods from year to year may cause some mortality. Unlike established cabbage palms, the densities of lower strata palms are also high in cypress habitats at the control sites, and no significant difference (p = 0.051) was observed between management regimes (1654.531 ±110.616 restoration and 1666.667 ±140.634 control) (Table 14). Weather and restoration effects on hydroperiod may be playing a role in the fluctuation in lower strata densities in cypress communities. For example, PC25, which is located adjacent to the Prairie Canal footprint on the southern end, showed a dramatic decrease from the 2004 baseline to 2008 (Barry and Saha 2008), which was encouraging for effects of restoration; however, recent sampling following several drought years indicates numbers in the lower strata have increased again (Appendix 2).

The density of cabbage palm in the lower strata of pineland habitats remains high in both control (1957.67 ±76.74) and restoration sites (2087.38 ±343.90) (Table 15, Figure 18). Densities of cabbage palm at the restoration transects in pineland were not significantly different from the lower strata at the control transects (p = 0.69, Table 18). Observed densities over 1,000 individuals per acre could have a substantial effect on the ecology of the site over the long term, especially in light of the gradual increase over time observed at both control and restoration sites. The difference between years was not significant (p = 0.641), but it is important to note that a general increase was observed. These numbers may simply reflect drought effects; however, they are nevertheless discouraging for potential restoration effects on the establishment of cabbage palms, if control sites are also continuing to exhibit such increases.

The density of lower strata of cabbage palm in wet prairies is consistently the lowest of all habitat types with no significant difference between control and restoration transects (p = 0.14, Tables 19 and 22, Figure 19). Though the differences are not significant, it is important to note that density is a little higher at restoration sites (309.755 ±65.155) compared to control (64.725 ±24.903) and has been increasing slightly over time, independent of management regime. It is interesting that wet prairies, with a hydroperiod between cypress and pineland transects (both of which have higher densities of cabbage palm), seem to have a resistance to establishment of cabbage palm. Although the lack of perches for birds, which are a known dispersal agents, may definitely be influencing this phenomenon (Mike Duever, personal communication), the edaphic characteristics of the marl may play a more important role. Soils of adjacent transitional cypress communities have both a readily observable higher organic content and more sand (less marl) and have dramatically higher densities of cabbage palm (Barry, personal observation). More research is needed to better understand cabbage palm establishment in wet prairies.

3.6 LINE INTERCEPT DATA

Percent cover by species for each transect sampled in 2011 and sampling data for prior years for these same transects is provided in Appendix 3. These data also are being provided to SFWMD electronically. Measures of shrub cover are important for characterizing overall species composition and structure of transects, and it can have an important influence on groundcover species richness. Typically, with increased shrub cover, there is an increase in shade over the groundcover and a resulting reduction in species richness. However, differences in overall shrub cover, excluding cabbage palm and saw palmetto, seemed to relate more to fire than hydrological restoration, with the exception of a few cases to date (Barry 2006, Barry and Saha 2008, Barry et al. 2009). This report reviews some of the results of previous analyses and some of the general observations from data collected in 2011. All of the analyses conducted during this event are not discussed, as it is not directly relevant to determining the effects of hydrological restoration.

Total shrub cover was analyzed for effects of time since fire and management regime in the 2-year monitoring report (Barry et al. 2009). Although differences were not found to be significant, the data from pineland transects suggest that the influence of fire may relate to fire return interval over a longer term (not simply time since fire) and also may be related to controlled burning versus more severe wildfires. In short, the changes observed following fire in transects on the FPNWR, which have been burned using controlled burning regularly every 3-5 years for the past 20 years, showed much less influence from fire (pre-fire total shrub cover was achieved much more quickly) than restoration transects. In contrast, marked decreases, though not significant, in shrub cover were observed in burned restoration transects, which typically were fairly long fire-suppressed prior to being burned by wildfires. Conversely, shrub cover steadily increased with fire suppression at restoration sites.

Because of the wildfire on May 12, 2011, it will be possible to analyze the effects of fire again during the next sampling. A few other smaller fires may actually have burned additional restoration transects in July as drought continued well into the summer following sampling in 2011. Unfortunately, only one pineland transect sampled this event, transect 67, a control transect in FSPSP, burned since the last event and because it burned just a few months prior to sampling during severe drought, any analysis of fire effects would be premature.

Cover by Brazilian-pepper was highest at restoration transects in prior reports (Barry 2006, Barry et al. 2009), and this has not changed (Appendix 3). A significant effect of fire on differences in Brazilian-pepper cover over time was observed at restoration transects in the 2-year monitoring report (Barry et al. 2009). One control transect sampled during 2011, transect 67, was burned since the last sampling event and a reduction in Brazilian-pepper cover had occurred.

A freeze event also occurred in mid-December 2010 that top-killed Brazilian-pepper in areas of sparse canopy or open areas (personal observation). The data collected in 2011 reflects this effect, with all of the transects with previous cover of Brazilian-pepper >1% showing marked decreases, except transect PC28. This transect has a dense canopy of cypress, which, with moist conditions, prevented freezing conditions. The top-killed individuals were not killed and were re-sprouting at the time of sampling; therefore, the observed reduction is likely temporary.

Brazilian-pepper has been observed dying from flooding in and around transect PC26 (Barry and Saha 2008). In 2011, data for transect PC26 indicated that cover was further reduced to zero percent (Appendix 3). This transect is located adjacent to the Prairie Canal footprint and, therefore, was more severely drained. As a result, the effects on Brazilian-pepper are similar to the effects on lower strata of cabbage palm on PC25 on the other side of the footprint.

Cover of middle and lower strata cabbage palm (meristems <4.5′) varied between transects and over time, but not as a result of the management regime (i.e. hydrological restoration). Cover correlates significantly with time, which is consistent with belt transect density analysis (Barry et al. 2009). The exception is that cover by cabbage palms measured by the line intercept method in cypress transects was substantially lower at control sites. Variables such as changes in density within measured strata (i.e., as palms grow over 4.5′ they are no longer recorded in line-intercept data) were most important, although predation by Florida black bear and temporary post-fire decreases were also noted (Barry et al. 2009). In data collected in 2011 (Appendix 3), cover by cabbage palm changed little, except in the pineland control transect 67, which had burned only a few months prior to sampling, and in a few other transects (consistent with belt transect densities in strata 3). For example, cabbage palm coverage changed in PC15 (lower) and PC27 (higher), which have high densities of palms in multiple strata, thus likely reflecting growth and changes in height, rather than mortality or establishment. Potentially, long-term hydrological restoration will reduce palm cover in this strata at least in the cypress communities, thereby becoming more comparable to control sites.

3.7 QUADRAT DATA EVALUATION

All data collected using 0.5-meter quadrats is maintained in the PLANT_RAWDATA.mdb database, which has been provided to the SFWMD. The "QUAD_DA' table in this database now houses 57,098 records. The data table includes the data summarized and discussed below. The data table also includes many data fields not analyzed to date for the PSRP, such as phenology, and evidence of browsing by white-tailed deer, as well as data from PSSF and FPNWR dating from 1999. Summaries by species and transects, habitat, and time since fire are available in the QUAD_ANALYSIS.mdb file, which also has been provided to SFWMD.

3.7.1 *Plant Identification*

Plant species were identified to the lowest possible taxonomic level during all sampling events. Approximately 97-98% of the records were identified to species- or variety-level. When weighted by percent cover, identification to the species or variety level exceeded 99% (see Table 6). Identification problems primarily included immature members of Poaceae, Cyperaceae, and Asteraceae.

3.7.2 *Mean Percent Cover and Frequency of Each Species Observed by Transect*

Transect mean values of percent cover and percent frequency of species for transects sampled in 2011, including data collected for the same transects in prior years are being provided to SFWMD electronically with some summary tables added in the Appendices. In past reports, data were summarized by habitat and management regime and presented as tables. However, prior analysis of these data (Barry et al. 2009), no trends over time identified in these tables were found to be significant with regard to the effects of management regime or hydrological restoration. Therefore, the tables are not included in this report. Cluster analysis and ordination have proven more reliable in determining effects of hydrological restoration on species cover, as discussed below in Section 3.7.4.

Species richness in previous analyses showed variation first by habitat, with highest species richness in pineland, followed by wet prairie, and finally by cypress habitats (Barry et al. 2009). Species richness was higher in control pineland transects than restoration transects, though this was more likely an influence of frequency of burning and time since fire, rather than hydrology. The recently burned and more frequently burned transects had significantly higher species richness compared to long fire-suppressed pineland transects (Barry et al. 2009).

Species richness in cypress transects was found to be higher in restoration transects, which may indicate the effects of drainage because of the shortened hydroperiod, allowing more species to become established (Barry et al. 2009). The expected outcome of restoration is to see a decrease in species richness in cypress restoration transects with a lengthening of the hydroperiod. Mean species richness was higher in control wet prairie transects than in restoration transects, but the differences were not significant.

Changes in species richness over time were not significant through 2009 (Barry et al. 2009), nor through 2011 (cypress: $p = 0.62$, pineland: $p = 0.82$, and wet prairie: $p = 0.56$, Appendix 5 (a-d)). It is unclear if the slight increase in species richness in 2011 was due to sampling variation (different field botanists) or ecological variables (e.g., drought, fire frequency or hydrology).

3.7.3 *Effects of Management Regimes on Wetland Affinity Index*

Wetland indicator values (Reed 1988) were utilized to calculate Wetland Affinity Indices (WAI) to assist with evaluating the effects of hydrological conditions on plant communities across management regimes (see Data Analyses Section 2.2.2 above). Transect mean WAI values for transects sampled in 2011, including data for the same transects from previous sampling events are being provided to SFWMD electronically and are presented in Appendix 6.

WAI values have generally remained stable or decreased slightly at control transects, while values have increased at restoration transects (Tables 24-29, Figure 20, Appendix 6). WAI also showed variation between habitats with both pineland and cypress transects, showing higher variability and perhaps following weather more closely than wet prairies, which have changed less at control sites. Given that drought has affected all transects, it is especially encouraging that restoration transects have exhibited increases in WAI, suggesting hydrological restoration is having an effect on the vegetation.

WAI at cypress transects was significantly higher at control sites (0.742 ±0.029) than restoration sites (0.670 ±0.023) ($p = 0.01$, Tables 24 and 25). Although differences were not significant between sampling years ($p = 0.99$), mean WAI at control transects showed a trend of decreasing over time (0.793 ±0.031 in 2008, 0.758 ±0.033 in 2009, and 0.742 ±0.029 in 2011), perhaps reflecting drought conditions. It is notable that during those same drought years, mean WAI at restoration transects increased (0.624 ±0.022 in 2008, 0.662 ±0.020 in 2009, 0.670 ±0.023 in 2011).

The 2005 data were not included in the statistical analyses because sampling that year was conducted during high water when there were fewer herbaceous plants, thus WAI reflected more woody vegetation and non-wetland species on hummocks and cypress. This resulted in a lower WAI for 2005 during high water (Appendix 6). Data from individual transects (Appendix 6) shows variability among control transects and between years, although control WAI values generally ranged between 0.70-0.85. Four of five restoration transects that had WAI values within that range in 2004, remained above 0.70 in 2011. Moreover, all six restoration transects with WAI <0.70 in 2004 had higher values in 2011, and the lowest value among all restoration transects went up from 0.53 in 2004 to 0.62 in 2011.

Transect PC26 exhibited the most dramatic increase in WAI from 0.70 in

2004 to 0.80 in 2011, which is largely a result of the die-off of Brazilian-pepper (see section 3.6) and subsequent increase in cover by Carolina willow and wetland herbs likely taking advantage of the increased light conditions. This transect and PC25, which also increased (0.60 in 2004 to 0.62 in 2011), are located in the southern series adjacent to the Prairie Canal footprint, which (as mentioned in Sections 3.5.3 and 3.6) were likely more severely drained and exhibiting more pronounced effects of restoration on vegetation as a result.

In pineland transects, overall differences between control (0.536 ±0.071) and restoration (0.649 ±0.045) sites were not significant ($p = 0.95$). Although differences between sampling years were not significant ($p = 0.91$), mean WAI at control sites decreased over time (0.642 ±0.071 in 2008, 0.624 ±0.071 in 2009, and 0.536±0.071 in 2011). The mean WAI at restoration transects increased over time (0.553 ±0.045 in 2008, 0.610 ±0.045, and 0.649 ±0.045 in 2011) (Tables 26 and 27, Figure 20). This may reflect topographic variation in pineland habitats (slash pine has a wide tolerance of hydroperiod) whose data were pooled for this statistical analysis. Pineland restoration transects analyzed in this report were more hydric, since a number of mesic pineland transects burned and were not sampled in 2011. Thus, the 2011 data set is expected to skew pineland restoration mean WAI values higher than control mean WAI values. Also, one of the three control transects (67) had recently burned (approximately 5 months prior), so this may have affected the WAI. As for the changes over time, in general, the most probable explanation for the decrease in WAI at the control sites is the recent drought years, while increases at restoration transects was likely due to hydrological restoration.

Mean WAI in wet prairie transects was significantly higher at control transects (0.788 ±0.031) than restoration transects (0.667 ±0.020) ($p = 0.01$, Tables 28 and 29, Figure 20), most likely reflecting the longer hydroperiods at the control sites. Changes over time in WAI in the wet prairie transects were more subtle than in other habitats. The trend in the subsample suggests that mean WAI of the wet prairie transects has remained stable since 2008. When previous years (spring 2004, see Appendix 6) are included, the data show an increase at the restoration sites over time (Barry et al. 2009). Comparisons can be extended for control sites on the FPNWR to include sampling conducted in May 1998, also a drought year. These data show similar values for transect 07WP11 (0.71 May 1998, 0.72 June 2011) and a decrease over time for transect 32WP33 (0.80 May 1998, 0.73 June 2011). Since 2004, seven of eight restoration transects increased in WAI values, and the lowest value among all restoration transects went up from 0.53 in 2004 to 0.63 in 2011.

The highest WAI values are at transect 39, a control transect in FSPSP. This transect is perhaps closer to a marsh than a wet prairie with gulf-dune paspalum completely dominating along with mostly obligate wetland plants (WAI=0.83 to 0.85 in all sampling events 2005-2011). PC06 is a restoration transect, which may have been similar to this control transect in pre-drainage conditions. PC06 is also completely dominated by gulf-dune paspalum and shows a much lower WAI (0.55 to 0.63 in 2011). PC06 is located adjacent to the canal, so was likely severely drained based on hydrological data (Mike Duever, personal communication). The increase in WAI at wet prairie restoration sites since 2004 is encouraging, since wet prairie habitats are inherently resistant to change.

3.7.4 *Classification and Ordination*

In the 2-year monitoring report (Barry et al. 2009), cluster analysis produced four major groups, but these did not correlate to habitat types (based on current condition for restoration sites rather than pre-drainage habitat type) or to management regimes (control vs. restoration). Owing to the lack of discernible patterns using all transects, analysis for the present habitat groups (based on pre-drainage habitat types) was conducted separately using a SIMPROF test with control, restoration, and the "less drained" transects identified (Figures 21-27). Fall 2005 (control) and late spring 2004 (restoration) sampling events were included for discussion purposes, despite the difference in seasonality that makes comparison between management regimes misleading.

Within cypress habitats, control and restoration transects generally grouped separately (at roughly a similarity of 30%) and secondarily by relative elevation or type of cypress habitat (e.g., deep strand swamp to transitional cypress) at similarity of 42% (lines presented on Figure 21). Hammock-like transitional transects (all with swamp dogwood (*Cornus foemina*) in the understory) grouped together (transects PC15, PC25, PC29, 42, and 56). Formerly longer hydroperiod (lower relative elevation) transects (PC11 and PC12) west of Prairie Canal (very drained) grouped together while the similar deeper strand transects east of the canal in the south (PC26 and some of the "less drained" transects PC20 and PC28) grouped together. The control transect 45 on FPNWR was an outlier as it represents the only intact, fire-maintained cypress with species-rich graminoid groundcover. PC13 also was somewhat an outlier grouped with restoration transects. PC13 probably was formerly cypress with graminoid habitat, but it is now a tangled vine thicket.

Interestingly, the 2005 sampling event for control strand swamp transect 32 sampled during high water fell out as an outlier, both from the same transect in other years and from all other transects. While transect 32 was the most extreme example, sampling during high water influenced other transects in 2005, as well, showing a greater dissimilarity during that sampling event. This further exemplifies the importance of season of sampling in order to standardize year-to-year comparisons of vegetation.

It appears the effects of restoration over time are minimal to date. With few exceptions, most transects show no trends over time. PC15 and PC25 showed greater distance between sampling events and clear direction towards control sites in MDS (Figure 22). PC26 also shows a directional shift towards control, with the 2004 event standing alone, then shifting after the Brazilian-pepper die-off observed since 2008 (Section 3.6). Not surprisingly, transects showing these trends are located adjacent to the Prairie Canal footprint that were most severely affected by the canal (Mike Duever, personal communication) and, therefore, were most affected by restoration. These transects were also some of the few transects showing the effects of restoration on woody vegetation and cabbage palm density (see Section 3.5.3 and Barry and Saha 2008). In a sense, these transects are the "canaries in the coal mine" with respect to observable restoration effects.

