

Landscape Pattern–Marl Prairie/Slough Gradients Year 5 Report (2019-2024)

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Cover photo: *Spikerush-Sawgrass* Marsh at site M2E-3600 located north of Chekika in the Northeast Shark River Slough Area. (Photo: Jesus Blanco, Date 2015/06/04). A recent photo taken at the same site is in Appendix 8.

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General Background

The Water Resources Development Act (WRDA) of 2000 authorized the Comprehensive Everglades Restoration Plan (CERP) as a framework for modifications and operational changes to the Central and Southern Florida Project needed to restore the South Florida ecosystems. Provisions within WRDA 2000 provide for specific authorization for an adaptive assessment and monitoring program. A CERP Monitoring and Assessment Plan (MAP; RECOVER 2009) has been developed as the primary tool to assess the system-wide performance of the CERP by the Restoration Coordination and Verification (RECOVER) program. The MAP presents monitoring and supporting research needed to measure the responses of the South Florida ecosystem to CERP implementation. In the Everglades, marsh vegetation in both marl prairie and ridge and slough landscapes is sensitive to large-scale restoration activities associated with the CERP. More specifically, changes in hydrologic regimes at both local and landscape scales are likely to continue affecting vegetation composition in the transition zone between these two landscapes, resulting in a potential shift in boundary between plant communities. To track these dynamics, Florida International University (Dr. Michael Ross, PI and Dr. Jay Sah, Co-PI) studied vegetation structure and composition in relation to physical and biological processes along the marl prairie-slough (MP-S) gradient beginning in 2005. Since the Fall of 2014 (Cooperative Agreement # W912HZ-14-2-0023 (2014-2019); W912HZ-19-2-0031 (2019-2024), and Federal Award Identification Number (FAIN) W912HZ-24-2-0026 (2024-current), the study has been led by Dr. Jay Sah, while Dr. Michael Ross is also actively involved as the Co-PI in the study.

Vegetation monitoring transects in the Shark Slough basin, funded by US Army Corps of Engineers (USACE) under RECOVER-MAP, capture the full range of marl prairie and slough plant communities, and address Performance Measure (PM):GE-15 (Landscape Pattern–Marl Prairie/Slough gradient) by "detecting spatiotemporal change in vegetation structure and composition in response to natural and restoration-induced hydrologic changes...". Monitoring of vegetation along the marl prairie/slough gradients addresses a working hypothesis that 'Spatial patterning and topographic relief of ridges and sloughs are directly related to the volume, timing and distribution of sheet flow and related water depth patterns,' identified in the hypothesis cluster "Landscape Patterns of Ridge and Slough Peatlands and Adjacent Marl Prairies in Relation to Sheet Flow, Water Depth Patterns and Eutrophication" (RECOVER 2009). The study also addresses the hypothesis that, 'Resumption of historical flow and related patterns of hydroperiod, water depth, and fire with the implementation of CERP will cause a noticeable change in plant community composition and structure along the gradient and in the transition zone between marl prairie and peat-dominated ridge and sloughs.'

Greater Everglades hypothesis clusters have recently been revised (RECOVER Landscape HC 20230615– unpublished). In the revised version of hypothesis clusters, the vegetation monitoring along marl prairie/slough gradients is relevant to the Hypothesis 7, which states, "Non-linear elevation breaks and slopes (topographic contours that do not progress smoothly or that exhibit abrupt changes) affect landscape patterning and vegetation

communities, as the non-linear elevation breaks and slopes control water movement on the landscape and landscape hydrology." Since the landscape-scale nonlinearities in elevation are likely to occur in each management compartment and are likely to be unique in each compartment (Supposition # 1), the composition and distribution of plant communities along elevation gradients within a compartment or compartment components (e.g. marl prairie-slough gradients), are determined by patterns of hydroperiod, water depth, nutrient dynamics, and fire patterns.

The primary objective of the study is to assess the impact of Everglades restoration activities on plant communities along the marl prairie-slough (MP&S) gradient, and to detect any shift in position and attributes of boundaries between those communities. The study is conducted on six transects, four of which extend across Shark River Slough (SRS) into adjacent marl prairies. Shark Slough portions of the four transects overlap transects that were established and surveyed under different sponsorships in 1998-2000, providing the prospect of assessing long-term temporal change in vegetation in those areas.

The specific objectives of the study are:

- 1) To characterize recent vegetation composition along the marl prairie-slough gradient,
- 2) To identify boundaries between different vegetation types, and
- 3) To assess changes in vegetation structure and composition associated with changes in hydrology resulting from CERP restoration projects.

Initiated in 2005 as an expansion on Shark Slough study transects that had been established and surveyed in 1998-2000 with funding from DOI's Critical Ecosystems Study Initiative (CESI), the ongoing study of vegetation monitoring along MP&S gradients under CERP RECOVER program is in its sixth sampling cycle. For the first three sampling cycles (2005-2008, 2008-2011 and 2011-2014), sites on five transects (M1-M5) were sampled every three years. However, with an extension of the existing transect M2 in 2015 (i.e., M2E) and an addition of the 6th Transect (M6) in 2019, sites are now sampled every four years. This document summarizes results for all five years (Base year and Option Years 1-4) of the current funding cycle (2019-2024; CA # W912HZ-19-2-003). The report describes the hydrology patterns and vegetation dynamics in both slough and/or marl prairie portions of these transects. For the slough portion of four transects (M1-M4), this report summarizes the shift in vegetation composition in response to hydrologic changes since 1998-2000 study. Moreover, since the 6th sampling cycle is still underway, the trend in vegetation shift on these transects is described for varying periods. For instance, the marl prairie portions of Transects M1 and M3 were sampled six times between 2006 and 2024, and that of M2 (i.e., M2E) were sampled three times between 2015 and 2023. Thus, for the marl prairie portions of Transects M1 and M3, vegetation responses to hydrologic changes are described for 18 years, while that of M2 are described only for 8 years.

1. Introduction

In the Everglades, plant communities arranged along environmental gradients are expressions of ecosystem processes associated with underlying physicochemical drivers that vary in space and time. Hence, determining the responses to spatiotemporal changes in key drivers of plant assemblages along environmental gradients, and the boundaries between them, is important for conservation and ecosystem restoration. The landscape in both Shark River and Taylor Slough basins of the Everglades includes long hydroperiod sloughs, flanked by short hydroperiod marl prairies. Particularly in the Shark River Slough (SRS) basin, vegetation structure and composition change gradually along an elevation and water depth gradient, from short-hydroperiod marl prairies to ridge and slough, which are characteristic features of the landscape of central SRS (Ross et al. 2003).

Hydrology is one of the major drivers of species differences between marl prairie and ridge-and slough landscapes. Hence, alterations in hydrologic conditions usually cause a shift in vegetation structure and composition within each landscape; extreme changes can even lead to dominance of hydric vegetation in marl prairie (Nott et al. 1998) or various levels of degradation of landforms in the ridge and slough (R&S) landscape (Watts et al. 2010; Larsen et al 2011; Ross et al. 2016). In the past century, changes in the amount and flow patterns of water, resulting from the construction and operation of a series of canals, levees, and water structures (Light and Dineen 1994, McVoy et al. 2011), have altered the proportions of prairie and slough vegetation in the region. Furthermore, changes in water management associated with the ongoing Comprehensive Everglades Restoration Plan (CERP 2000) and associated projects and/or plans, Central Everglades Planning Project (CEPP) and Combined Operations Plan (COP), are likely to affect vegetation composition along the marl prairie-slough (MP-S) gradient, especially in the transition zone, resulting in a shift in the boundary between marl prairie and slough communities. It is therefore important to understand how restoration affects the dynamics of prairie and slough landscapes and the boundaries between the two.

Along the marl prairie-slough (MP&S) gradient, vegetation in the marl prairie portion of the gradient is likely to respond to hydrologic changes more rapidly than vegetation in the slough portion. Armentano et al. (2006) also argued that the transition from one vegetation type to another (e.g., prairie to marsh) in response to hydrology may take place in as little as 3 to 5 years. However, while vegetation within the ridge and slough landscape can also change in four years (Zweig and Kitchens 2008), the transition from marsh to prairie vegetation may take longer (Armentano et al. 2006, Sah et al. 2014). In the southern Everglades, recent water management efforts have been directed towards ameliorating the adverse effects caused by previous water management activities. In this respect, a series of water detention ponds have been brought into operation along the eastern boundary of the park to mitigate the wet-season water reversals that were prevalent in this region due to the loss of water from the rocky glades to the canal (Van Lent et al. 1999). In contrast, strategic regulation of water deliveries through the S-12 structures along US 41 has been in place since 2002 to reverse the damage that was caused by the extended

wet conditions which resulted from both highwater deliveries and rains in the mid-to-late -1990s. These modifications in water management activities, along with those being carried out under Central Everglades Planning Project (CEPP), Modified Water Deliveries (MWD) Project, and Combined Operations Plan (COP), including construction and operation of Tamiami Bridges, have affected and are likely to continue influencing water conditions within ENP (USACE 2014, USFWS 2016, USACE 2020, USACE/ENP/SFWMD 2023). As outlined in CEPP and COP, restoration activities have increased water deliveries from WCA 3A to ENP through NESRS (USACE 2020). Under the preferred plan (ALTQ+) identified in COP, water delivery into ENP (both northeast and western SRS combined) was projected to increase by 25%, and the delivery into NESRS is projected to increase by approximately 162,000 acre-feet per year on average (USACE 2020). In fact, the volume of water delivered to the NESRS region has consistently increased since the implementation of Increment Field Tests associated with the Modified Water Delivery (MOD) followed by full implementation of COP in 2020 (USACE/ENP/SFWMD 2023), resulting in an increase in hydroperiod and mean water depth in the region (Sarker et al. 2020; Nocentini et al. 2024). Changes in water conditions within ENP have begun showing effects on vegetation composition (Sah et al. 2024a, 2024b, 2025; Nocentini at al. 2024) and are likely to continue affecting vegetation communities in SRS and marl prairies on both sides of the slough.

In 2005, we initiated a long-term study of vegetation dynamics in relation to changes in underlying environmental drivers, especially hydrology, along the MP-S gradient. The broader goal of the study is to assess the impact of Everglades restoration activities on plant communities along the gradient, and to detect any shift in the transition zone between those communities. The study is now conducted on six transects (M1 to M6) that extend across SRS into adjacent marl prairies. Shark Slough portions of four transects (M1-M4) overlap transects that were established and surveyed under different sponsorships in 1998-2000 (hereafter 1999 study), providing the prospect of assessing long-term temporal change in vegetation in those areas.

In the ongoing monitoring study, our specific objectives are, i) to characterize recent vegetation composition along the marl prairie-slough gradient, and ii) to assess changes in vegetation in both the Shark Slough and marl prairie portions of the transects since 1999 and 2005, respectively. We hypothesize that variation in vegetation composition along the MP-S gradient is mainly driven by hydrology, i.e., duration and depth of flooding. We also hypothesize that Shark River Slough vegetation follows a temporal trend in hydrologic regime, and in the last twenty-five years has changed in species composition first toward assemblages more indicative of dry conditions and then toward wetter types. In addition, in compliance with the contrasting water management goals on the east and west peripheries of SRS, we hypothesize that marl prairie vegetation follows a spatially differentiated temporal trend in hydrologic regime. More specifically, vegetation in the western marl prairies would continue shifting toward a drier type, while vegetation in the eastern marl prairies would shift toward a wetter type.

2. Methods

2.1 Study Sites

This study is part of an ongoing long-term vegetation monitoring program along MP-S gradients in the southern Everglades. The study design includes six transects (M1 to M6), varying in length from 3.4 km to 35.8 km. Five (M1-M5) of these six transects were established in 2005, when systematic survey along MP-S gradient began. Four transects (M1-M4) extend across SRS to adjacent short-hydroperiod marl prairie habitat (**Figure 1**). M1, located in NESRS, extends only to the marl prairie east of the slough. M2 originally covered an area restricted to the ridge and slough portion of the Shark River Slough (SRS) basin, extending on either side of the L-67S canal. But in 2015, this transect was extended further east by 5 km (hereafter, named as M2E), thereby covering prairie vegetation along the eastern boundary of the ENP and transitional zone between marl prairie in NESRS and R&S landscape in SRS. Both M3 and M4 transects extend across SRS to marl prairies on both sides of the slough. Transect M5 covers an area between fresh and brackish water ecosystems in the southeastern corner of SRS, extending to the east into freshwater marl prairies located on both sides of the Main Park Road. Transect M6, established in spring 2019, extends from Main Park Road, southwest of Pa-Hay-Okee, to the edge of SRS (**Figure 1**).

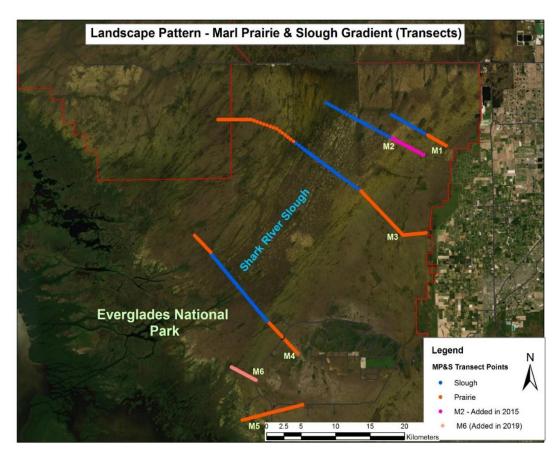


Figure 1: Location map of Marl prairie-Slough Gradient Study plots on Transects M1-M6

Table 1: Sites surveyed on MAP transects M1-M6 between 2005 and 2024. The numbers of sites on each transect sampled during the 5-year project performance period (2019-2024) are in bold.

Transect		Sites Surveyed					
	Sampling	Slou	gh sites	Prairie sites			
	Event	Year	Number of Sites	Year	Number of Sites		
M1	E1	2005	20	2006	11		
	E2	2008	20	2009	11		
	E3	2011	20	2012	11		
	E4	2014	20	2015	11		
	E5	2018	20	2019	11		
	E6	2022	20	2023	10		
M2 & M2E	E1	2005	25				
	E2	2008	26				
	E3	2011	25				
	E4	2014	25	2015	18		
	E5	2018	25	2019	18		
	E6	2022	26	2023	18		
	E1	2006	37	2007	72		
	E2	2009	37	2010	72		
	E3	2012	37	2013	72		
М3	E4	2015	37	2016	71		
	E5	2019	25	2020	38		
			37	2022	27		
	E 6	2023	38	2024	38		
M4	E1	2007	55	2008	32		
	E2	2010	55	2011	32		
	E3	2013	55	2014	32		
	E4	2016	50	2017	30		
	E5	2020	55	2021	30		
M5	E1			2008	31		
	E2			2011	31		
	E3			2014	31		
	E4			2018	31		
	E5			2022	31		
M6	E5			2019	34		

In the most recent 5-year cycle of the project (2019-2024), we completed a vegetation survey on all five transects (M1-M5). In both R&S and marl prairie portions of the transects M1 and M2 and in the slough and eastern marl prairie portions of M3, vegetation was sampled for the 6th time. Likewise, in the western prairie portion of M3 (M3W), and in both the slough and prairie portions of M4 and M5, the vegetation was sampled for the 5th time. As in the previous surveys, sites in the slough portions of the transects were accessed for sampling in the wet season by airboat, and in the marl prairie portions of the transects M1, M2 (i.e., M2E), M3 and M4, and all sites on M5 were accessed for sampling in dry season by helicopter. One site (M3-12000) was

the exception. This site, which had previously been accessed by helicopter, was accessed by airboat in 2023 due to extended flooding throughout the year. Likewise, one site on Transect M1 (M1-0300) and two sites on M4 (M4-20500 and M4-22000) were not sampled during this survey because the growth of cattail and sawgrass on the sites made the plot almost inaccessible. In fact, M1-0300 was also not sampled during the 2018 survey. Moreover, another site (M3-03600) had also not been sampled after the third (E3) sampling, because the site had changed to open water since the spring of 2016 when the water level was unusually high in the region.