Pineland transects did not cluster according to management regime (control vs. restoration). However, there appears to be a strong influence of time since fire on cluster analysis, followed secondarily by relative elevation or type of pineland (e.g., hydric vs. mesic, correlating with percent cover of saw palmetto) (Figures 23 and 24). One exception is PC23, which fell out as an outlier, perhaps because of its transitional nature to the adjacent cypress habitats and its high density of cabbage palms in all strata. It is not surprising that fire seems to have a strong effect on clustering, since we have demonstrated in past reports the importance of time since fire on species richness, with fire-maintained transects showing significantly higher diversity (Barry et al. 2009).

Fire suppressed transects (>7 years since fire) fell out as a distinct group (similarity of 40%). This group also included transect 53 (restoration) and 67 (control). Fire seems important even within the group for transect 67, with the 2011 event (only a few months post-fire) falling out at a similarity of roughly 50%, while all prior sampling events showed about 70% similarity. Two of the three other transects in which a sampling event occurred <1 year since fire exhibited similar groupings (i.e., the recently burned sampling event is less similar).

The effect of year (sampling event) did not show specific trends, suggesting no effect of restoration in pineland transects MDS (Figure 25). As noted above, time since fire has a stronger influence. It is important to note, however, that the fire suppressed transects were the only transects to show a trend and were clearly moving away from the other transects. Thus, it is not surprising that transect 53, for which all sampling events are long fire-suppressed, has a directional trend away from control sites. Conversely, it was a bit surprising to see that the 2011 sampling event at recently-burned transect 67 also trended away from the other pineland control transects. This may be because the groundcover had not yet recovered from the fire. It will be interesting to see if the next sampling event for transect 67 exhibits a trend back towards the fire maintained pinelands.

Cluster analysis of the wet prairie group of transects showed fairly well defined clustering by management regime, with control and restoration transects separating into 2 distinct groupings at about 55% similarity based on the SIMPROF test (Figure 26). Exceptions include three transects, PC30, 39, and PC14, which separated from the rest of the transects regardless of management regime. This is thought most likely due to the lower relative elevations of these locations, although edaphic characteristics cannot be ruled out. PC30 was a definite outlier, which is not surprising as this "less-drained" transect is located in the transition from cypress habitats to open wet prairie and is now dominated by cabbage palms. As a result, PC30 does not conform to either cypress or wet prairie habitats specifically. Transect 39, a control transect in FSPSP off Janes Scenic drive, also is somewhat separated, as it is perhaps closer to a marsh then a wet prairie (see WAI discussion, Section 3.7.3). Finally, PC14 also represents a transition to an adjacent cypress community and includes a few small cypress at the west end of the transect, as it approaches the strand swamp. This transect also has very high and unique diversity of groundcover, perhaps in part due to soil characteristics, as it has a sand and marl mix.

To date, cluster analysis of most wet prairie transects has not shown trends over time, with an encouraging exception (Figure 27). Data for PCO6, which lies adjacent to the Prairie Canal footprint, show an obvious directional trend over time towards the control transect 39, which it closely resembles in terms of relatively low elevation and dominance by gulf-dune paspalum.

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Tables

Table 1: Summary of Sampling Events Included in Database.

Location	Funding Source	Principal Investigator	Management Regime	Sampling Event No.	Start Date	End Date	No. of Transects
Florida Panther National Wildlife Refuge (FPNWR)	USFWS	Dr. M. Main	Control	0	12/20/1997	1/5/1998	4
	USFWS	Dr. M. Main	Control	1	5/20/1998	6/2/1998	4
	SFWMD PC P502173	M. Barry & S. Woodmansee	Control	4	10/19/2005	12/5/2005	6
	SFWMD 4500026581	M. Barry	Control	5	6/7/2008	6/7/2008	3
	SFWMD 4500026581	M. Barry	Control	6	5/29/2009	6/11/2009	6
	SFWMD 4600001953	M. Barry & M. Bonness	Control	7	5/26/2011	6/1/2011	6
	USFWS	Dr. M. Main	N/A	0	4/29/1996	1/7/1998	212
	USFWS	Dr. M. Main	N/A	1	8/12/1996	6/2/1998	201
	USFWS	Dr. M. Main	N/A	2	11/14/1996	12/10/1997	153
	USFWS	Dr. M. Main	N/A	3	4/23/1997	9/20/1998	135
	Everglades Reprogram	M. Barry	N/A	4	5/13/2005	9/20/2006	72
Fakahatchee Strand Preserve State Park	SFWMD PC P502173	M. Barry & S. Woodmansee	Control	4	9/30/2005	11/10/2005	5
	SFWMD 4500026581	M. Barry	Control	5	6/5/2008	7/8/2008	5
	SFWMD 4500026581	M. Barry	Control	6	6/18/2009	6/25/2009	5
	SFWMD 4600001953	M. Barry & M. Bonness	Control	7	6/1/2011	6/4/2011	5
	Interagency	M. Barry	Restored	0	3/11/2004	5/3/2004	15
	SFWMD 4500026581	M. Barry	Restored	5	5/8/2008	6/4/2008	15
	SFWMD 4500026581	M. Barry	Restored	6	5/21/2009	6/22/2009	15
	SFWMD	M. Barry & M. Bonness	Restored	7	5/17/2011	6/21/2011	11
Picayune Strand State Forest	Interagency	M. Barry	Restored	0	12/9/2003	5/11/2004	23
	SFWMD PC P502173	M. Barry & S. Woodmansee	Restored	4	9/6/2005	10/6/2005	46
	SFWMD 4500026581	M. Barry	Restored	5	5/20/2008	7/9/2008	20
	SFWMD 4500026581	M. Barry	Restored	6	5/19/2009	6/16/2009	20
	SFWMD 4600001953	M. Barry & M. Bonness	Restored	7	5/16/2011	7/9/2011	14

Location	Funding Source	Principal Investigator	Management Regime	Sampling Event No.	Start Date	End Date	No. of Transects
Ten Thousand Islands National Wildlife Refuge	SFWMD PC P502173	M. Barry & S. Woodmansee	Restored	4	8/10/2005	10/14/2005	4
Rookery Bay National Estuarine Research Reserve	N/A	M. Barry	N/A	0	10/21/2010	10/21/2010	1
309 permanently marked transects						Sample Total:	1,006

Table 2: Summary of Transects and Sampling Events Analyzed in this Report.

Location	Management Regime	Sampling Event No.	Start Date	End Date	Transect ID	No. of Transects
FPNWR	Control	4	10/19/2005	12/5/2005	07WP11, 07PI11, 32, 32PI33, 32WP33, 45	6
FPNWR	Control	5	6/7/2008	6/7/2008	07WP11, 07PI11, 32 (32PI33, 32WP33, 45 not sampled due to Rx burn)	3
FPNWR	Control	6	5/29/2009	6/11/2009	07WP11, 07PI11, 32, 32PI33, 32WP33, 45	6
FPNWR	Control	7	5/26/2011	6/1/2011	same as above)	6
FSPSP	Control	4	9/30/2005	11/9/2005	37, 39, 51, 64, 67	5
FSPSP	Control	5	6/5/2008	7/8/2008	(same as above)	5
FSPSP	Control	6	6/18/2009	6/25/2009	(same as above)	5
FSPSP	Control	7	6/1/2011	6/4/2011	(same as above)	5
FSPSP	Restored	0	3/11/2004	5/3/2004	PC06, PC07, PC08, PC09, PC10, PC20, PC26, PC27, PC28, PC29, PC30; (PC16, PC17, PC18, PC19 excluded from analysis due to wildfire 5/12/2011)	11
FSPSP	Restored	5	5/8/2008	6/4/2008	(same as above)	11
FSPSP	Restored	6	5/21/2009	6/22/2009	(same as above)	11
FSPSP	Restored	7	5/17/2011	6/21/2011	(same as above)	11
PSSF	Restored	0	12/9/2003	5/11/2004	PC11, PC12, PC13, PC14, PC15, PC21, PC22, PC23, PC24, PC25, 42, 53, 56, 57 (PC01, PC02, PC03, PC04, PC05, 55 excluded from analysis due to wildfire 5/12/2011)	14
PSSF	Restored	5	5/20/2008	7/9/2008	(same as above)	14
PSSF	Restored	6	5/19/2009	6/16/2009	(same as above)	14
PSSF	Restored	7	5/16/2011	7/9/2011	(same as above)	14

Table 3: Transects by Existing Habitat Type and Management Regime.

Management Regime	Habitat Name	Habitat	Total No. of Transects	No. Sampled in 2011
Control	Cypress	C	3	3
Control	Cypress with graminoid understory	Cg	1	1
Control	Pine flatwoods/hydric	Ph	3	3
Control	Wet Prairie	G	4	4
Restored	Cypress	C	5	5
Restored	Cypress with graminoid understory*	Cg	5 (7)	5 (5)
Restored	Cypress with hardwoods	Ch	2	1
Restored	Hammock/cabbage palm	Hp	1	1
Restored	Hammock/hydric (historically C)	Hh (C)	1 (0)	1
Restored	Pine flatwoods/hydric (2 were historically Cg)	Ph	10 (8)	5 (5)
Restored	Pine flatwoods/mesic	Pm	2	0
Restored	Wet Prairie	G	9	7
Totals			46	36

* 2 Cg historically colonized by slash pine.

Table 4: Transect Descriptions.

Transect	Management Regime	Location	Habitat Group	Pre-Drainage NRCS Habitat	Baseline NRCS Habitat	Soil No.	Soil Type Name
07PI11	Control	FPNWR	Pineland	Ph	Ph	11	Hallandale Fine Sand
07WP11	Control	FPNWR	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
32	Control	FPNWR	Cypress	C	C	51	Ochopee Fine Sandy Loam
32PI33	Control	FPNWR	Pineland	Ph	Ph	49	Hallandale and Boca Fine Sands
32WP33	Control	FPNWR	Wet Prairie	G	G	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional
37	Control	FSPSP	Cypress	C	C	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional
39	Control	FSPSP	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
42	Restored	PSSF	Cypress	C	C	11	Hallandale Fine Sand
45	Control	FPNWR	Cypress	Cg	Cg	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional
51	Control	FSPSP	Cypress	C	C	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional
53	Restored	PSSF	Pineland	Pm	Pm	11	Hallandale Fine Sand
55	Restored	PSSF	Cypress	Cg	Ph	50	Ochopee Fine Sandy Loam, Low
56	Restored	PSSF	Cypress	C	Hh	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional
57	Restored	PSSF	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
64	Control	FSPSP	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
67	Control	FSPSP	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam, Low
PC01	Restored	PSSF	Pineland	Pm	Pm	11	Hallandale Fine Sand
PC02	Restored	PSSF	Cypress	Ch	Ch	11	Hallandale Fine Sand
PC03	Restored	PSSF	Pineland	Ph	Ph	11	Hallandale Fine Sand
PC04	Restored	PSSF	Cypress	Cg	Ph	51	Ochopee Fine Sandy Loam
PC05	Restored	PSSF	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam
PC06	Restored	FSPSP	Wet Prairie	G	G	51	Ochopee Fine Sandy Loam
PC07	Restored	FSPSP	Wet Prairie	G	G	51	Ochopee Fine Sandy Loam
PC08	Restored	FSPSP	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam
PC09	Restored	FSPSP	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam
PC10	Restored	FSPSP	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam
PC11	Restored	PSSF	Cypress	Cg	Cg	49	Hallandale and Boca Fine Sands
PC12	Restored	PSSF	Cypress	C	C	49	Hallandale and Boca Fine Sands
PC13	Restored	PSSF	Cypress	Cg	Cg	49	Hallandale and Boca Fine Sands
PC14	Restored	PSSF	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
PC15	Restored	PSSF	Cypress	C	Ch	11	Hallandale Fine Sand
PC16	Restored	FSPSP	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
PC17	Restored	FSPSP	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
PC18	Restored	FSPSP	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam, Low
PC19	Restored	FSPSP	Pineland	Ph	Ph	51	Ochopee Fine Sandy Loam, Low
PC20	Restored	FSPSP	Cypress	C	C	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional

Transect	Management Regime	Location	Habitat Group	Pre-Drainage NRCS Habitat	Baseline NRCS Habitat	Soil No.	Soil Type Name
PC21	Restored	PSSF	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
PC22	Restored	PSSF	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
PC23	Restored	PSSF	Pineland	Ph	Ph	49	Hallandale and Boca Fine Sands
PC24	Restored	PSSF	Wet Prairie	G	G	50	Ochopee Fine Sandy Loam, Low
PC25	Restored	PSSF	Cypress	Cg	Cg	49	Hallandale and Boca Fine Sands
PC26	Restored	FSPSP	Cypress	C	C	49	Hallandale and Boca Fine Sands
PC27	Restored	FSPSP	Hammock	Hp	Hp	49	Hallandale and Boca Fine Sands
PC28	Restored	FSPSP	Cypress	C	C	51	Ochopee Fine Sandy Loam
PC29	Restored	FSPSP	Cypress	Cg	Cg	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional
PC30	Restored	FSPSP	Cypress	Cg	Cg	25	Boca, Riviera, Limestone substratum, Copeland Fine Sands, Depressional

Table 5: Transects by Habitat and Time Since Fire.

Management Regime	Habitat	Transect	Time Since Fire Category					Burned Since Last Event		
			2004 (Spring)	2005 (Fall)	2008 (Spring)	2009 (Spring)	2011 (Spring)	2008	2009	2011
Control	C	32		3	3	3	3	Yes		
Control	C	37		3	3	3	3			
Control	C	51		3	3	3	3			
Control	Cg	45		2		1	2		Yes	
Control	G	07WP11		2	2	2	1	Yes		Yes
Control	G	32WP33		2		2	2		Yes	
Control	G	39		2	2	2	1			Yes
Control	G	64		3	2	1	2	Yes	Yes	
Control	Ph	07PI11		2	2	2	1	Yes		Yes
Control	Ph	32PI33		2		2	2		Yes	
Control	Ph	67		3	3	3	1			Yes
Restored	C	42	3	3*	3	3	3			
Restored	C	PC12	3		3	3	3			
Restored	C	PC20	2		3	3	3			
Restored	C	PC26	3		3	3	3			
Restored	C	PC28	3		3	3	3			
Restored	Cg	PC11	3		3	3	3			
Restored	Cg	PC13	3		3	3	3			
Restored	Cg	PC25	2		2	2	2	Yes		
Restored	Cg	PC29	2		2	2	3			
Restored	Cg	PC30	2		2	2	3			
Restored	Ch	PC02	3		2	2	N/A	Yes		Yes
Restored	Ch	PC15	3		3	3	3			
Restored	G	57	2	2*	2	2	2	Yes		
Restored	G	PC06	2		1	2	2	Yes		
Restored	G	PC07	2		1	2	2	Yes		
Restored	G	PC14	3		3	3	3			
Restored	G	PC16	3		2	2	N/A	Yes		Yes
Restored	G	PC17	2		1	2	N/A	Yes		Yes
Restored	G	PC21	2		2	2	2	Yes		
Restored	G	PC22	2		2	2	2	Yes		

Management Regime	Habitat	Transect	Time Since Fire Category					Burned Since Last Event		
			2004 (Spring)	2005 (Fall)	2008 (Spring)	2009 (Spring)	2011 (Spring)	2008	2009	2011
Restored	G	PC24	2		2	2	2	Yes		
Restored	Hh	56	3	3*	3	3	3			
Restored	Hp	PC27	3		3	3	3			
Restored	Ph	55	1	2*	2	2	N/A			Yes
Restored	Ph	PC03	2		2	2	N/A	Yes		Yes
Restored	Ph	PC04	2		2	2	N/A	Yes		Yes
Restored	Ph	PC05	2		2	2	N/A	Yes		Yes
Restored	Ph	PC08	2		1	2	2	Yes		
Restored	Ph	PC09	2		1	2	2	Yes		
Restored	Ph	PC10	2		1	2	2	Yes		
Restored	Ph	PC18	2		1	2	N/A	Yes		Yes
Restored	Ph	PC19	2		1	2	N/A	Yes		Yes
Restored	Ph	PC23	2		2	2	2	Yes		
Restored	Pm	53	3	3*	3	3	3			
Restored	Pm	PC01	3		2	2	N/A	Yes		Yes

** These data were not included in analysis*

Table 6: Comparison of Relative Growth Rate of Slash Pine between Control and Restoration Pineland Transects. Relative growth rate was significantly higher in restoration than control sites.