2.2 Vegetation survey

Vegetation was surveyed in a nested-plot design that allowed for efficient sampling of the range of plant growth forms (herbs, shrubs, and trees) present along the transects (Ross et al. 2005; Sah et al. 2015a). Vegetation plots were sampled at 200-500 m intervals. Higher intensity sampling occurred in areas accessible by airboat, based on the contention that increased sampling intensity would enable us to make a more meaningful comparison of current vegetation with that present on the same transects in 1999 (Ross et al. 2001; Ross et al. 2003). At each survey site, a PVC tube or EMT marked the SE corner of a 10x10m tree plot. Nested within each tree plot, a 5x5m herb/shrub plot was laid out, leaving a 1-m buffer strip along the southern and eastern border of the tree plot. In the 10x10m tree plots, we measured the DBH and crown length and width of any woody individual ≥ 5cm DBH and then calculated species cover assuming horizontally flattened elliptical crown form. Within each 5x5m herb/shrub plot, we estimated the cover class of each species of shrub (woody stems>1m height and <5cm DBH) and woody vines, using the following categories: <1%, 1-4%, 4-16%, 16-33%, 33-66%, and >66%. We estimated the cover percent of herb layer species (all herbs, and woody plants <1m height) in five 1-m² subplots located at the four corners (NE, NW, SE, and SW) and the center (CN) of the 5x5m plot. Species present in the 5x5m plot but not found in any of the 1m² subplots were assigned a mean cover of 0.01%. In addition, to enable estimation of plant biomass, a suite of structural parameters was recorded in a 0.25m² quadrat in the SW corner of each of the five subplots. Structural measurements included the following attributes: 1) The height and species of the tallest plant in the plot; 2) Canopy height, i.e., the tallest vegetation present within a cylinder of ~5cm width, measured at 4 points in each 0.25m² quadrat; 3) Total vegetative cover, in %, and 4) Live vegetation percent cover, expressed as a % of total cover.

2.3 Water depth measurements

In the field whenever there was standing water, we measured water depths in each subplot of a site. Field water depths in combination with EDEN (Everglades Depth Estimation Network, http://sofia.usgs.gov/eden) water surface elevation data serve as the basis for calculation of ground elevation and estimation of hydrologic conditions at each site. Water depth was measured at each site along a transect, whether marl prairie or slough. We measured water

depths at the PVC, the marker of the plot, and in the center of five vegetation sub-plots in a 5x5m plot. At the marl prairie sites of four transects (M1, M3-M5), water depths were measured in the Fall of 2008. Likewise, water depths on Transect M2E were measured in Spring 2016, when the water level was unusually high, and the area had up to 30 cm of standing water. On the most recently established transect, M6, the water depths were measured in August 2019.

2.5 Data Analysis

2.5.1 Hydroperiod and annual mean water depth

We used field water depth-derived elevation and EDEN water surface elevation data to estimate the hydrologic conditions at each survey site on an annual basis. We calculated the ground elevation of each plot using mean water depth for the plot and EDEN estimates of water surface elevation at the plot center during the same survey date. Daily water levels for each plot were estimated based on ground elevation and the time series data of water surface elevation extracted from EDEN database. The hydroperiod (the number of days per year when a location had water depth >0cm) and mean annual water depth were calculated for each plot. We then averaged hydroperiod and mean annual water depth for the four water years (May1st—April 30th) prior to each survey to examine vegetation response to hydrologic changes.

2.5.2 Fire frequency and time since last fire

A fire geodatabase, covering the period 1948 to 2012 (Smith III et al. 2015), was obtained from Everglades National Park (ENP). The shape files for 2013-2024 fires were also obtained from the ENP and later added to the geodatabase. The database contains shape files of fires with other attributes such as type of fire (Natural, RX, incendiary, etc.), date of incidence, etc. The fire data were used to calculate fire frequency and time since the last fire (TSLF) for vegetation-monitoring sites on transects M1-M6 using ArcGIS Pro.

2.5.3 Vegetation classification and ordination

We summarized species data by calculating the importance value (IV) of each species present in the herb and shrub layers in each plot. We calculated species' importance value as IV = (relative cover + relative frequency)/2. Species that did not occur in any of five subplots but occurred within the 5 x 5 m² plot were assigned a frequency of species occurrence as 4%. The assumption was that, had all 25 1 x 1 m² subplots within a plot been surveyed, the species would have occurred in at least one subplot. To analyze the changes in species' abundance over time, major species were identified in each section of the transects by a criterion of mean IV greater than 2.0% at slough portions or greater than 4.0% at marl prairie portions. However, for the marl prairie sites of the transect M1 and western portion of M5 (i.e., M5W), the species with the mean IV greater than 3.5% were considered major species.

Vegetation types at all sites that were surveyed along the five transects between 2005 and 2008 had already been defined using a hierarchical agglomerative cluster analysis (Sah et al.

2015a). In the analysis, Bray-Curtis dissimilarity was used as the distance measure, and relatedness among groups and/or individual sites was calculated with the flexible beta method (McCune and Grace 2002). For this study, similar method was used to define the vegetation types at the sites surveyed on five transects (M1-M5) during the most recent surveys over last four years (2021-2024), when the transects M1, M2 (including M2E) and M3 (Slough and eastern prairie) were surveyed for the sixth time (E6), and M3 (western prairie), M4 and M5 were surveyed for the fifth time (E5). Non-metric multidimensional scaling ordination (NMDS) was done to analyze the shift in species composition using trajectory analysis (*see below subsection 2.5.5*).

2.5.4 Vegetation structure and Biomass estimation

For the sites in the marl prairie portion of the gradient, vegetation structural measurements were summarized for each plot, and mean canopy height and total vegetative cover were used to estimate aboveground plant biomass, using the allometric equation developed by Sah et al. (2007) for marl prairie vegetation within CSSS habitat. The equation for calculating biomass was as follows:

$$\sqrt{Biomass} = 6.708 + 15.607 * arcsine \sqrt{\frac{Cover}{100}} + 0.095 * Ht$$

where, Biomass = Total plant biomass (g/m^2) , Cover = Crown cover (%), and Ht = Mean crown height (cm).

To account for the variability inherent in the repeated measurement of vegetation structural variables (vegetation height, total cover, and green cover) and above ground biomass, General Linear Mixed Models (GLMM) were used to examine differences in structural variables and among survey years. The vegetation cover was square root-transformed and biomass data was log-transformed to approximate normality. Models were run in R v.4.3.1 (R Core Team, 2023) using the lmer function in the 'lme4' package (Bates, 2014). Sites (PlotID) were treated as a random variable. We treated sampling event (Sampyear) as a fixed effect to examine the differences in cover, height, and biomass among sampling events, which was done in a post hoc test using glht function implemented in 'multicomp' package. Nevertheless, the nonparametric Wilcoxon Paired Test was used to examine the differences in importance values (IV) of major species among survey years.

2.5.5 Vegetation response to hydrology – Trajectory analysis

At both marl prairie and slough sites on Transects M1-M5, changes in vegetation composition since the 1999 survey were analyzed using trajectory analysis (Minchin et al. 2005; Sah et al. 2014), an ordination-based technique designed to test hypotheses about rates and directions of community change. In the NMDS ordination performed for trajectory analysis for slough sites, we included vegetation data for prairie as well as R&S sites that were collected between 1999 and 2024. Prairie sites were included to cover the full range of hydrologic

conditions on the transects. In the NMDS ordination, the hydrology vector represented by mean annual water depth was defined through a vector fitting technique in DECODA (Kantvilas and Minchin 1989; Minchin 1998; Sah et al. 2014). To quantify the degree and rate of change in vegetation composition along the reference vector, two statistics, delta (Δ) and slope, were calculated (Minchin et al. 2005). Delta, which measures the total amount of change in the target direction, was calculated as the difference between the projected score at the final and initial time steps. Slope measures the mean rate of change in community composition in the direction of the target vector. The statistical significance of both delta (Δ) and slope was tested using Monte Carlo simulations, with 1,000 permutations of the importance values (IV) of species among surveys within each trajectory; the NMDS ordination and calculation of trajectory statistics were repeated on each permuted data matrix.

2.5.6 Weighted averaging and Vegetation-inferred hydroperiod

Vegetation change analysis in the marl prairie portion of the gradient also included calculation of vegetation-inferred hydroperiod, i.e., the hydroperiod for a site indicated from its vegetation composition using a weighted averaging (WA) regression model. The training-data set with which we developed the WA regression model was the species cover data, instead of IV used in trajectory analysis, plus hydroperiod estimates from 291 plots on six topographically surveyed transects within the Cape Sable seaside sparrow habitat (Ross et al. 2006). In developing the WA models, species cover values were fourth square root transformed, which down-weights the influence of very dominant species. Mean hydroperiod was calculated across different time periods (i.e., years preceding vegetation survey). The performance of the models was judged by the improvement in R² value and RMSEP (root mean square error of prediction). RMSEP was estimated by a leave-one-out (jackknife) cross-validation procedure, in which a model is developed from all samples except one and consequently applied to predict the hydroperiod of the left-out point based on its vegetation. We used the C₂ program (v. 1.7.7) of Juggins (2016) to develop the WA model.

Finally, the WA model was applied to the calibration data set, which included vegetation data collected at the marl prairie portions of the Transects M1-M5 during multiple sampling periods (E1-E6). The predicted hydroperiods for those sites were termed 'vegetation-inferred hydroperiod'. A change in vegetation-inferred hydroperiod between successive survey dates reflects the amount and direction of change in vegetation, expressed in units of days (0-365) along a gradient in hydroperiod.

3. Results

3.1 Hydrologic pattern (1999-2024)

Hydrologic conditions in Shark River Slough and adjacent marl prairies varied in both space and time over the last two and a half decades. In the slough portion of the transects studied (M1-M4), both hydroperiod and annual mean water depth averaged over four years prior to each vegetation survey varied over the 1999-2023 period. In the four years preceding the 1999 (E0) vegetation survey, mean hydroperiod on all four transects were >360 days (**Figure 2**) and mean (\pm SD) annual water depths were 38.0 ± 6.8 , 45.4 ± 7.7 , 42.8 ± 10.3 cm and 42.2 ± 5.3 cm on transects M1, M2, M3 and M4, respectively (**Figure 3**). At the slough sites on those transects, mean hydroperiod and annual water depth were significantly lower during three subsequent surveys (2005-2007 (E1), 2008-2010 (E2) and 2011-2013 (E3)) than the 1999 survey. However, during the 2014-2016 (E4) survey that coincided with the beginning of increment in water delivery into ENP due to Field Tests associated with the Modified Water Delivery (MOD), slough sites were wetter than the E3 survey, and four-year average hydroperiod at the sites on M1, M2, M3, and M4 were 317, 337, 340 and 359 days (**Figure 2**) while annual mean water depths were 26, 34, 32 and 38 cm (**Figure 3**), respectively.

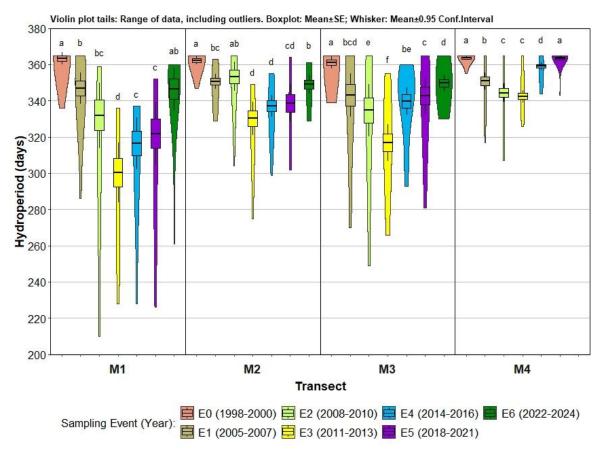


Figure 2: Violin plot showing hydroperiod (days) averaged over four years prior to vegetation survey in the Shark River Slough portions of MAP transects M1, M2, M3 and M4. Different letters represent a significant (pairwise t-test; p < 0.05) difference in 4-year average hydroperiod among surveys on individual transects.

At the sites on these transects (M1-M4), the wetting trend observed between E3 and E4, continued through E5 (2018-2021), when four-year average hydroperiods were 322, 339, 343 and 363 days (**Figure 2**), and annual mean (\pm SD) water depths were 32.9 \pm 6.8, 38.6 \pm 6.9, 38.0 \pm 10.6 cm and 42.8 \pm 5.5 cm, respectively (**Figure 3**). Nonetheless, both hydroperiod and mean annual water depth during the 2018-2021 (E5) survey were still lower than in the late 1990s (E0) except for M4, for which mean hydroperiod was only one day shorter and mean water depth 0.6 cm higher than in the four years prior to the 1999 survey. The wetting trend persisted until the most recent survey (E6: 2022-2024) on the transects M1, M2 and M3. On the slough sites of these three transects, four-year average hydroperiods were 346, 349 and 350 days (**Figure 2**), and annual mean (\pm SD) water depths were 45.6 \pm 6.6 cm, 41.0 \pm 6.9 cm, and 40.7 \pm 10.9 cm, respectively (**Figure 3**). During the E6 (2022-2024) survey, the hydroperiod on each of the M1, M2 and M3 transects and mean water depth on M2 and M3 were still lower than the hydroperiod and water depth in the late 1990s (E0). In contrast, at the sites on M1, which is entirely located in the NESRS region, the mean water depth during the E6 survey was 7.6 cm higher than the mean water depth during the years prior to the E0 (1999) survey.