Dependent Variable: Relative

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	.002	1	.002	13.587	.001
Intercept	.008	1	.008	66.915	.000
Management	.002	1	.002	13.587	.001
Error	.004	34	.000		
Total	.014	36			
Corrected Total	.006	35			

Table 7: Mean Relative Growth Rate of Slash Pine in Pineland Transects

Dependent Variable: Relative

Management Regime	Mean	Standard Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Restoration	.022	.003	.016	.027
Control	.008	.003	.003	.013

Table 8: Mean Relative Growth of Cypress in Cypress Transects. Transect PC28 was not included in the analysis; however, the means are shown here to clarify that despite being considered a restoration transect, PC28 was less drained and resembled a control transect.

Dependent Variable: Relative

Management Regime	Mean	Standard Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Restoration	.000	.001	-.002	.002
Control		.001	.005	.009
PC28*		.002	.021	.029

Table 9: Comparison of Relative Growth Rate of Pop Ash between Control and Restoration Cypress Transects. Differences between Control and Restoration were not significant. Restoration Cypress transects showed a lower growth rate compared to control sites.

Dependent Variable: RELATIVE

Comment [MJB5]: Sonali needs to double check.

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	.000	1	.000	1.173	.291
Intercept	.001	1	.001	8.683	.007
Management	.000	1	.000	1.173	.291
Error	.002	22	.000		
Total	.005	24			
Corrected Total	.002	23			

Table 10: Mean Relative Growth Rate of Pop-Ash in Cypress Transects. The transect PC28 was not included in the analysis but is included in this table to demonstrate that it is a significantly wetter site compared to control and restoration cypress habitats.

Dependent Variable: Relative Growth Rate

Management Regime	Mean	Standard Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	.012	.002	.008	.016
Restoration	.005	.005	-.006	.017
PC28	.032	.007	.018	.046

Table 11: Mean Density of Cabbage Palm Individuals in Upper, Lower and Intermediate (Strata 3) Strata in Cypress transects.

Year	Strata	Control		Restoration	
		Mean	Standard Error of the Mean	Mean	Standard Error of the Mean
2008	Upper	21.58	14.27	133.50	42.10
	Strata3	26.97	12.35	107.20	32.14
	Lower	3009.71	175.53	1288.43	92.53
2009	Upper	21.58	14.27	143.61	46.43
	Strata3	26.97	16.81	107.20	38.07
	Lower	1871.63	153.43	819.18	78.53
2011	Upper	26.97	19.09	147.65	48.31
	Strata3	43.15	28.10	127.43	42.45
	Lower	1666.67	140.63	1654.53	110.62

Table 12: Comparison of Density of Cabbage Palm in Upper Strata in Cypress Transects. Density is significantly higher in the restoration transects.

Dependent Variable: Upper Strata Cypress Habitat

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	92377.18	5	18475.435	1.387	.260
Intercept	178110.69	1	178110.69	13.375	.001
Mgmt. Regime	91468.04	1	91468.04	6.868	.014
Year	417.21	2	208.61	.016	.984
Mgmt. Regime * Year	131.58	2	65.789	.005	.995
Error	359561.07	27	13317.08		
Total	846503.49	33			
Corrected Total	451938.24	32			

Table 13: Density of Cabbage Palm in Strata 3 in Cypress Transects. No significant difference in the number of Strata 3 palms was found between restoration and control sites.

Dependent Variable: Strata 3 Cypress habitat

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	46267.931	5	9253.586	.653	.663
Intercept	140107.004	1	140107.004	9.864	.004
Mgmt. Regime	43562.332	1	43562.332	3.067	.091
Year	1928.037	2	964.019	.068	.935
Mgmt. Regime * Year	23.803	2	11.901	.001	.999
Error	383485.981	27	14203.184		
Total	707208.764	33			
Corrected Total	429753.913	32			

Table 14: Comparison of Cabbage Palm Density in Lower Strata in Cypress Transects. No significant difference was found in density of cabbage palm in lower strata between years or management regime.

Dependent Variable: Lower strata Cypress habitat

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	11590872.991	5	2318174.598	1.719	.164
Intercept	77308357.612	1	77308357.612	57.315	.000
Mgmt. Regime	5644409.236	1	5644409.236	4.185	.051
Year	2862064.604	2	1431032.302	1.061	.360
Mgmt. Regime * Year	3236913.099	2	1618456.549	1.200	.317
Error	36418742.126	27	1348842.301		
Total	122984677.588	33			
Corrected Total	48009615.117	32			

Table 15: Mean Density of Cabbage Palm by Strata in Pineland Transects.

Year	Strata	Control		Restoration	
		Mean	Standard Error of the Mean	Mean	Standard Error of the Mean
2008	Upper	89.33	30.03	135.92	24.33
	Strata3	323.75	121.57	359.22	71.53
	Lower	1423.67	37.69	1715.21	341.31
2009	Upper	97.12	26.97	200.65	50.81
	Strata3	331.29	90.74	339.81	62.25
	Lower	1885.00	30.37	1686.08	323.44
2011	Upper	80.33	23.51	203.88	54.30
	Strata3	339.08	65.40	330.10	54.54
	Lower	1957.67	76.74	2087.38	343.90

Table 16: Comparison of Cabbage Palm Density in the Upper Strata between Control and Restoration Pineland Transects. Restoration sites had significantly greater density of established cabbage palm individuals. Year and the interaction of year and density were not significant.

Dependent Variable: Upper strata Pineland

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	92226.044	5	18445.209	2.450	.073
Intercept	332363.983	1	332363.983	44.144	.000
Mgmt. Regime	77295.791	1	77295.791	10.266	.005
Year	6486.166	2	3243.083	.431	.657
Mgmt. Regime * Year	4827.894	2	2413.947	.321	.730
Error	135524.353	18	7529.131		
Total	672908.794	24			
Corrected Total	227750.397	23			

Table 17: Comparison of Cabbage Palm Densities between Control and Restoration in Strata 3 Pineland Transects. Management effects were not significant for strata 3 *Sabal* densities

Dependent Variable: Strata 3 Pineland

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	55115.676	5	11023.135	.492	.778
Intercept	1989718.178	1	1989718.178	88.860	.000
Mgmt. Regime	46923.238	1	46923.238	2.096	.165
Year	1101.150	2	550.575	.025	.976
Mgmt. Regime * Year	8039.703	2	4019.852	.180	.837
Error	403047.055	18	22391.503		
Total	2746619.810	24			
Corrected Total	458162.731	23			

Table 18. Comparison of Cabbage Palm Density between Control and Restoration in Lower Strata in Pineland Transects. None of the effects (year, management regime, or their interaction) were significant

Dependent Variable: Lower strata density of Sabal in pineland – Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	859466.681	5	171893.336	.226	.946
Intercept	55087759.919	1	55087759.919	72.328	.000
Mgmt. Regime	586925.546	2	293462.773	.385	.687
Year	23401.564	1	23401.564	.031	.863
Mgmt. Regime * Year	178317.701	2	89158.850	.117	.890
Error	11424602.798	15	761640.187		
Total	80964013.782	21			
Corrected Total	12284069.478	20			

Table 19: Mean Density of Cabbage Palm per Size-class Category in Wet Prairie Transects

Year	Strata	Control		Restoration	
		Mean	Standard Error of Mean	Mean	Standard Error of Mean
2008	Upper	8.09	12.40	9.25	4.63
	Strata 3	0.00	.00	23.12	8.05
	Lower	48.54	14.377	131.76	34.96
2009	Upper	8.09	12.40	9.25	4.63
	Strata 3	.00	.00	20.80	7.677
	Lower	48.54	14.377	157.19	36.346
2011	Upper	8.09	12.40	9.25	4.63
	Strata 3	0.00	.00	39.297	10.16
	Lower	64.73	24.90	309.755	66.16

Table 20: Comparison of Cabbage Palm Density in the Upper Strata between Control and Restoration Wet Prairie Transects. No significant management regime and year affect on Upper strata Cabbage Palms in wet prairie

Dependent Variable: Upper strata

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	6.234	5	1.247	.004	1.000
Intercept	1402.672	1	1402.672	4.565	.045
Mgmt. Regime	6.234	1	6.234	.020	.888
Year	.000	2	.000	.000	1.000
Mgmt. Regime * Year	.000	2	.000	.000	1.000
Error	6452.293	21	307.252		
Total	8640.462	27			
Corrected Total	6458.528	26			

Table 21: Comparison of Cabbage Palm Density in Strata 3 between Control and Restoration Wet Prairie Transects. No significant management regime and year affect on strata 3 Cabbage Palms in wet prairie

Dependent Variable: Strata 3

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	5012.216	5	1002.443	.440	.816
Intercept	3590.842	1	3590.842	1.575	.223
Mgmt. Regime	3590.842	1	3590.842	1.575	.223
Year	315.861	2	157.931	.069	.933
Mgmt. Regime * Year	315.861	2	157.931	.069	.933
Error	47877.887	21	2279.899		
Total	65458.049	27			
Corrected Total	52890.104	26			

Table 22: Comparison of Cabbage Palm Density in Lower Strata between Control and Restoration Wet Prairie Transects. No significant management regime and year affect on Lower Strata Cabbage Palms.

Dependent Variable: Lower Strata

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	229065.768	5	45813.154	1.105	.387
Intercept	299904.538	1	299904.538	7.234	.014
Mgmt. Regime	98972.570	1	98972.570	2.387	.137
Year	34650.513	2	17325.256	.418	.664
Mgmt. Regime * Year	23556.586	2	11778.293	.284	.756
Error	870629.460	21	41458.546		
Total	1854557.451	27			
Corrected Total	1099695.227	26			

Table 23: Level of Plant Identification in Quadrat Sampling Data in 2011.

Level of Identification	Total Cover	Total No. of Records	% Total Cover	% Total Records
Above family	7	9	0.0%	0.4%
ID to family	16	22	0.1%	1.0%
ID to Genus	31.5	24	0.2%	1.1%
Total Partial ID	54.5	55	0.3%	2.4%
Full ID	18,298	2,230	99.7%	97.6%
Totals	18,407	2,340		

Table 24: Wetland Affinity Index for Control and Restoration Cypress Transects

Dependent Variable: WAI

Year	Management	Mean	Standard Error	95% Confidence Interval	
				Lower Bound	Upper Bound
2008	Control	.793	.031	.726	.860
	Restoration	.624	.022	.583	.665
2009	Control	.758	.033	.692	.825
	Restoration	.662	.020	.621	.703
2011	Control	.742	.029	.676	.809
	Restoration	.670	.023	.629	.710

Table 25: Comparison of Wetland Affinity Index between Control and Restoration, and Between Years, for Cypress Transects. WAI was significantly higher in control than the restoration Cypress sites.

Dependent Variable: WAI

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	.097	5	.019	6.121	.001
Intercept	13.129	1	13.129	4140.430	.000
Mgmt. Regime	.000	2	.000	.011	.989
Year	.083	1	.083	26.290	.000
Mgmt. Regime * Year	.011	2	.006	1.741	.194
Error	.086	27	.003		
Total	15.553	33			
Corrected Total	.183	32			

Table 26: Wetland Affinity Index for Control and Restoration Pineland Transects

Dependent Variable: WAI

Year	Management	Mean	Standard Error	95% Confidence Interval	
				Lower Bound	Upper Bound
2008	Control	.642	.071	.490	.794
	Restoration	.553	.045	.457	.649
2009	Control	.624	.071	.473	.776
	Restoration	.610	.045	.514	.706
2011	Control	.536	.071	.385	.688
	Restoration	.649	.045	.553	.745

Table 27: Comparison of Wetland Affinity Index between Control and Restoration, and between Years, for Pineland Transects. No significant effect of management regime was found

Dependent Variable: WAI

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	.036	5	.007	.708	.626
Intercept	6.224	1	6.224	613.419	.000
Mgmt. Regime	.000	1	.000	.004	.952
Year	.002	2	.001	.097	.908
Mgmt. Regime * Year	.030	2	.015	1.456	.264
Error	.152	15	.010		
Total	7.828	21			
Corrected Total	.188	20			

Table 28: Wetland Affinity Index for Control and Restoration Wet Prairie Transects

Dependent Variable: WAI

Year	Management	Mean	Standard Error	95% Confidence Interval	
				Lower Bound	Upper Bound
2008	Control	.778	.031	.714	.841
	Restoration	.658	.020	.617	.699
2009	Control	.783	.031	.720	.846
	Restoration	.650	.020	.608	.691
2011	Control	.788	.031	.725	.851
	Restoration	.667	.020	.625	.708

Table 29: Comparison of Wetland Affinity Index between Control and Restoration, and between Years, for Wet Prairie Transects. A significant effect of management regime was observed with greater WAI in control transects. There was an increase in WAI with time in restoration transects but the change was non-significant.

Dependent Variable: WAI

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Corrected Model	.099	5	.020	7.057	.000
Intercept	13.082	1	13.082	4652.806	.000
Mgmt. Regime	.098	1	.098	34.857	.000
Year	.001	2	.000	.111	.895
Mgmt. Regime * Year	.000	2	.000	.041	.960
Error	.067	24	.003		
Total	14.680	30			
Corrected Total	.167	29			

Figures

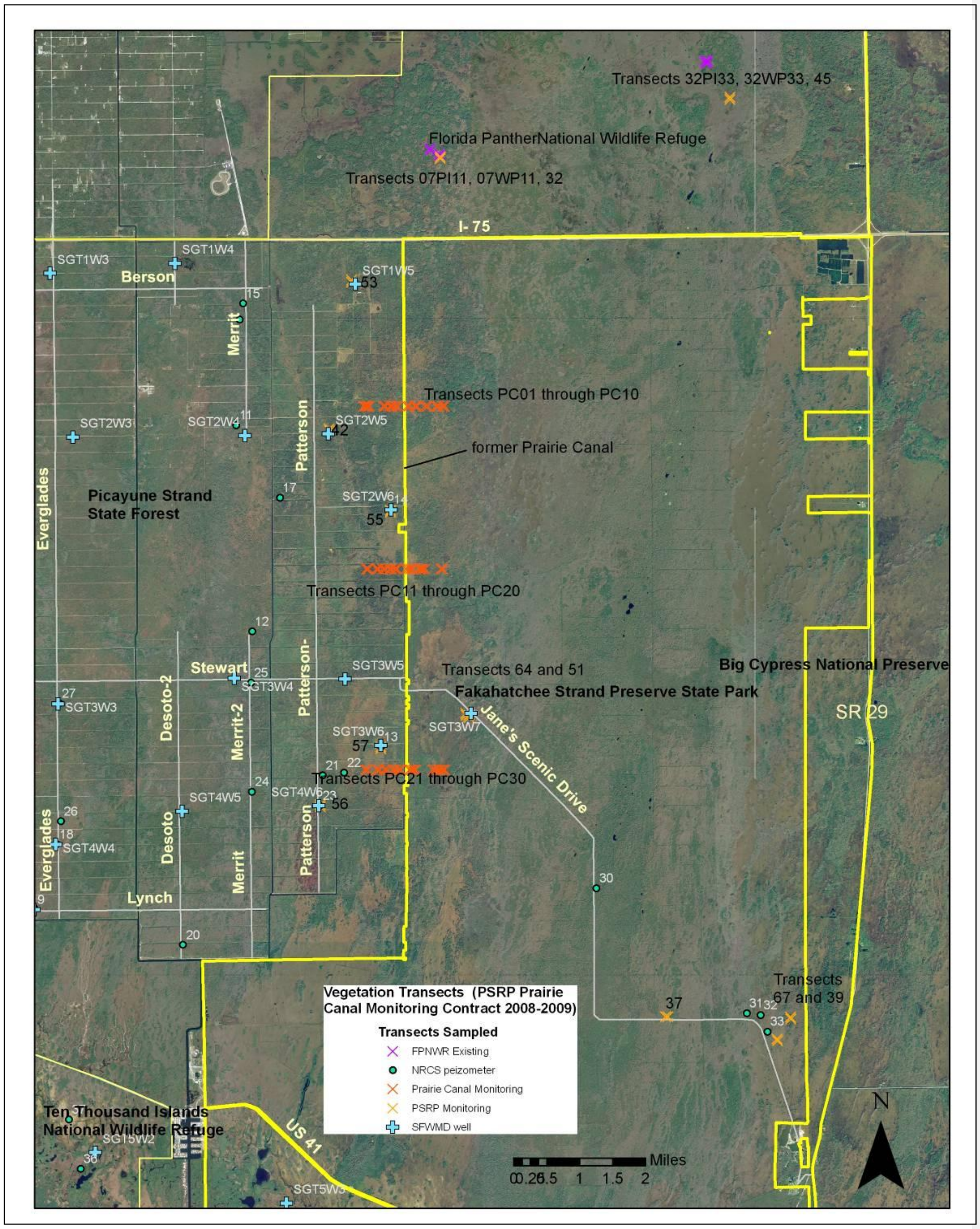

Figure 1. Picayune Strand State Forest Vegetation Monitoring Study Area

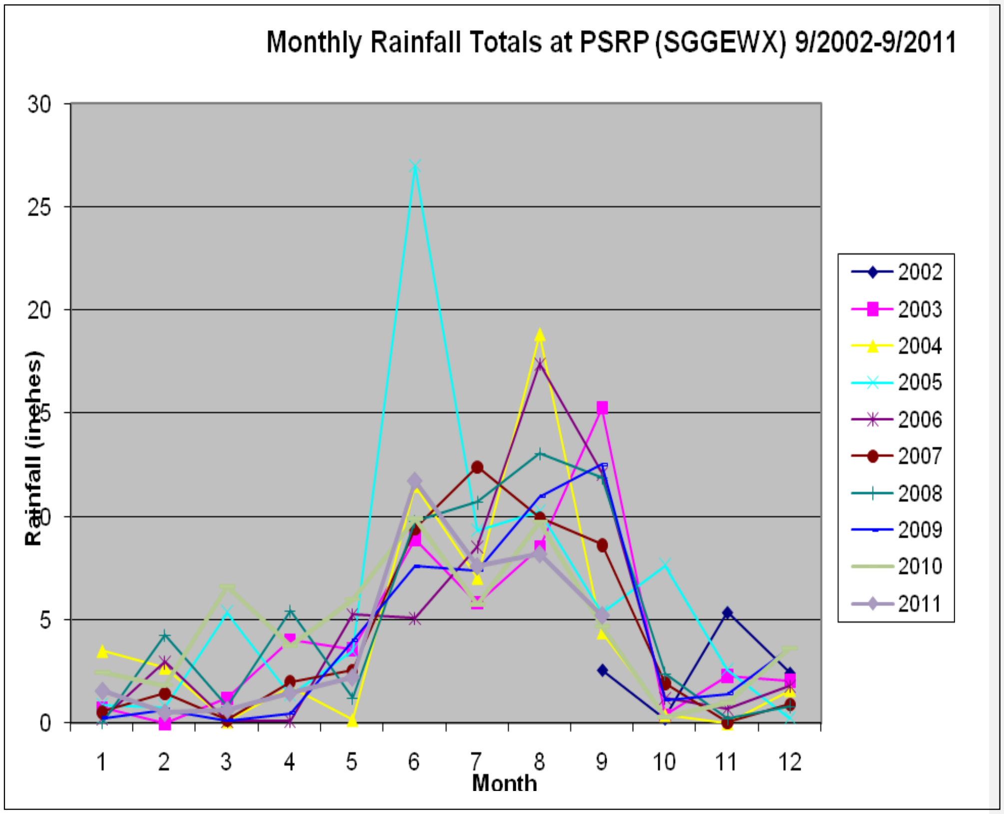

Figure 2. Monthly Rainfall Totals at PSRP (SGGEWX) 2002-2011

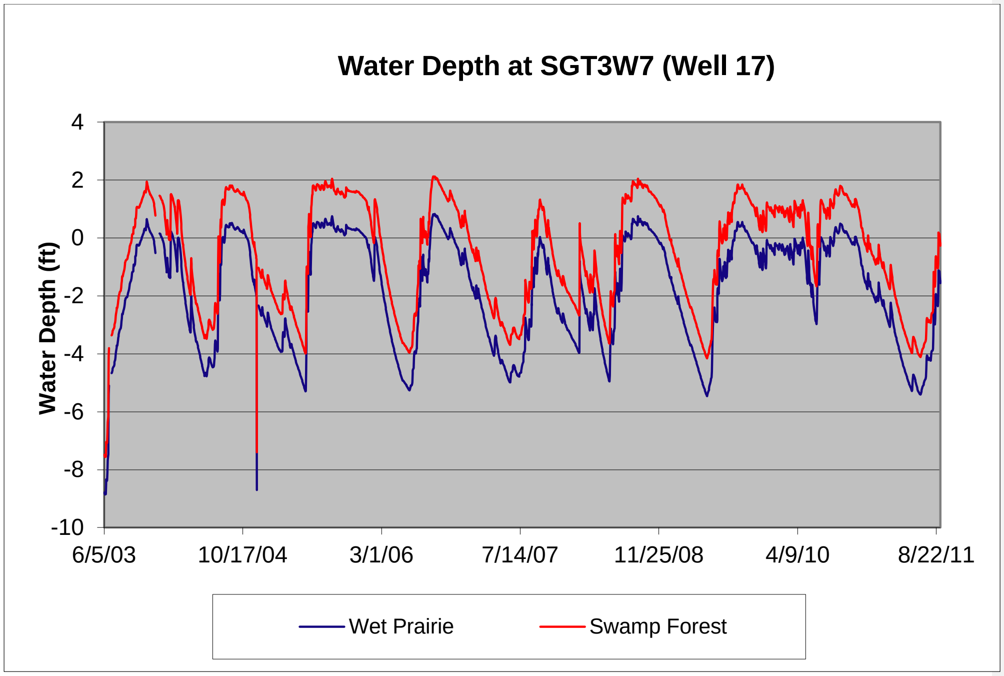

Figure 3. *Water Depth at SGT3W7 (Well 17)*

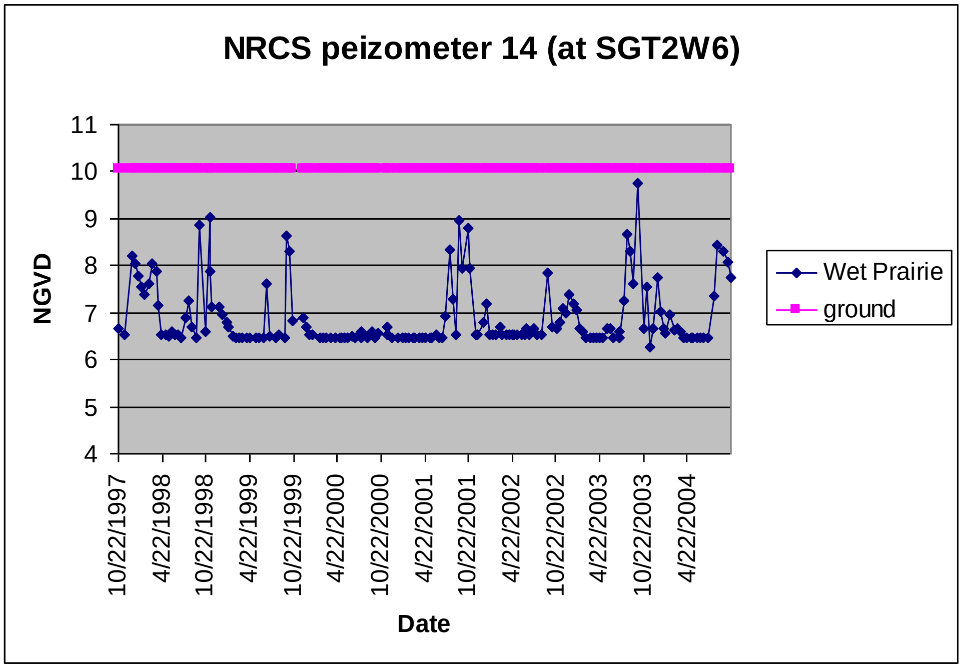

Figure 4. *NRCS Piezometer 14 (at SGT2W6)*

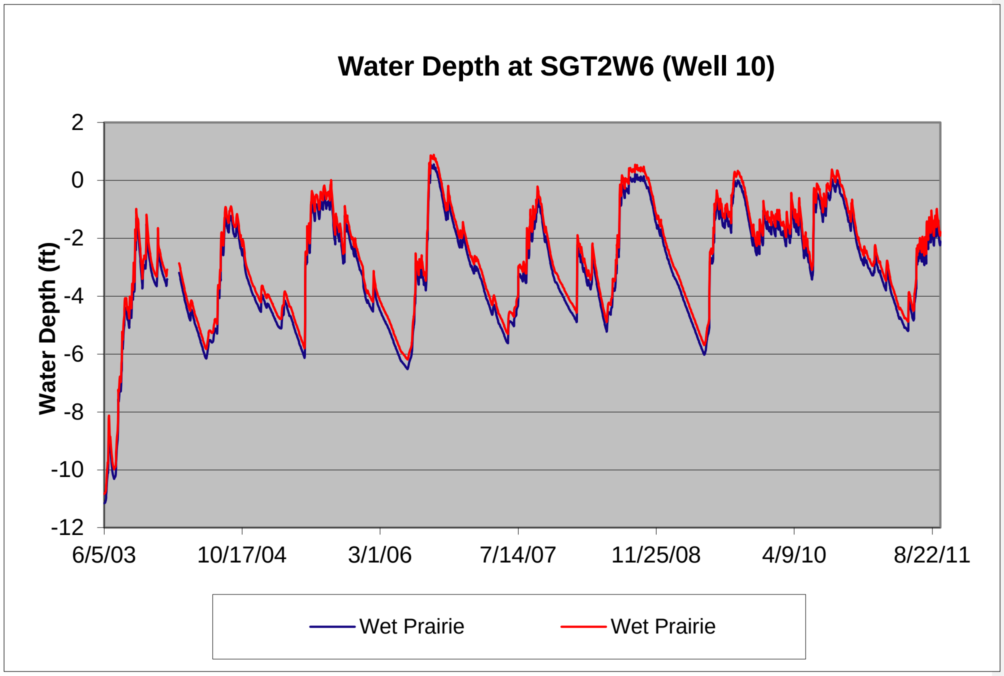

Figure 5. Water Depth at SGT2W6 (Well 11)

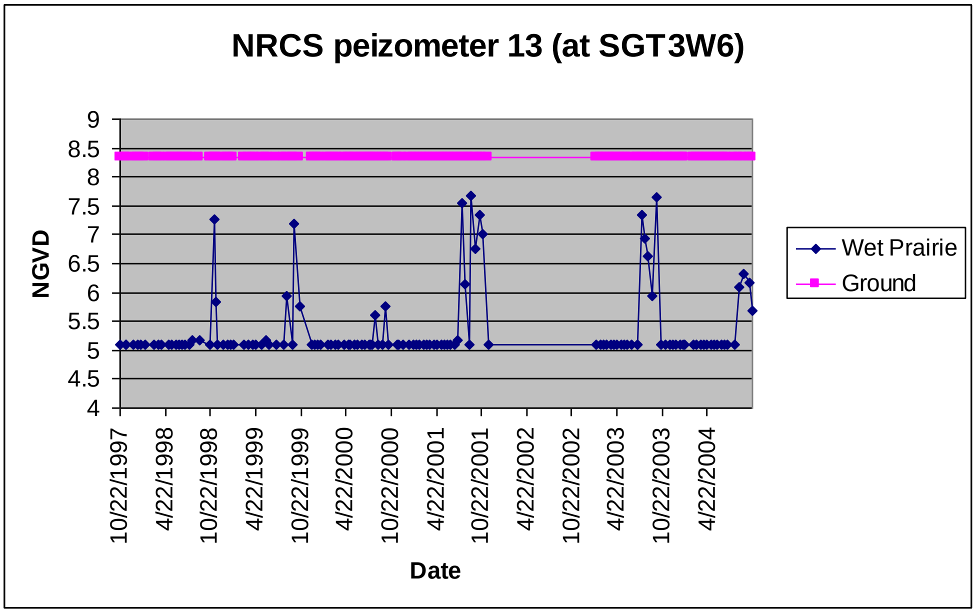

Figure 6. NRCS Piezometer 13 (at SGT3W6)

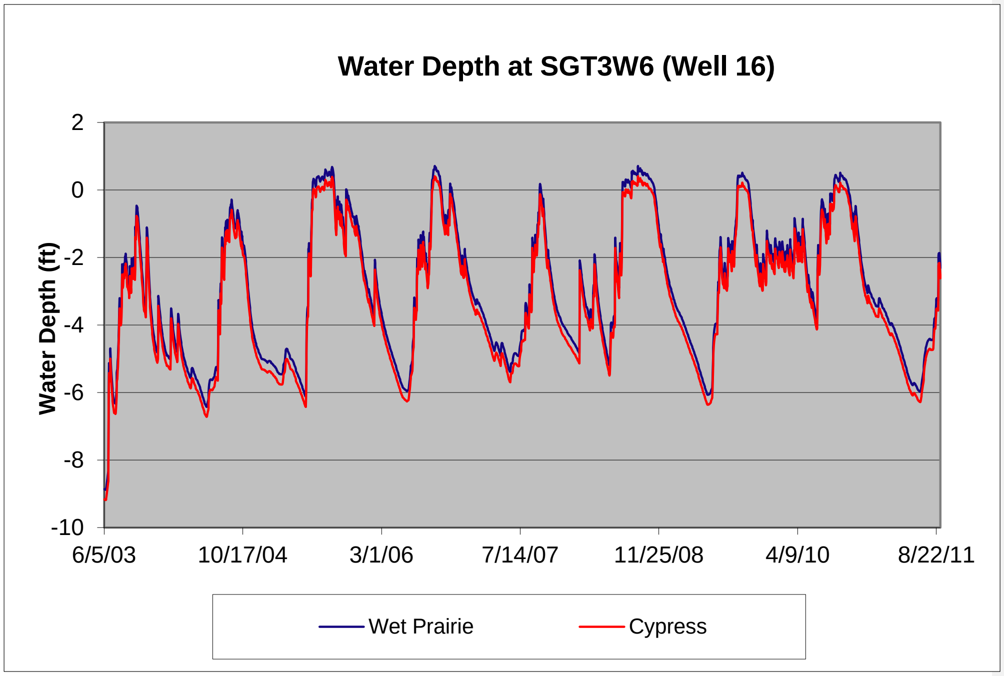

Figure 7. Water Depth at SGT3W6 (Well 23)

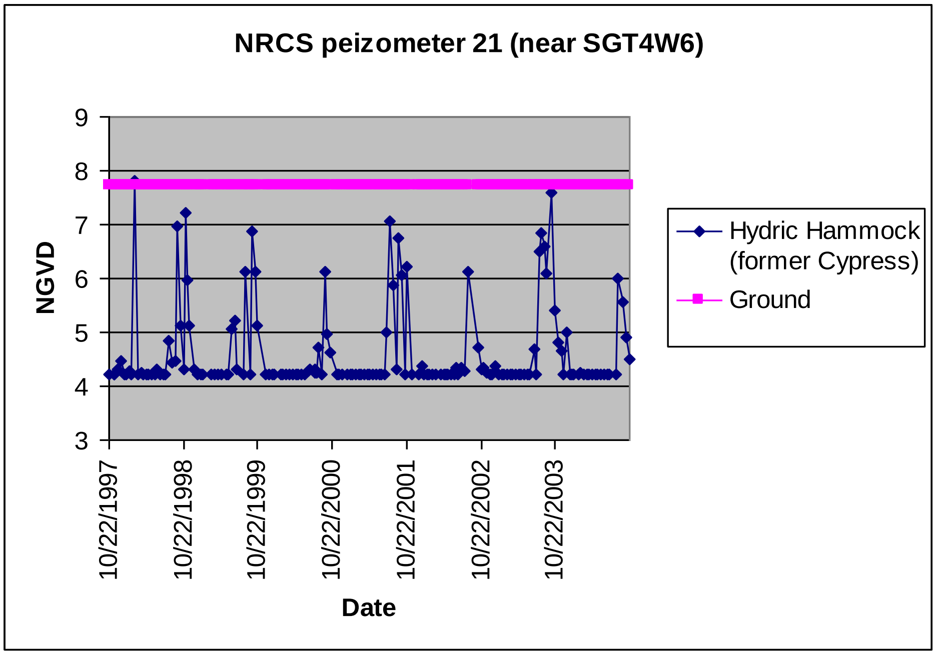

Figure 8. NRCS Piezometer 21 (near SGT4W6)