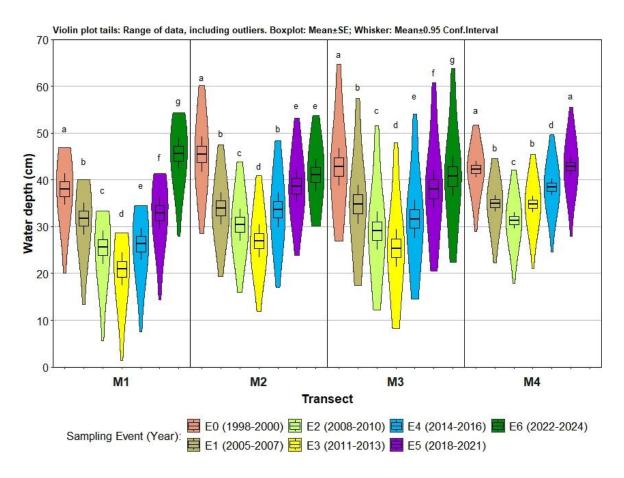


Figure 3: Violin Plots showing annual mean water depth (WD, cm) averaged over four years prior to vegetation survey in the Shark River Slough portions of MAP transects M1, M2, M3 and M4. Different letters represent significant (pairwise t-test; p < 0.05) difference in 4-year average water depth among surveys on individual transects.

Water conditions in the marl prairie portion of transect M1 varied among different surveys. Mean hydroperiod, averaged over four years before the 2009 (E2) survey, was 224 ± 30 days, i.e., 67 days shorter than in the years before 2006 (E1) (**Figure 4a**). However, the hydrological conditions in subsequent years, i.e., after the E2 survey, became wetter, and the wetting trend continued until the most recent 2023 (E6) survey, when the mean hydroperiod was 106 days longer than in the four years before E2. A similar trend was observed on M2E, which was surveyed in 2015 for the first time and then two times (2019 and 2023) thereafter. On this transect, the mean (\pm SD) hydroperiod was 339 \pm 19 days in 2023, i.e., 45 and 30 days longer than the hydroperiod during the 2015 and 2019 surveys, respectively (**Figure 4a**).

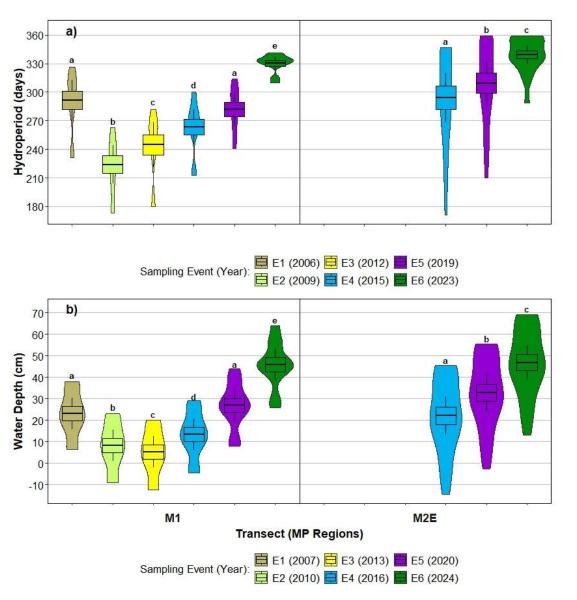


Figure 4: Violin Plots showing mean ($\pm 95\%$ CI) hydroperiod (a) and annual mean water depth (b) averaged over four years prior to vegetation survey in the marl prairie portions of MAP transects M1 and M2 (M2E). Different letters represent significant (pairwise t-test; p < 0.05) difference in 4-year average hydroperiod and water depth among surveys on individual transects.

On the marl prairie portion of Transect M1, the 4-year average annual mean water level during the 2023 (E6) survey was 45.7 ± 11 cm, which was higher than all the previous surveys (**Figure 4b**). Likewise, in the years prior to 2023, Transect M2E had an annual mean water depth of 46.8 ± 16.1 cm, i.e., 24 cm and 14 cm higher than during the years prior to the 2015 and 2019 surveys, respectively (**Figure 4b**). In general, hydroperiod and annual mean water depth are in tandem with each other. But on the marl prairie portion of Transect M1, the 4-year average annual mean water level was lowest during E3, not during E2 as was observed for hydroperiod (**Figure 4b**). However, both the hydroperiod and the mean annual water level before the 2015 (E4), 2019 (E5) and 2023 (E6) surveys were higher than E2 and E3. The differences in hydrologic conditions between surveys, especially the discrepancy between hydroperiod and annual mean water level observed between E1 and E6 as well as between E4 and E6 (**Appendix 1**), were due to extreme events. While the prolonged dry period between 2006 and 2008 saw water levels dip far below the ground level, in the spring of 2011, i.e., just before the 3^{rd} survey (E3), the water level on both M1 and M2E was the lowest in the last two decades (**Figures 5, 6**).

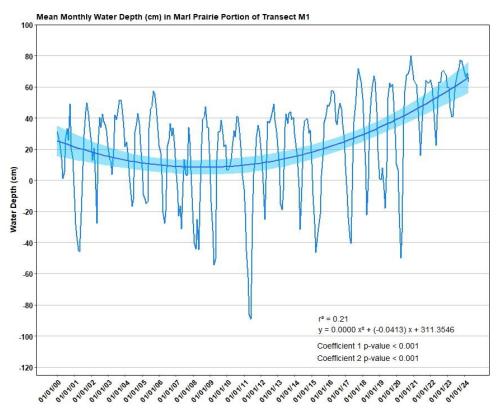


Figure 5: Mean monthly water depth on the marl prairie portion of the transect M1. The trend line was fitted using a polynomial model.

In the marl prairie portion of both M2E and M1, the wetter conditions during the 2019 and 2023 survey than in the previous surveys were expected, as these transects are in the NESRS region, where water delivery from the WCAs to the Park were enhanced during the 2016 emergency operations (Abtew and Ciuca, 2017) and winter of 2020/2021 and 2022/2023 (Cortez et al. 2022; Cortez 2024). In addition, the water delivery to this region is higher in recent years

than before the 2015 survey due to the MWD field tests followed by full implementation of COP in 2020 (USACE/ENP/SFWMD 2023), resulting in water levels that rarely receded below the ground, as shown by mean monthly water level on Transect 1 (**Figure 5**). In fact, at 9 of 11 sites on M1, and 15 of 18 sites on M2E, water level never receded below the ground in two years, WY 2022 and WY 2023. Also, mean monthly water levels along these transects also revealed an increasing trend in recent years (**Figures 5, 6**).

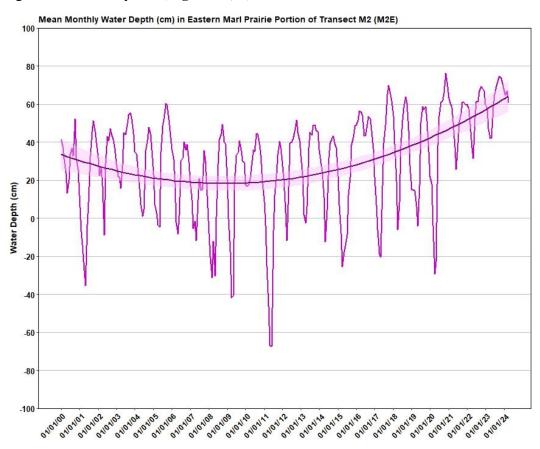


Figure 6: Mean monthly water depth on the marl prairie portion of transect M2 (M2E). The trend line was fitted using a polynomial model.

The hydrologic conditions on transect M3 are described through E6 (2024) while those on M4 and M5 are described only through E5 (2018-2022). Transects M3 and M4 are unique, as the hydrologic conditions in the marl prairie portion of these two transects differ between eastern and western sections, i.e., the east and west sides of SRS. On transect M3, water conditions were wetter in the eastern than western prairies. However, conditions on both sides of the slough were much drier during E2 than E1. In contrast, an increasing trend in both the four-year average hydroperiod and mean annual water depth was observed during the subsequent surveys (**Figures 7, 8**), although in the western portion both parameters decreased between E4 and E5 (**Figure 7b**).