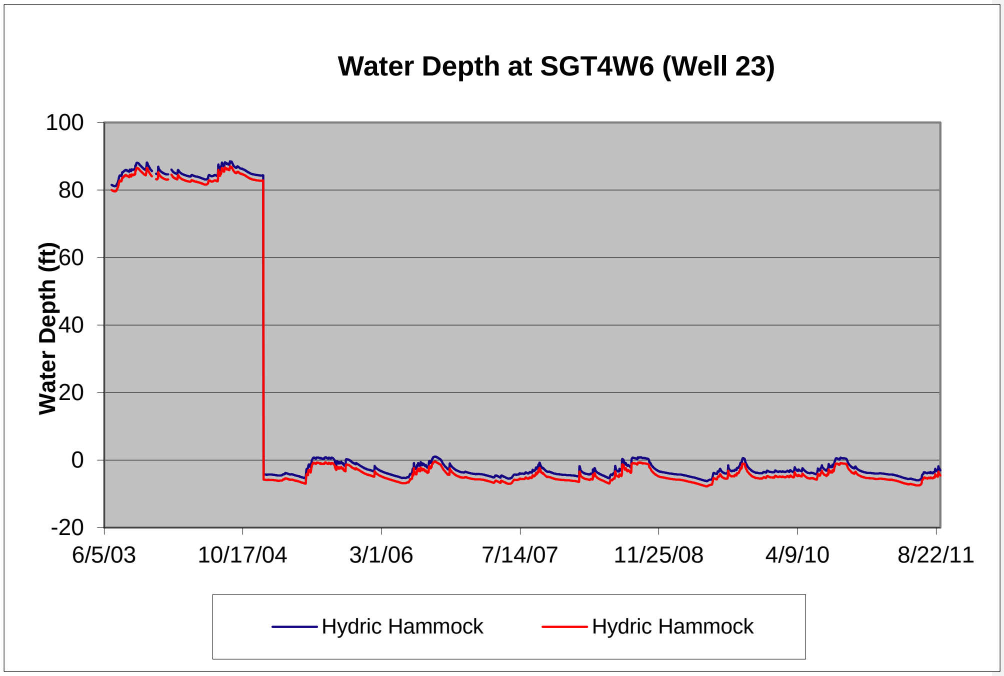

Figure 9. Water Depth at SGT4W6

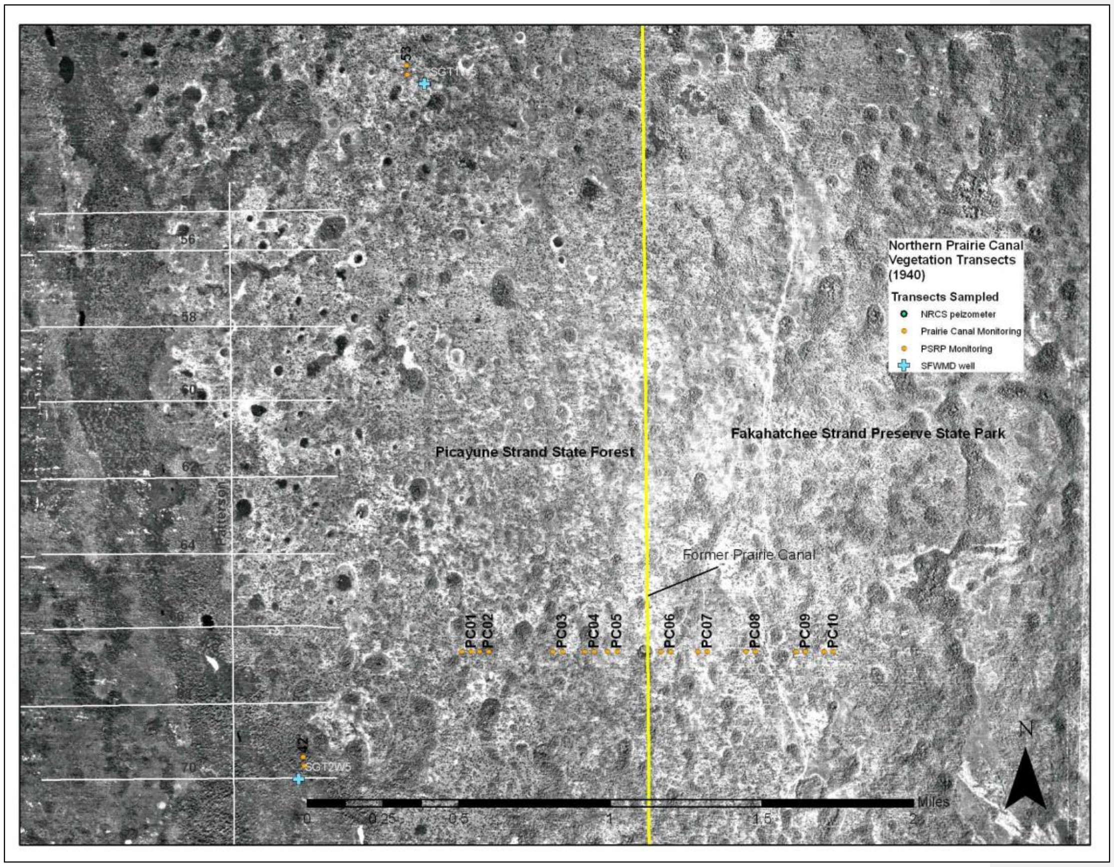

Figure 10. Northern Prairie Canal Vegetation Transects (1940)

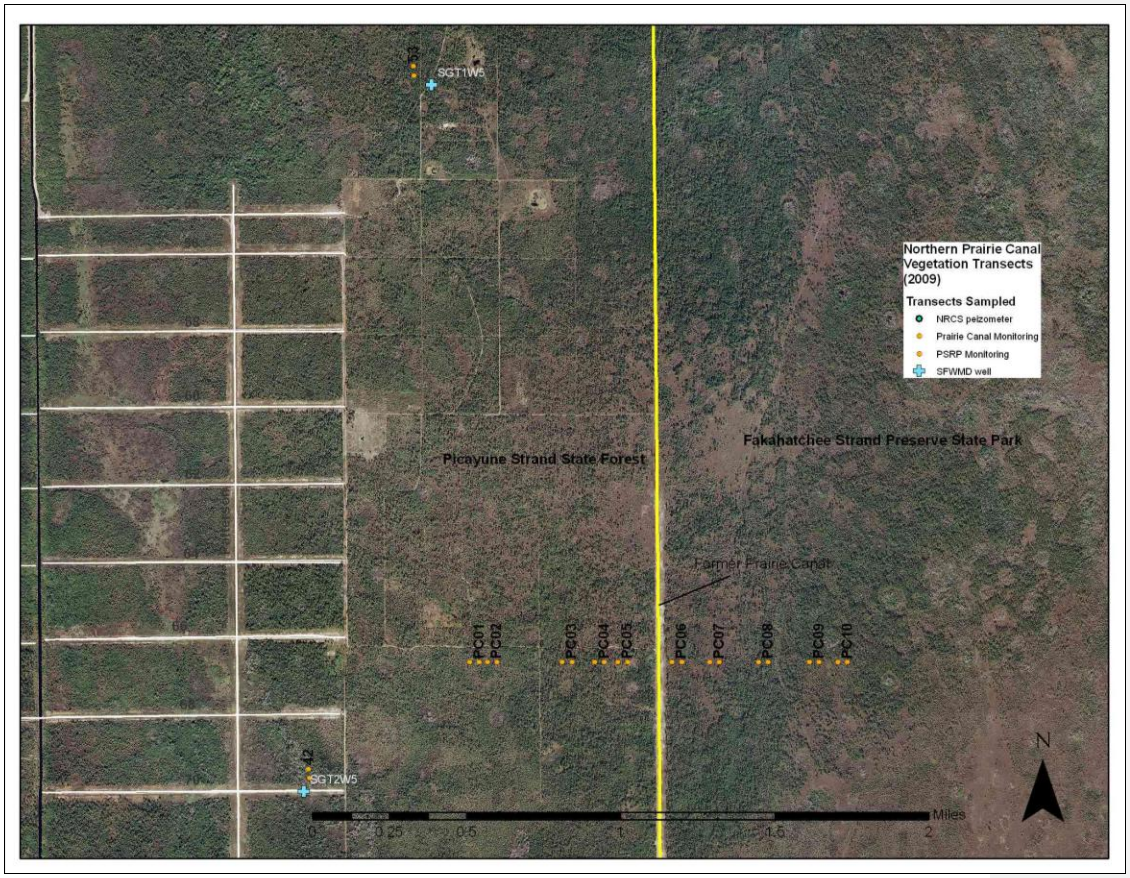

Figure 11. Northern Prairie Canal Vegetation Transects (2009)

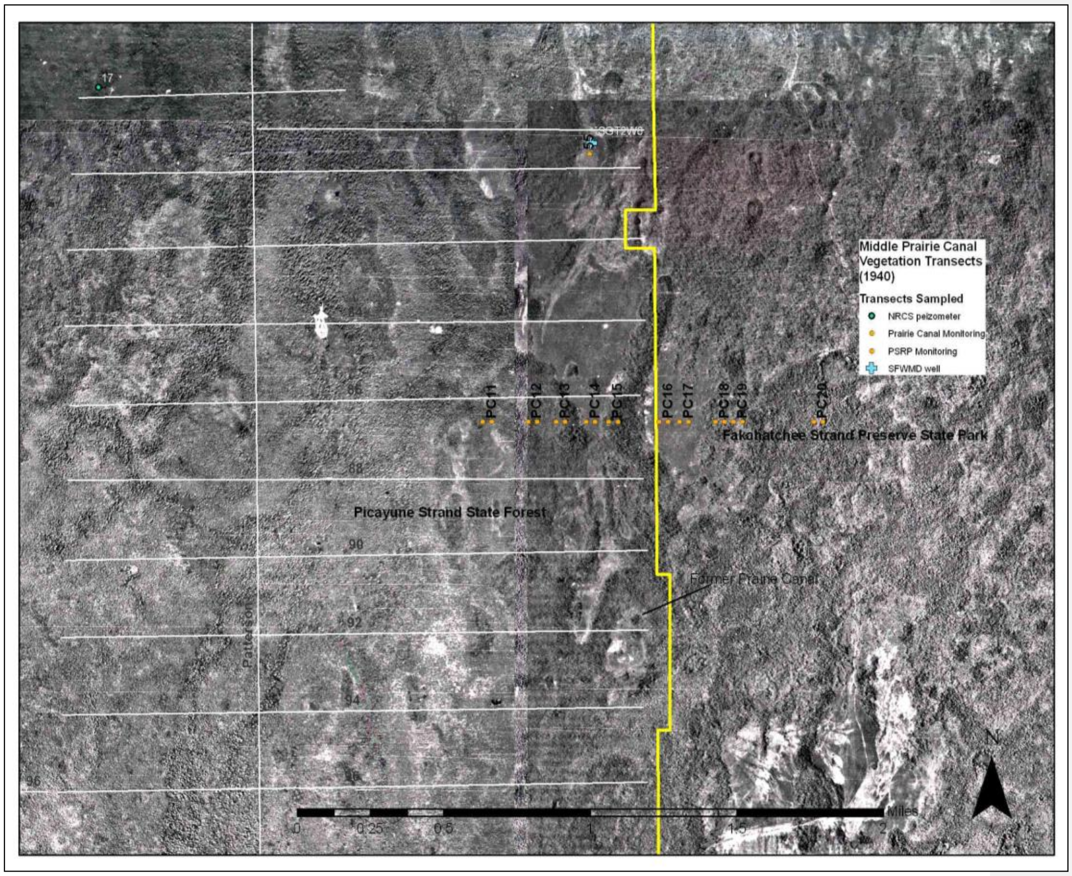

Figure 12. Middle Prairie Canal Vegetation Transects (1940)

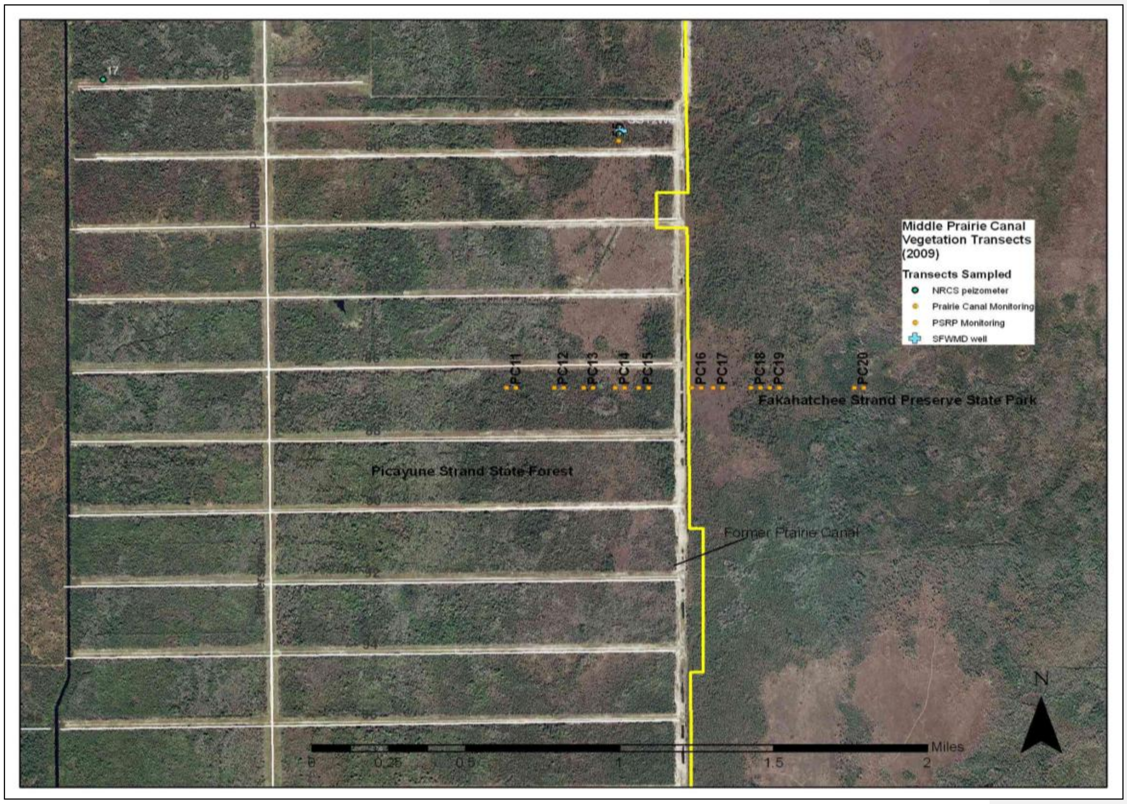

Figure 13. Middle Prairie Canal Vegetation Transects (2009)

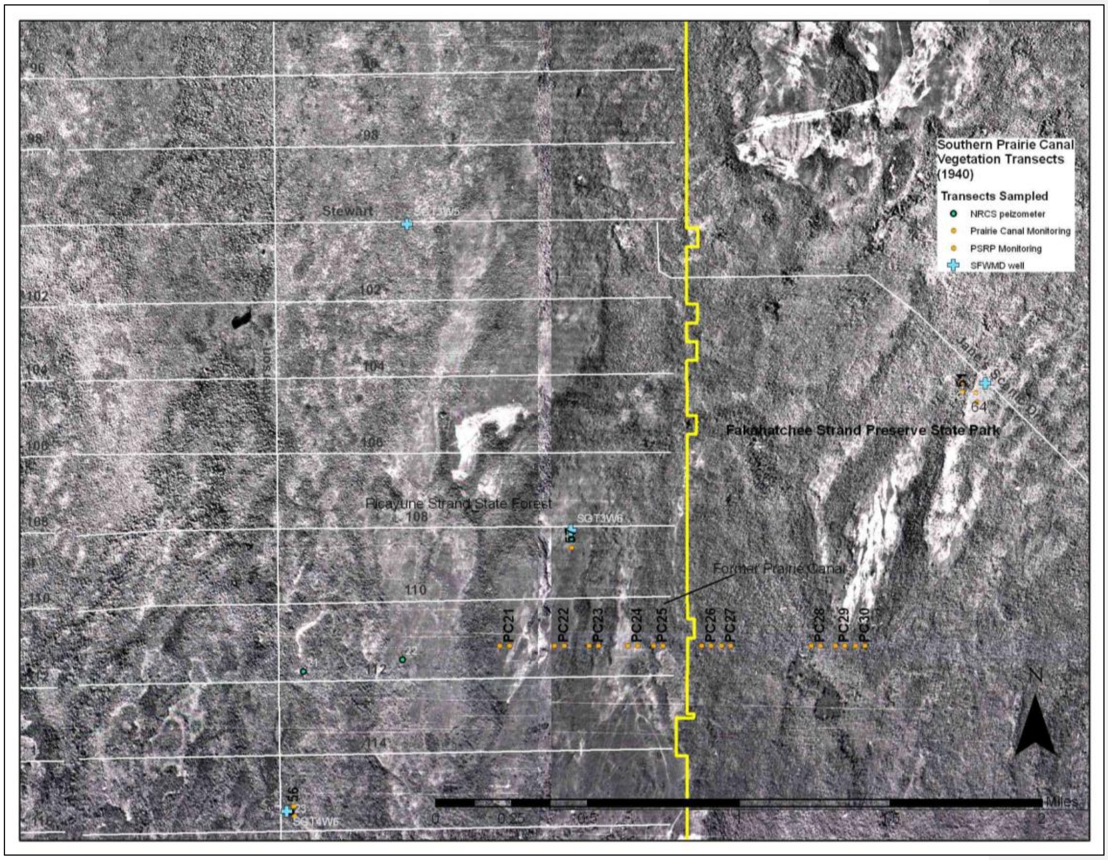

Figure 14. Southern Prairie Canal Vegetation Transects (1940)

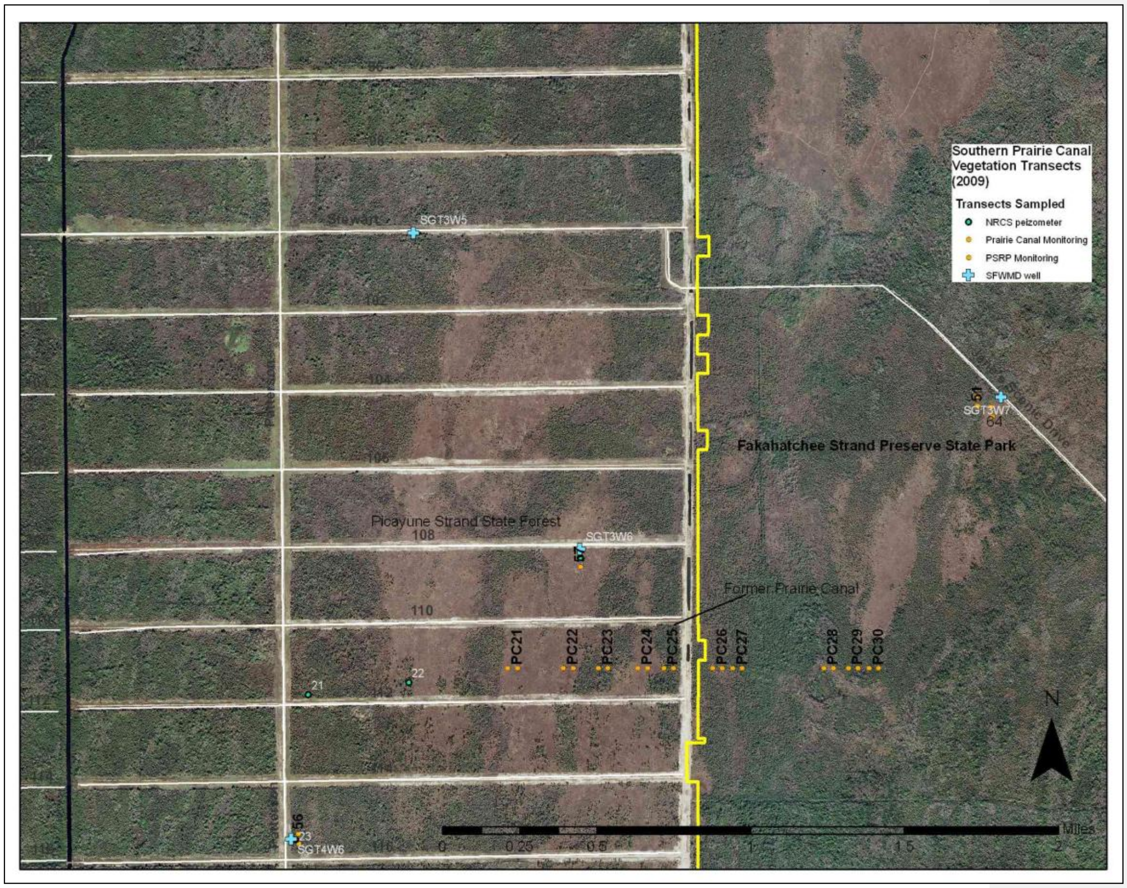

Figure 15. *Northern Prairie Canal Vegetation Transects (2009)*

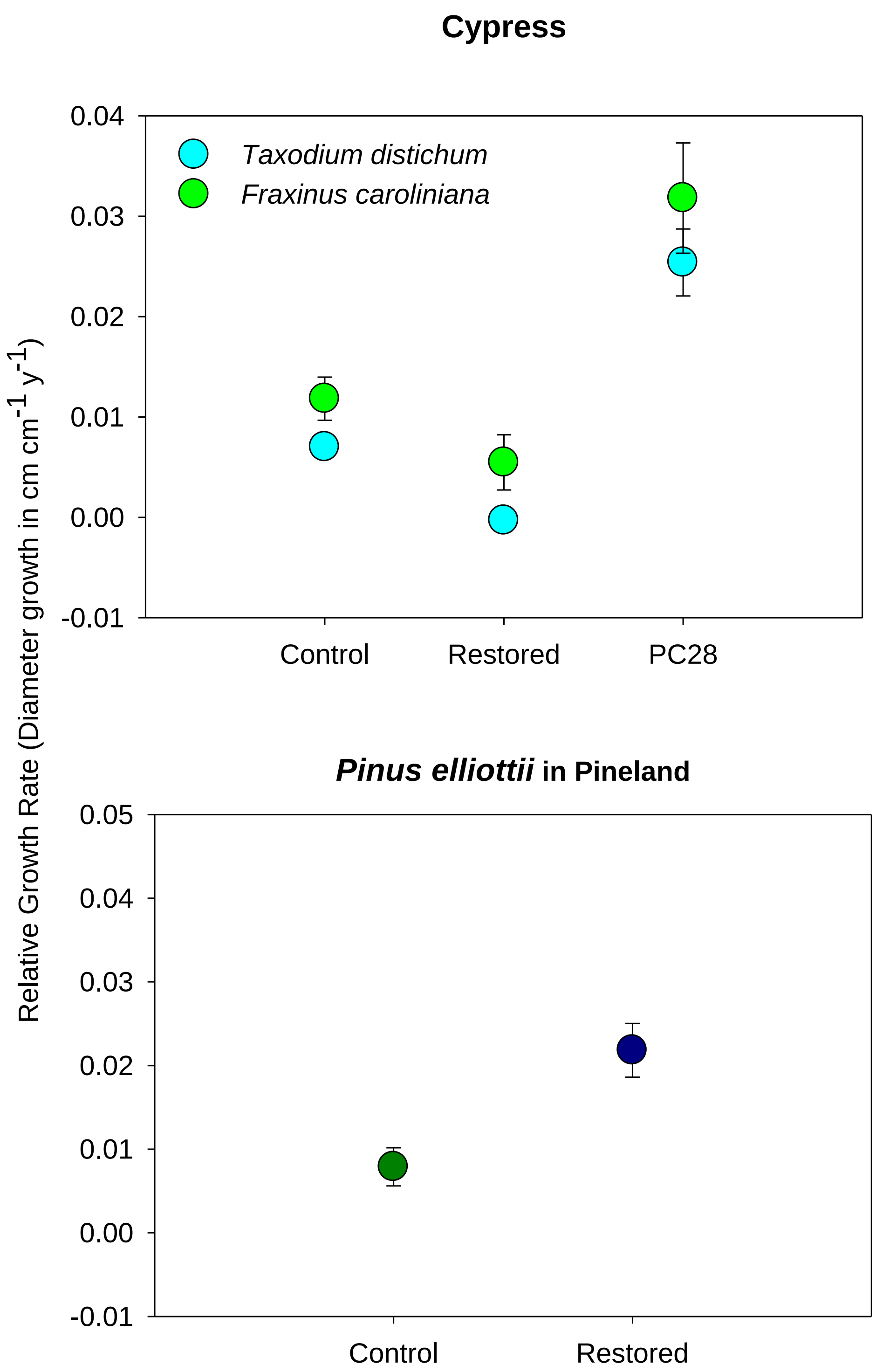

Figure 16. Relative Growth Rates of Slash Pine, Cypress, and Pop Ash

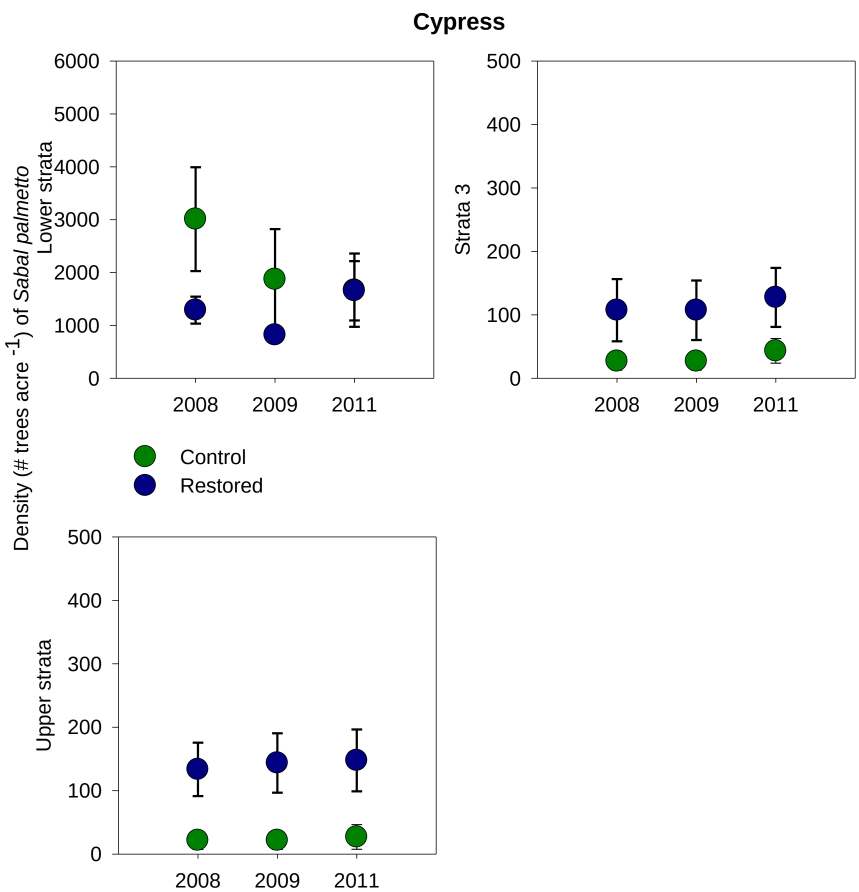

Figure 17. Cabbage Palm Density in Cypress Transects

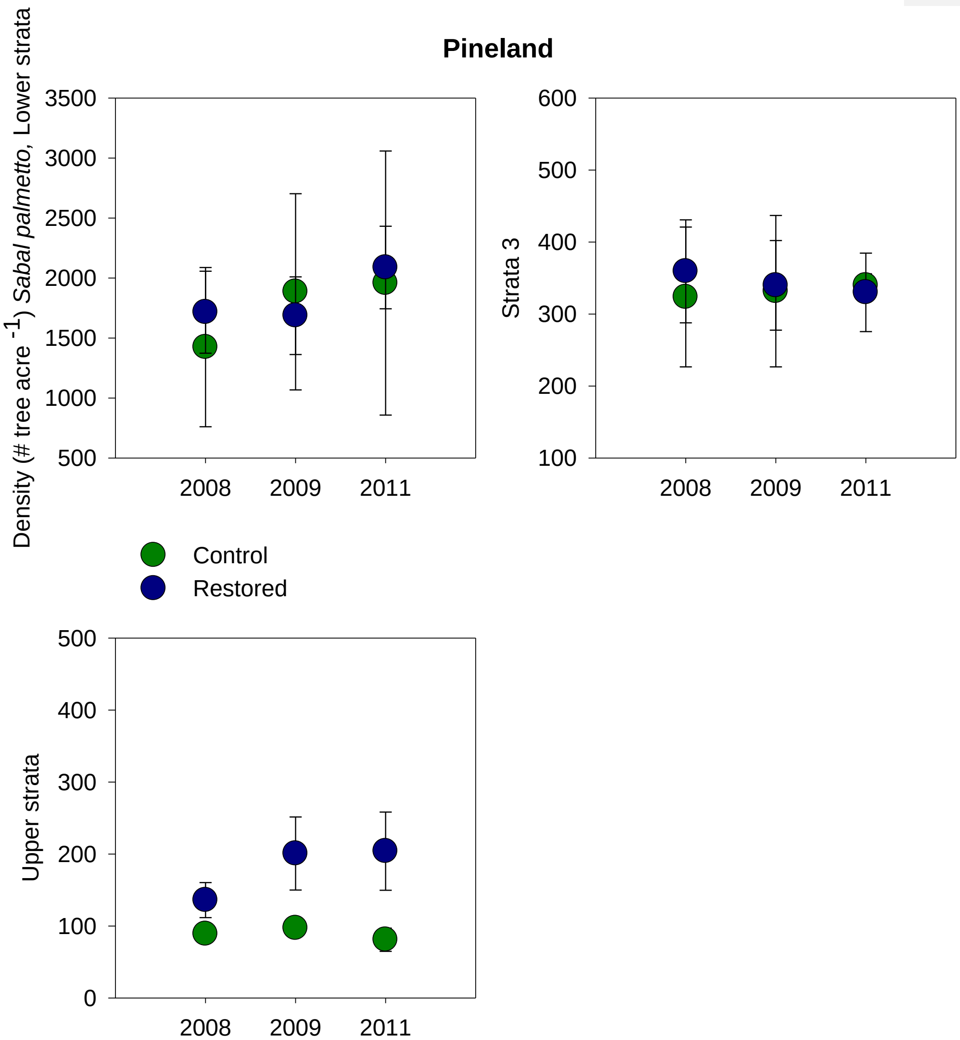

Figure 18. Cabbage Palm Density in Pineland Transects

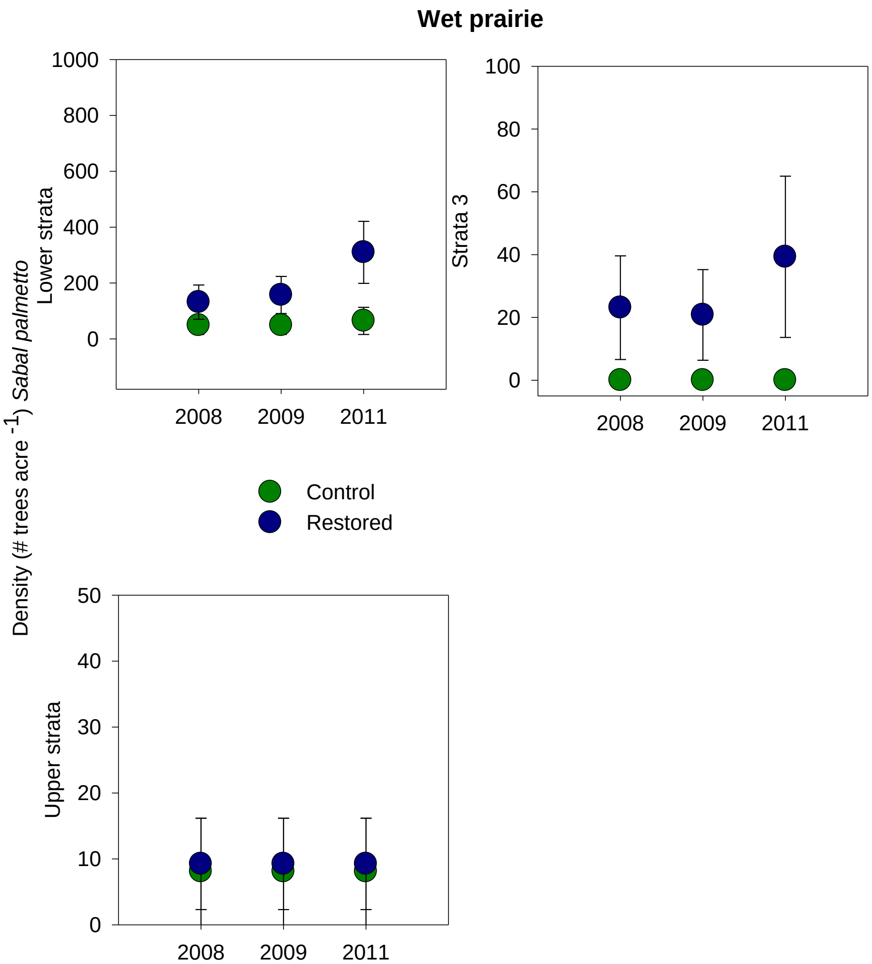

Figure 19. Cabbage Palm Density in Wet Prairie Transects

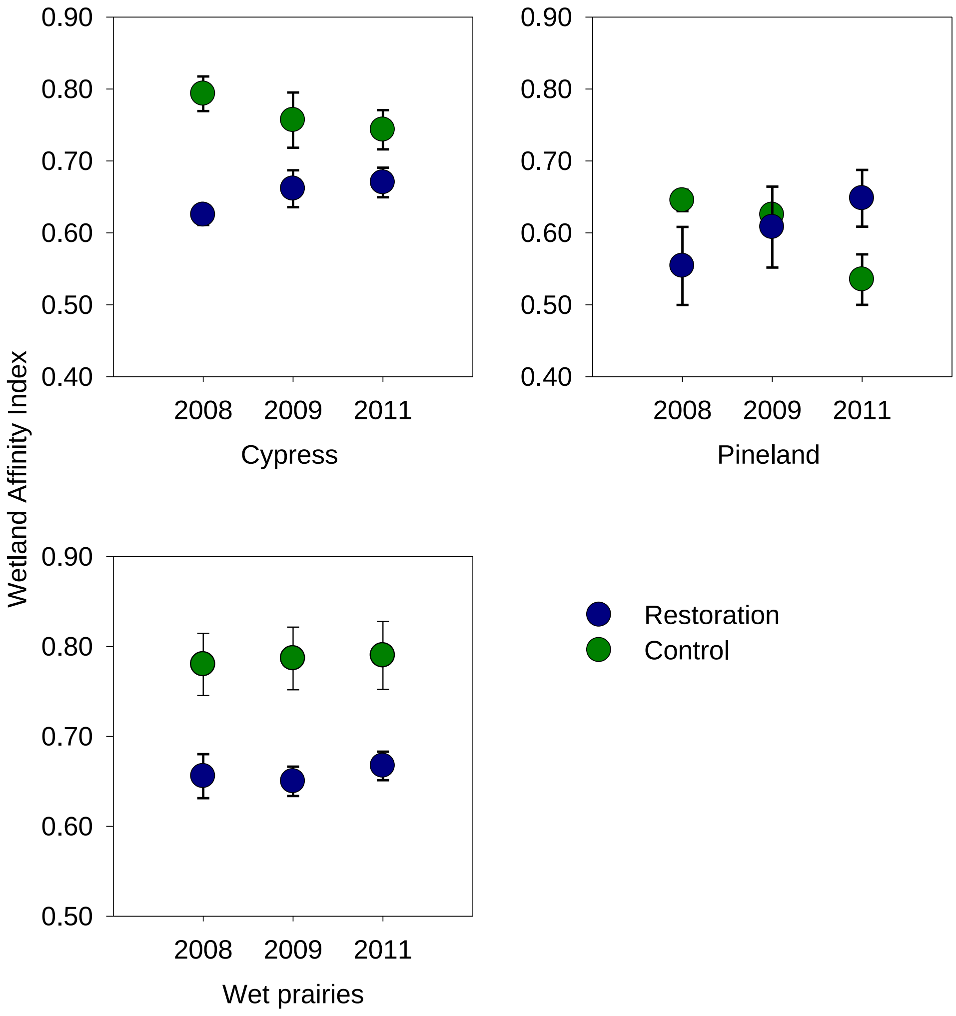

Figure 20. Wetland Affinity Index by Habitat Group

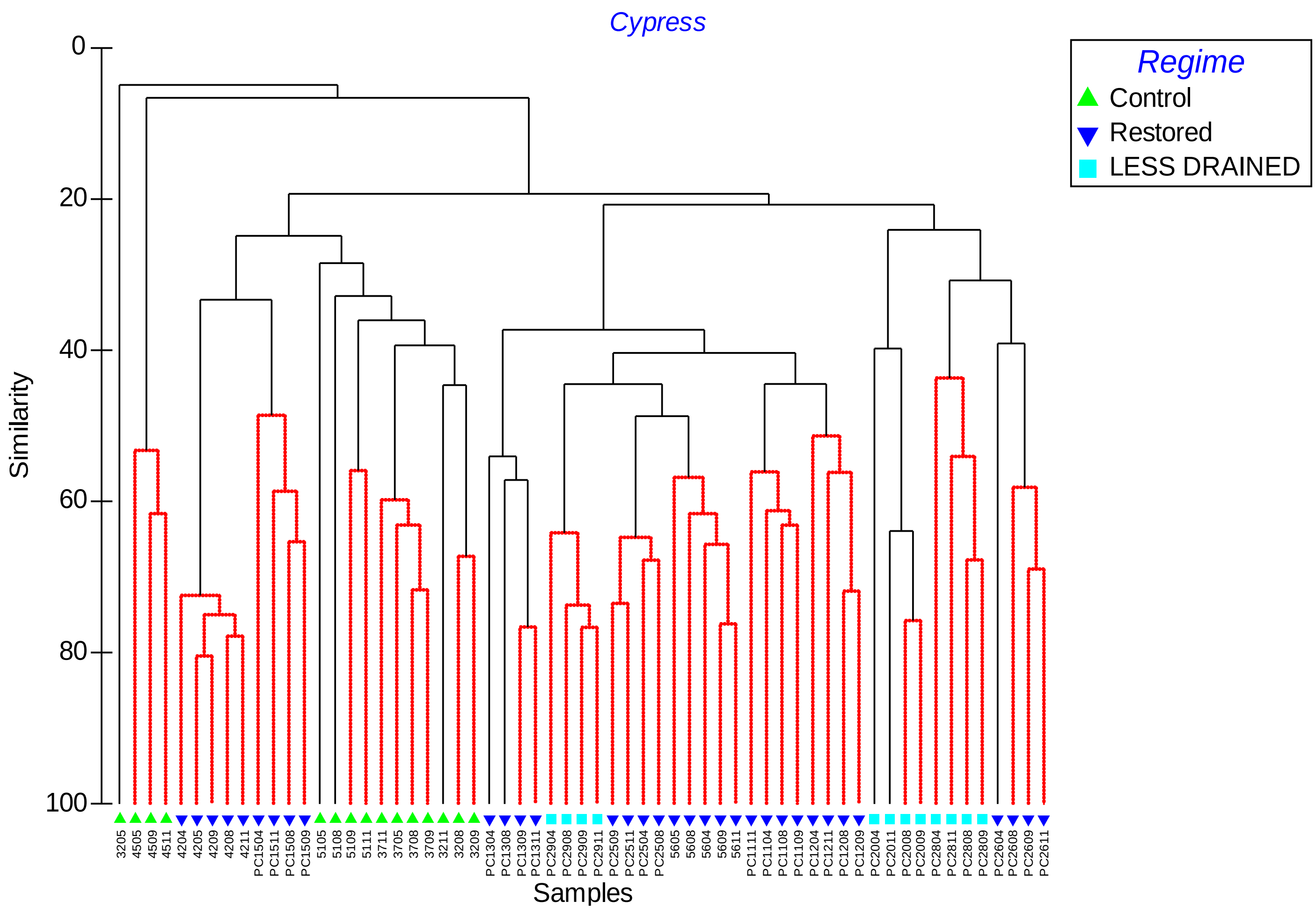