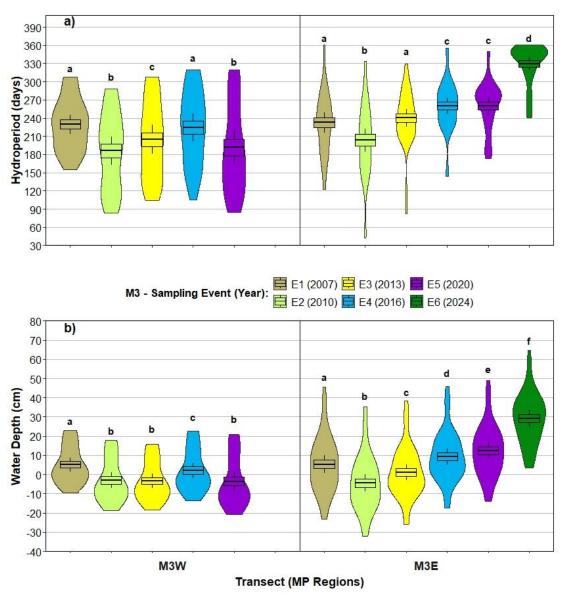


Figure 7: Violin Plots showing mean ($\pm 95\%$ CI) hydroperiod (a) and annual mean water depth (b) averaged over four years prior to vegetation survey in the marl prairie portions of MAP transect M3, which is separated into east (M3E) and west (M3W) based on location of sites on both sides of Shark River Slough. Sites on the eastern portion of Transect M3 were surveyed last (E6) in 2024, whereas the sites on western portion of M3 were last (E5) surveyed in 2022. Different letters represent significant (pairwise t-test; p < 0.05) difference in 4-year average hydroperiod and water depth among surveys on individual sections of the transect.

The eastern prairie sites of M3 were significantly (Paired T-test; p < 0.001) wetter during the most recent survey, 2024 (E6) than during previous surveys. During the E6 survey, the mean (\pm SD) of four-year average hydroperiod was 329 \pm 34 days, which was 69 days higher than during E5, and 97 days higher than the hydroperiod during E1 (Appendix 1). The four-year average water depth during E6 was also 17 cm higher than during E5. Since the western marl prairie portion of M3 was not sampled during E6, it is important to compare the hydrologic changes between eastern and western marl prairies only until E5, especially when a different trend in hydrological changes was observed between the two regions (**Figure 8, Appendix 1**).

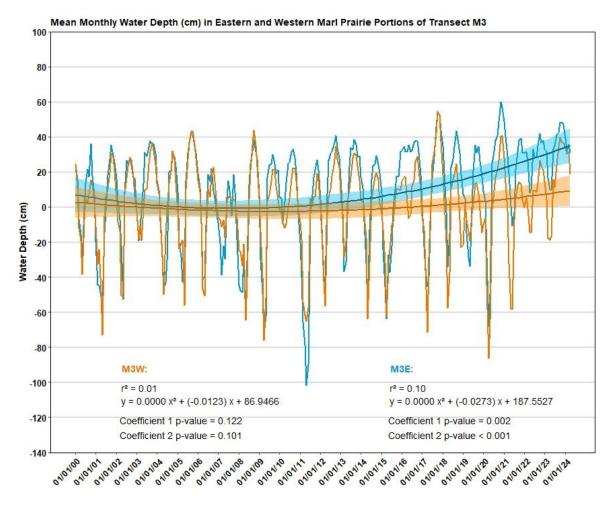


Figure 8: Mean monthly water depth on the marl prairie portions of transect M3, separated into east (M3E) and west (M3W) based on the location of marl prairie sites on both sides of the Shark River Slough. The trend line was fitted using a polynomial model.

On the eastern marl prairie portion of M3 (i.e., M3E), while the mean \pm SD (260 \pm 41 days) four-year average hydroperiod during E5 was the same as during the E4 survey (**Figure 7a**), the mean annual water depth was 3.1 cm higher (paired t-test: n = 41, p < 0.001) during the 2020 survey than during the 2016 survey (**Figure 7b**). Likewise, the sites on M3E had longer hydroperiods and deeper water depths during the four years prior to E5 than that of the E1 survey. In contrast, the sites on M3W had shorter hydroperiods and shallower water depths during the four years prior to E5 than that of all previous surveys, including E4. In 2022 (E5), the four-year average hydroperiod in the western prairies of M3 was 191 \pm 74 days, while the mean annual water depth was -3.6 \pm 13.0 cm. It is also important to note that at the western prairie (M3W) sites, despite unusually high-water conditions in the spring of 2016 (E4), the four-year mean annual water depth associated with the 2016 survey was still significantly lower (paired t-test: n = 31, p < 0.001) than during the 2007 (E1) survey (**Figure 7b**). Also, the difference in water level between M3E and M3W was very distinct in the dry season, when water levels at western sites dropped far below the ground (**Figure 8**), primarily due to different seasonal closure schedules of the S-12s between Nov 15 and July 15.

On the transect M4, the hydrologic conditions in the marl prairie portion also differed between eastern and western sections (**Figure 9**). In this region of the marl prairie landscape, the Main Park Road affects the hydrologic conditions. In general, sites located southeast of the road (M4E_1) were drier than sites in the northwestern portion (M4E_2) of the transect (**Figure 10**). The difference in water level is especially distinct in the dry season, when the water level at eastern sites falls far below the surface, while sites between the Main Park Road and the SRS had water level higher than water level at the eastern sites, but lower than the sites west of SRS.

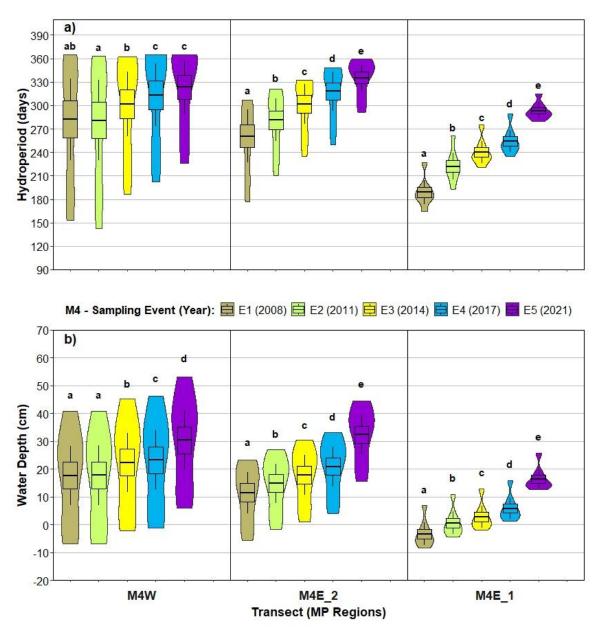


Figure 9: Violin Plots showing mean ($\pm 95\%$ CI) hydroperiod (a) and annual mean water depth (b) averaged over four years prior to vegetation survey in the marl prairie portions of MAP transect M4, separated into east (M4E) and west (M4W) based on location of sites on both sides of Shark River Slough. M4E is further separated into M4E_1 and M4E_2, based on the east and west side of the Main Park Road. Different letters represent significant (pairwise t-test; p < 0.05) difference in 4-year average hydroperiod and water depth among surveys on individual transects.

On transect M4, in the prairies on both sides of the slough, it was drier during E1 than during any other survey. In fact, both the four-year average hydroperiod and mean annual water depth showed an increasing trend during the next four surveys. The increase in water depth across the five surveys was less in the western prairies (~13 cm) than in the eastern prairies (~20 cm) (**Figure 9b**). The four-year average hydroperiod prior to E5 (2021) survey in M4E_1, M4E_2 and M4W portions of this transect were 293 (\pm 11), 335 (\pm 23) and 323 (\pm 53) days, respectively (**Figure 9a**). Likewise, the mean annual water depths were 16.4 (\pm 4.2), 32.3 (\pm 10.0) and 30.4 (\pm 16.6) cm, respectively (**Figure 9b**).

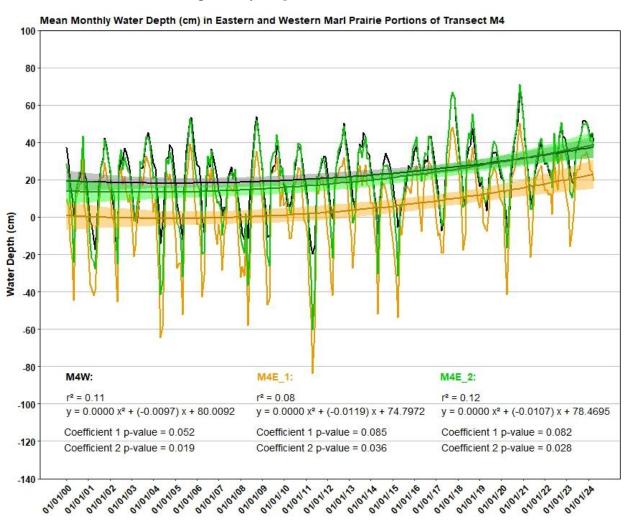


Figure 10: Mean monthly water depth on the marl prairie portions of transect M4. Transect M4 is separated into east (M4E) and west (M4W) based on location of sites on both sides of the Shark River Slough. The eastern marl prairie sites are further separated into east (M4E_1) and west (M4E_2) of the Main Park Road. The trend lines were fitted using polynomial models.

On transect M5, both the four-year average hydroperiod and mean annual water depth exhibited an increasing trend during the E1 to E5 survey period (**Figure 11a, b**). However, conditions were consistently wetter at sites west of the Main Park Road than at eastern sites (**Figure 12**). Particularly, in the dry season when the water level drops below the ground on

both sides of the Main Park Road, the water level in M5W remains about 20 cm higher than the water level in M5E. Between 2008 and 2022, the four-year average hydroperiod increased from 238 to 331 days and from 196 to 309 days on the western (M5W) and eastern (M5E) portions of the transect, respectively (**Figure 11a**). In 2008 (E1), the mean annual water depths were 4.4 (\pm 4.0) and -3.1 (\pm 4.3) cm in the western and eastern portions of the transect, respectively (**Figure 11b**). However, the increase in the mean annual water depth between E1 and E5 surveys was much higher in the eastern portion of the transect than in the western portion. In 2022 (E5), the mean annual water depths were 16.3 (\pm 3.8) and 10.3 (\pm 4.0) cm in the western and eastern portions of the transect, respectively.

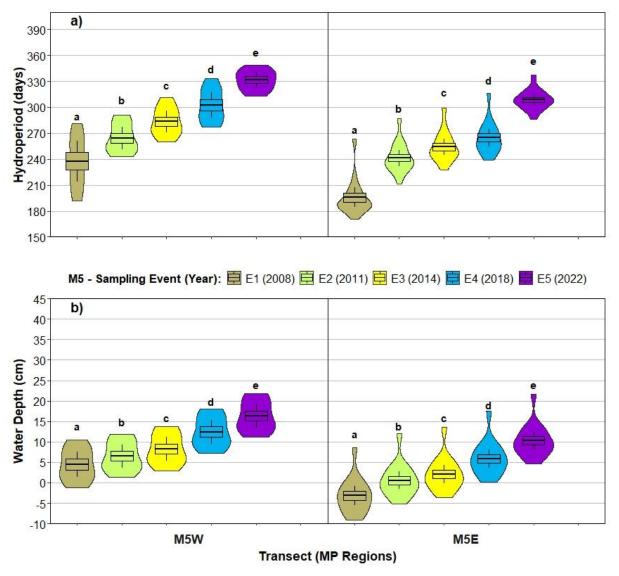


Figure 11: Mean ($\pm 95\%$ CI) hydroperiod (a) and annual mean water depth (b) averaged over four years prior to vegetation survey in the marl prairie portions of MAP transect M5. The transect M5 is separated into east (M5E) and west (M5W) based on location of sites on both sides of the Main Park Road. Different letters represent significant (pairwise t-test; p < 0.05) difference in hydroperiod and mean water depth among surveys on individual sections of the transect. The transect was last (E5) surveyed in spring 2022.

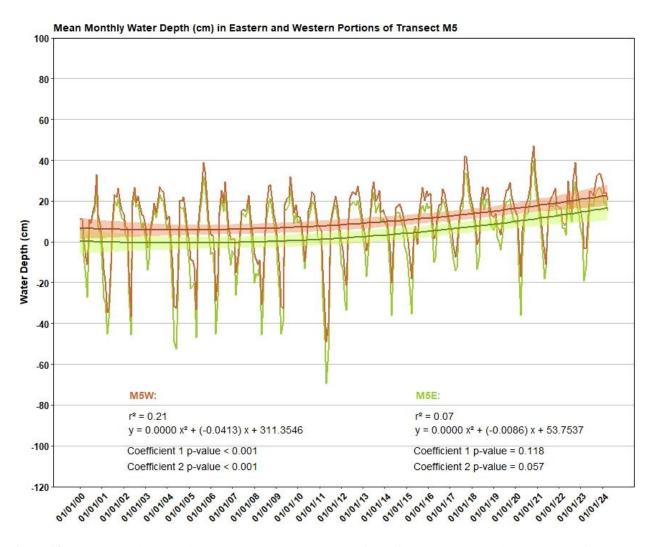


Figure 12: Mean monthly water depth on eastern and western portions of the transect M5. The transect M5 is separated into M5E and M5W based on the sites east and west of the Main Park Road. The trend lines were fitted using polynomial models.

3.2 Fire frequency and time since last fire

Historically, sites on the MP-S gradient transects have burned frequently. However, between 1990 and 2005, the period that included the E0 vegetation surveys (1998-2000) in SRS, there were few fires within the area. Burned plots included only two sites on M2E in 1990, and eight sites on M4, where four sites burned in 1999 and four in 2003. After 2005, when vegetation monitoring began at regular intervals along marl prairie-slough (MP&S) gradient transects, fire frequency seems to have increased. Both prairie and slough sites on four transects (M1, M2, M3 & M4) frequently burned due to either prescribed burns (Rx), human-caused fire or lightningignited fires (**Table 2**). Several sites on Transects M4 and M5 and almost all survey sites on Transect M6 were burned in 2023, while ten sites on M4 burned in 2024.

Table 2: Vegetation survey sites burned over the study period (2005-2023). The fire attributes were obtained from the Fire database of Everglades National Park.