Figure 21. Cluster Diagram of Cypress Transects, by Sampling Event and Management Regime. Significant groups are identified by black lines. Groups in red are not significantly different from the SIMPROF random permutation test.

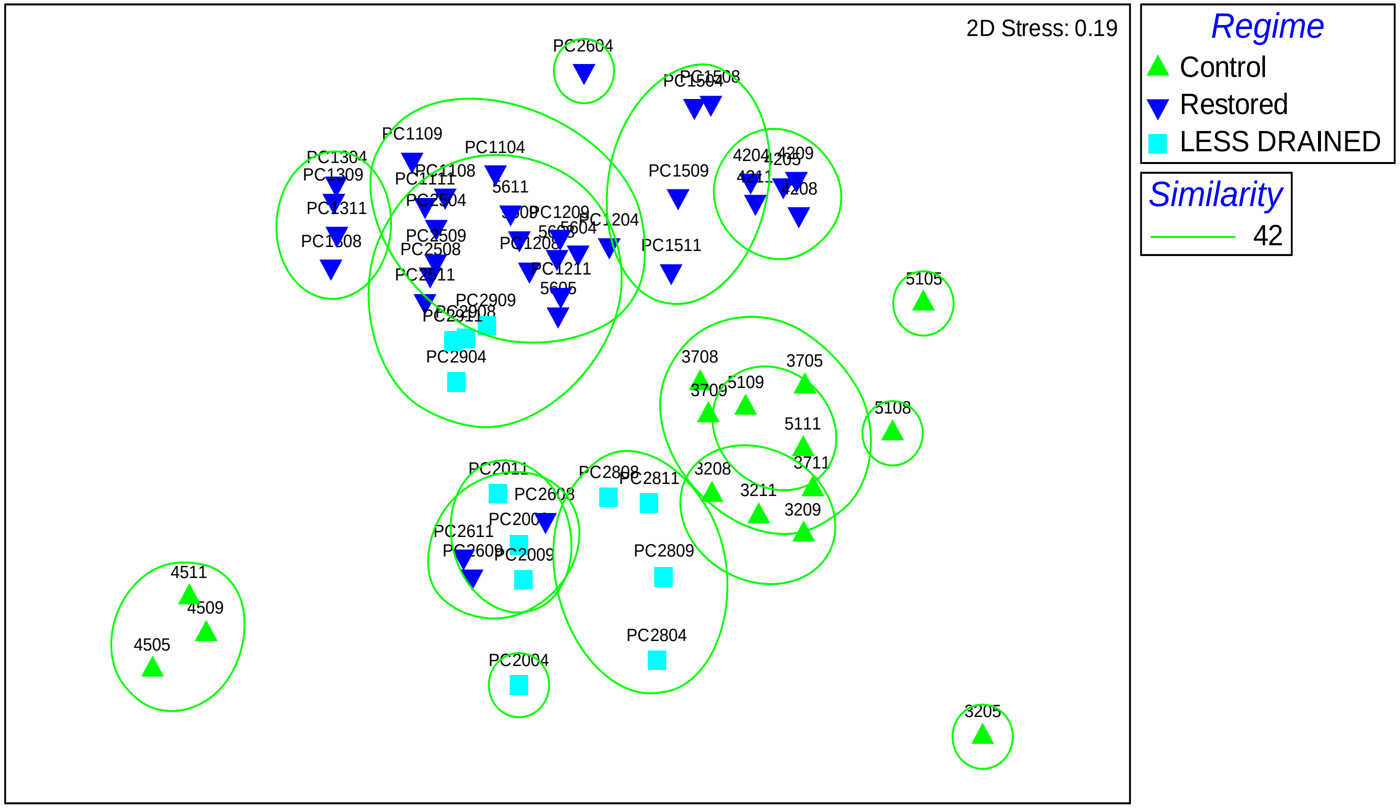

Figure 22. MDS of Cypress Sites, by Sampling Event and Management Regime with Bubble Overlay of Major Groups at 42% Similarity from the Cluster Analysis and SIMPROF Test.

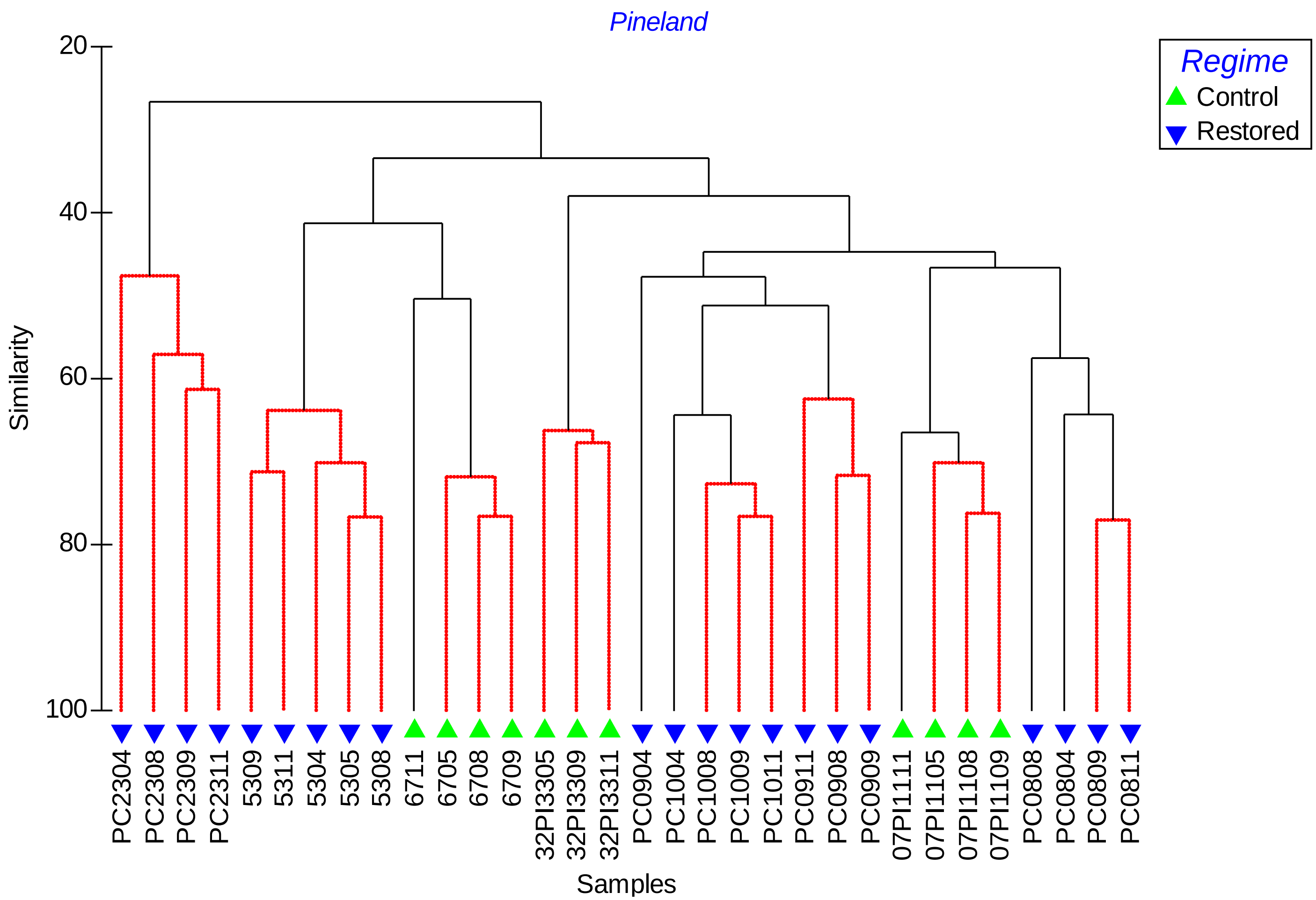

Figure 23. Cluster Diagram of Pineland Transects, by Sampling Event and Management Regime. Significant groups are identified by black lines. Groups in red are not significantly different from the SIMPROF random permutation test.

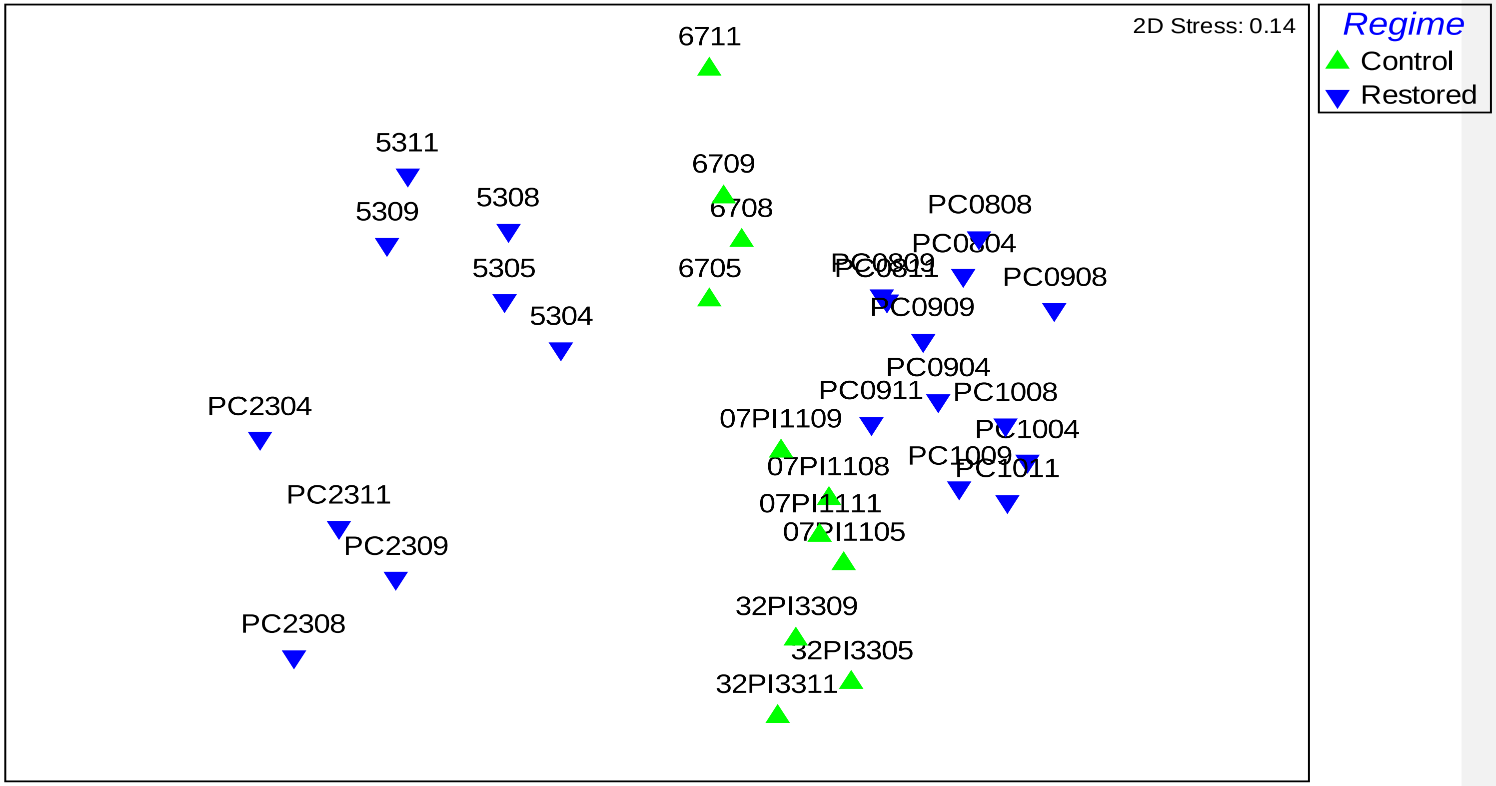

Figure 24. MDS of Pineland Sites, by Sampling Event and Management Regime.

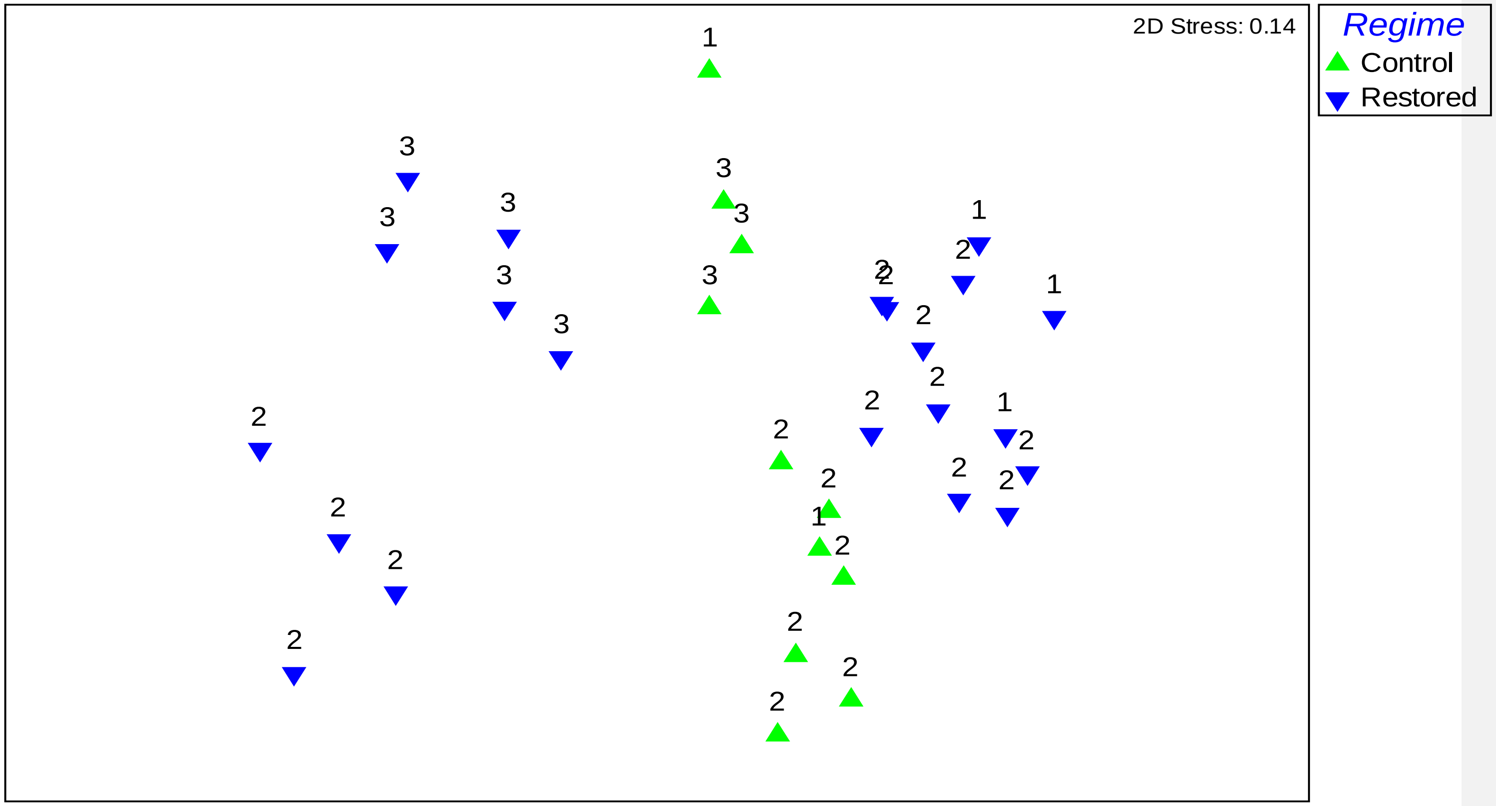

Figure 25. MDS of Pineland Sites, by Time since Fire and Management Regime. Influence of fire frequency is clearly evident in influencing ordination position of both control and restored sites. (1= <1 year, 2= 1-7 years, 3= >7 years).

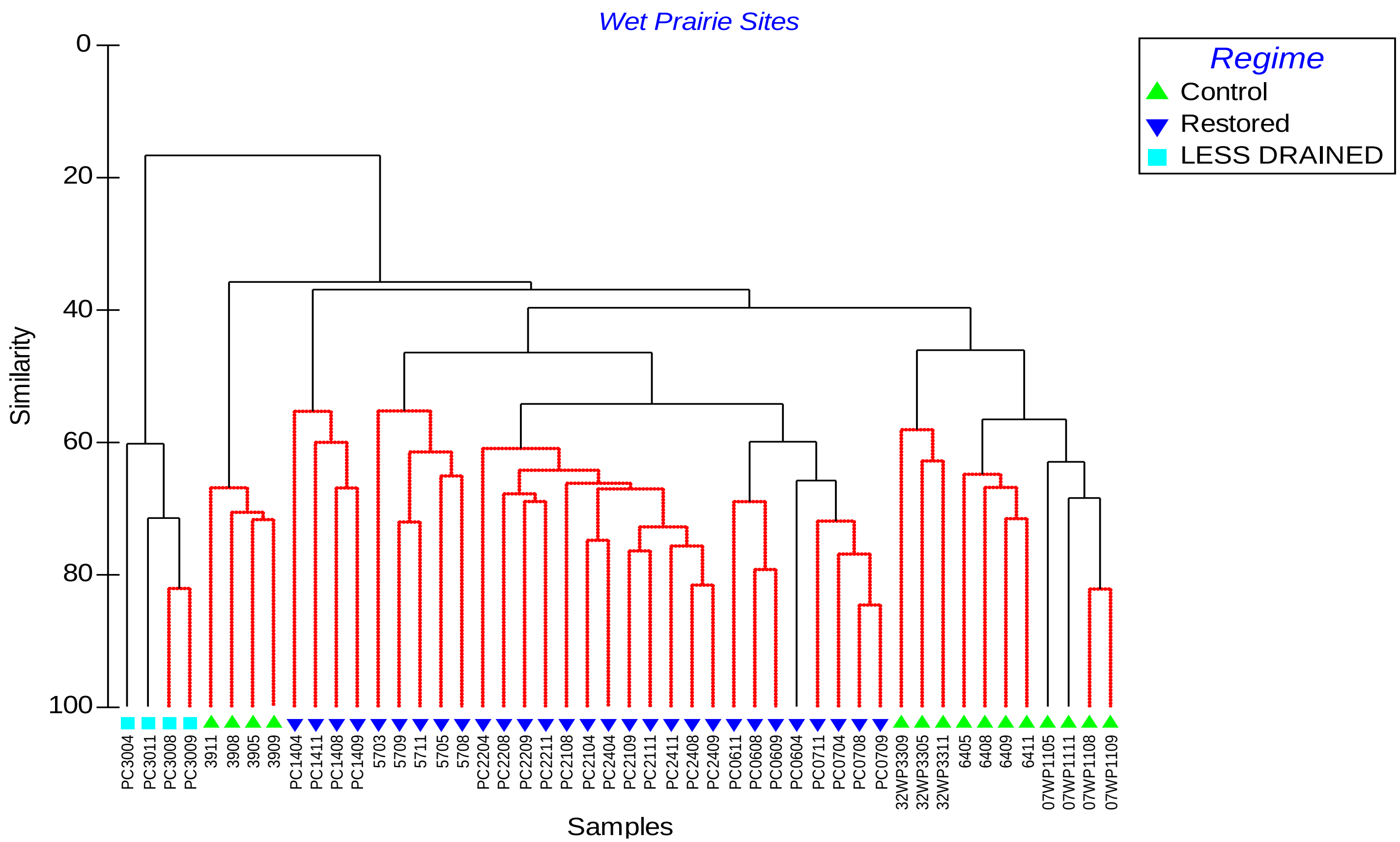

Figure 26. Cluster Diagram of Wet Prairie Transects, Sampling Event, and Management Regime. Significant groups are identified by black lines. Groups in are red not significantly different from the SIMPROF random permutation test.

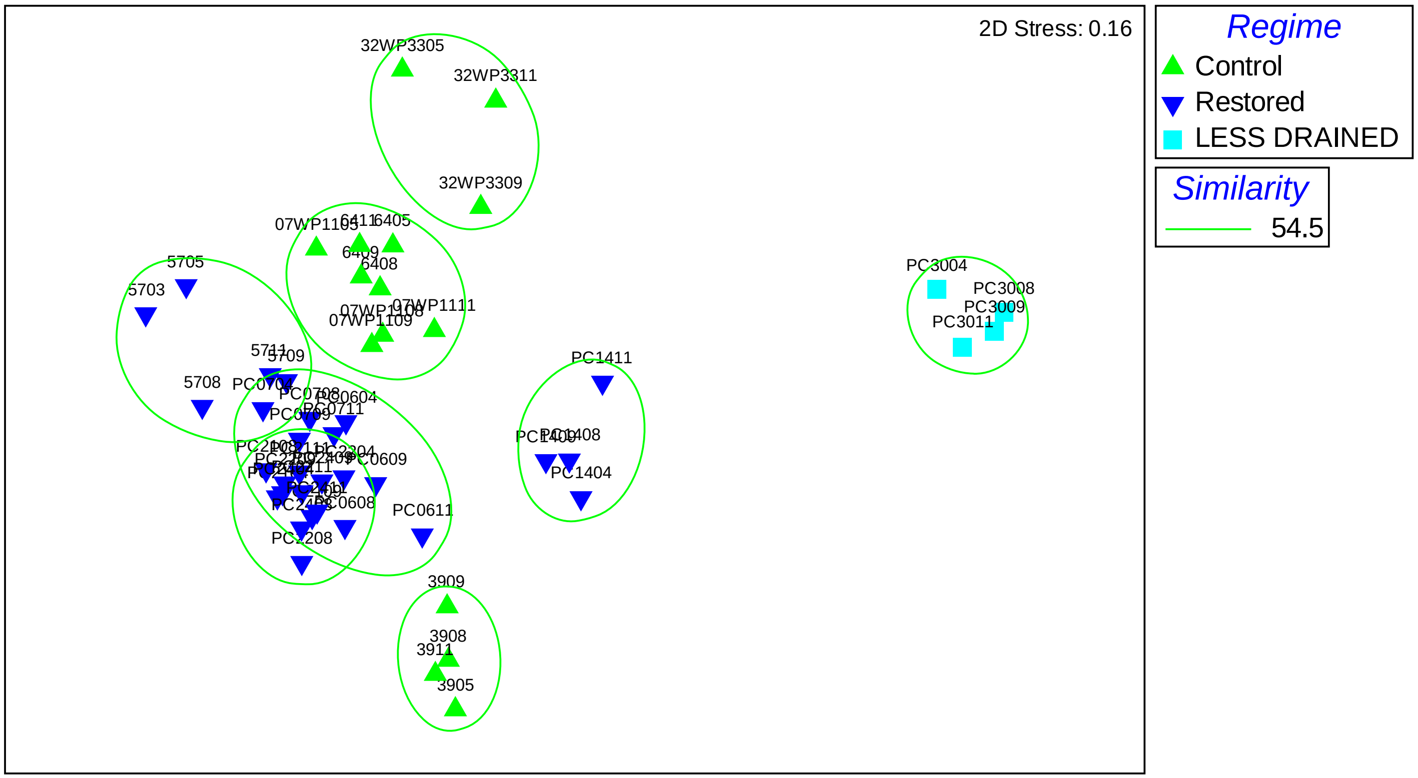

Figure 27. MDS of Wet Prairie Sites, by Sampling Event and Management Regime, with Bubble Overlay of Major Groups at 54.5% Similarity from the Cluster Analysis and SIMPROF Test.

Appendices

Appendix 1
Picayune Vegetation Monitoring Methods
Field Measurement Guide

Appendix 1:
Picayune Vegetation Monitoring Methods
Field Measurement Guide
Revised September 7, 2011

Equipment:
50-meter tape; 2.5-meter stick; flagging tape; compass; 0.5 m^2 quadrat; camera; hand lens; tree tags; hammer and nails; DBH tape (in cm); pen/pencil; clipboard; previous year data sheet; field notebook; GPS; field safety equipment, including water

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Set-up:

Avoid stepping on quadrat locations. Locate transect ends. Set tape alignment on transect. N. or E. = start, unless noted otherwise. Follow previous line (not necessarily straight) with guidance from flagging on vegetation and field notes from previous years. Flagging tape knot = transect tape location. Refresh flagging on ends, and within transect as needed.

Photos:

Consult field notebook identifying transect, date, time, researchers. First Photo - Start of transect: from ~2 meter away, take photo of end-post and tape showing 1st quadrat. Vertical photo preferred. Photos 2+ additional photos as needed (e.g., treetops to show live specimens vs. snags); if view of whole transect is obstructed, take general photo facing away from transect end. Final Photo - end of transect & final quad

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Belt Transect 1:

Avoid stepping on quadrat locations - Using 2.5 m pole as guide for belt boundary, walk along each side of tape to record canopy and sub-canopy. Stems are "in" belt, if >50% of the trunk base is within belt boundary. Record data on data sheet with previous year information.

Canopy (≥10 cm dbh): measure DBH - trees are numbered and tagged; measure just above nail; make sure dbh tape is level; check notes about vines or obstructions; tag any trees that have grown to be ≥10 cm dbh

Sub-canopy (dbh 2.5 – 10 cm): count no. of stems for each species - "sub-canopy" = woody plants that could become trees(e.g., bay, dahoon holly, sapling pine, sapling cypress, etc.); exclude shrub species: (e.g., Brazilian-pepper, willow, saltbush, wax myrtle, palmetto, dogwood, myrsine); see notes below.

Count Sabal Palm Trees in Strata 1 and 2 - apical meristem >8ft; Strata 1.5 - old growth (bootless, no leaf scars, adventitious roots); Strata 2 - apical meristem 4.5 – 8 ft;

Belt Transect 2:

Avoid stepping on quadrat locations
Count Sabal Palm in each of strata 3 through 5
Strata 3 - trunk above ground to 4.5 ft tall

ERM

Strata 4- palmate leaves; no trunk
Strata 4 – simple; 4 or more simple leaves
Strata 5 - ≤ 3 leaves (including old leaf stems); largest leaf ≤ 3 folds

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Quadrats Numbers 0 – 5.

Short side of quadrat placed along tape at 0-0.5 m, 10-10.5, 20-20.5, 30-30.5, 40-40.5, 50-50.5 meters on north or west side of tape (unless noted otherwise); when standing at 0 m, facing transect, quadrat is always located to the RIGHT of transect line. Record data in field notebook.

Identify all species within quadrat. Record 8-letter species code. For herbaceous groundcover spp., exclude plants, if stem is outside of quadrat.
Include vines & epiphytes
Include trees <2.5 cm dbh
Include shrubs (see notes below) overhanging quadrat
Include Sabal Palm strata 3–5

Record "cover class" for each species.
0.5 (0-1%), 37.5 (25-50%), 3 (1-5%), 62.5 (50-75%), 15 (5-25%), 85 (75-95%), 97.5 (95-100%).

Record notes:
SE=seedling, SA=sapling, ?=unsure, FL=flowering, FR=fruit, B=deer-browsed. For palms, record number of seedlings in quadrat. Label unknown species "P_[family or genus]" + description

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Line Intercept:

Avoid stepping on quadrat locations
Record % cover of shrubs, young trees, and Sabal Palm strata 3–5 that are directly over transect tape. Use 0.1 meter increments. Record all data in field notebook.
Include all woody plants <2.5 cm dbh
Include all "shrub" species regardless of dbh. (See notes below)
Include seedlings & saplings of woody plants
Include Sabal palm strata 3–5 (lumped together)
Exclude perennial forbs, suffructescent (e.g., *Hypericum*, *Stillingia*, *Lythrum*…)

Follow-up: scan/photo data for back-up

SHRUB NOTES:

"Shrubs" = multi-stem woody species; stem numbers and % cover varies much year-to-year. (e.g., Brazilian-pepper, dogwood, wax myrtle, saltbush, willow, myrsine, shiny blueberry, *Psychotria* spp., gallberry)

Sereno arepens is always considered to be a shrub.

ERM

Shrubs = plants that could become sub-canopy trees (e.g., bay, dahoon, popash, strangler fig, pond apple, magnolia, oak) when DBH is <2.5cm.

NOT shrubs = perennial, suffructescent forbs (e.g., *Stillingia*, *Hypericum*, *Lythrum*, *Urena*).

ERM

Appendix 2 (a-c)
Belt Transect Data by Transect

Appendix 3 (a-f)
Line Intercept Data by Transect

Appendix 4
Mean Quadrat Percent Cover and Frequency by Transect

Appendix 5 (a-d)
Mean Quadrat Species Richness by Transect and Habitat

Appendix 6 (a-d)
Wetland Affinity Index by Transect