Fire Name	Year	M1	M2	M2E	M3	M4	M5	M6
Between 1990 and 2	2005	0	0	2	0	8	0	0
L67 Rx	2005	0	1	0	0	0	0	0
Airboat	2006	18	4	6	7	0	0	0
U Road Rx	2007	0	0	10	0	0	0	0
Coptic	2007	1	0	0	0	0	0	0
West L67 WFU	2007	0	1	0	0	0	0	0
Mustang Corner	2008	11	1	9	44	0	0	0
Shark Valley Tram Rx	2009	0	0	0	1	0	0	0
ROG NE Rx	2012	0	12	0	31	0	0	0
EE 1 Rx	2012	18	13	0	0	0	0	0
ROG NW Rx	2014	0	0	0	11	0	0	0
Branch	2015	0	0	0	0	1	0	0
Dog Wood	2015	0	0	0	2	0	0	0
ROG West wui	2017	0	0	0	3	0	0	0
Cane Mill Hammock	2018	0	0	0	0	1	0	0
ROG NE	2018	0	12	0	24	0	0	0
Western Pines	2018	0	0	0	0	10	0	0
ROG East	2019	0	0	0	0	12	0	0
Guava	2020	0	0	0	0	18	0	0
MoonFish	2020	0	0	0	7	0	0	0
Northeast EE-3 Rx	2021	4	0	0	0	0	0	0
Northeast Corner	2021	0	6	0	0	0	0	0
Shark Slough	2021	0	1	0	0	0	0	0
ROG West (Dr311) Rx	2022	0	0	0	0	24	0	0
EE-1 (DR311) Rx	2022	11	4	0	0	0	0	0
EE-4 (BIL) Rx	2022	0	1	3	0	0	0	0
Tarpon Rx	2023	0	0	0	0	22	15	34
Western Pines Rx	2024	0	0	0	0	10	0	0

The fire-frequency on these transects over the 77 years (1948-2024) for which fire data were available from ENP records is summarized in **Figure 13**. Fire frequency was as high as 1.25 fires per decade, and northern transects (M1-M3) burned more often than southern ones (M4-M6) where fire frequency was as low as 0.1 fires per decade. An exception was the eastern portion (east of Main Park Road) of the transect M4, where some sites had fire frequency similar

to those on the marl prairie portion of the northern transects. Of the four transects (M1-M4) that include both prairie and slough sites, fire frequency was higher in the marl prairie sites than the slough portion of the transects. However, at the marl prairie sites, 1.25 fires/decade (i.e., fire return interval of 8 years) is within the range of the recommended strategy of 3–12-years set by the Everglades National Park Fire Management Plan (NPS 2015).

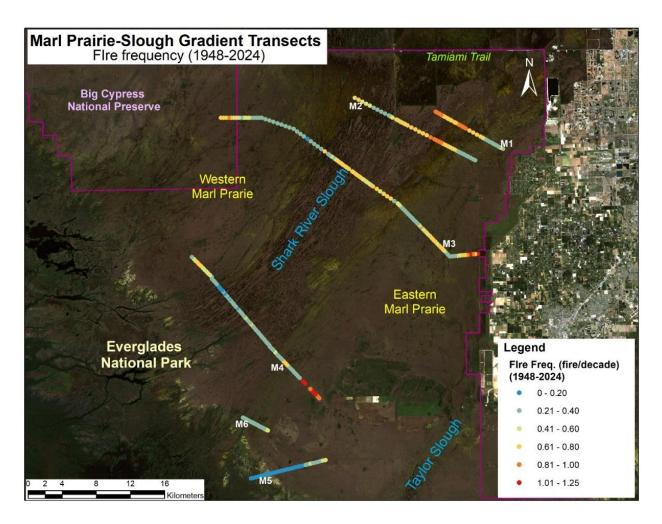


Figure 13: Fire frequency (number of fires/decade) at the vegetation survey sites on Transect M1-M6. Fire frequency was calculated over 77 years (1948-2024) for which the fire shape files were available in Everglades National Park Fire database.

Fire regimes, including fire intensity, frequency, and time since last fire (TSLF), i.e., the time elapsed between the burned-year and vegetation survey, are one of the major drivers of vegetation dynamics in the Everglades, including the vegetation pattern observed at the survey sites on the MP&S gradient transects. A comprehensive analysis of the effects of fire and its interaction with hydrology on vegetation composition on all six surveyed transects is underway, and the detailed results will be included in the 2025/2026 report, when all transects will have been sampled for the 6th time.

3.3 Vegetation change

3.3.1 Vegetation change in Slough (1999-2024)

The slough sites on three transects (M1-M3) were sampled six times after the 1999 survey, while those on M4 were sampled only five times. Moreover, over the two and half decades, vegetation shift patterns differed among four transects, depending on their location along the north-south gradient of SRS. Two transects, M1 and M2, which are in the north, and were most recently surveyed in 2022, showed a similar pattern in vegetation shift. Between 1999 and 2022, marsh vegetation on these two transects showed a shift in relative abundance of species that were indicative of sensitivity to hydrologic change. However, the direction and rate of vegetation change was not uniform throughout the study. Trajectory analysis results revealed that species composition at slough sites of M1 and M2 tracked the trend in hydrologic changes and continued to shift towards drier vegetation types until 2011 (E3) (**Figures 14, 15**). However, between 2011 (E3) and 2022 (E6), species composition shifted in the opposite direction, i.e. toward wetter vegetation types. In the first three years, i.e., between 2011 and 2014, the shift toward wetter vegetation composition was nominal, especially on Transect M1. However, on both transects, the change in vegetation composition was very distinct between 2014 (E4) and 2022 (E6), the period marked by an increase in both hydroperiod and mean annual water depth (**Figures 2, 3**).

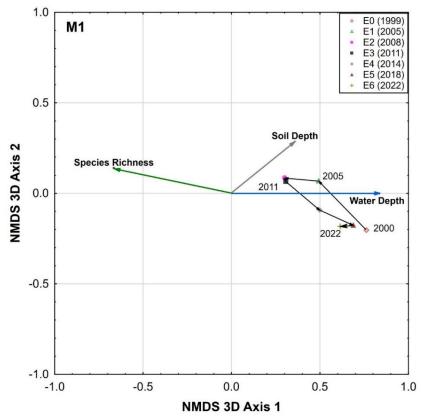


Figure 14: NMDS ordination biplots of the trajectory of centroids, calculated using the Axis scores of sites on slough portions of the Transect M1, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected seven times between 1999 and 2022 on this transect. The initial point of the trajectory represents 1999, whereas the end point of the trajectory is 2022.

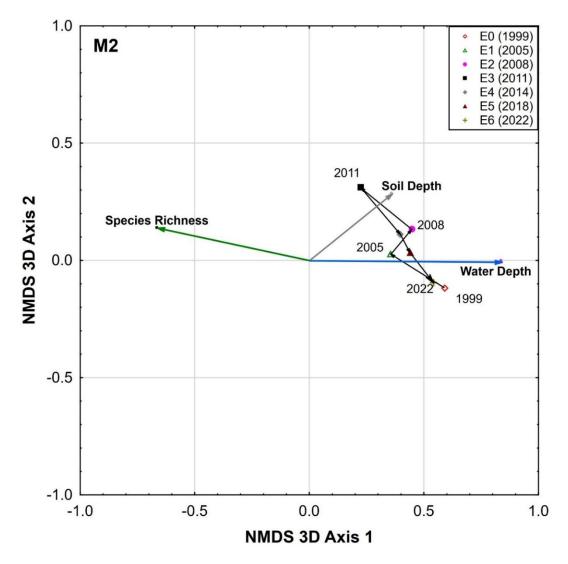


Figure 15: NMDS ordination biplots of the trajectory of centroids, calculated using the Axis scores of sites on slough portions of the Transect M2, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected seven times between 2000 and 2022 on this transect. The initial point of the trajectory represents 2000, whereas the end point of the trajectory is 2022.

Moreover, the results revealed that over 23 years, between 1999 and 2022, only a few sites were significantly displaced away from the base year along the hydrologic vectors in the ordination space (**Appendix 2**), resulting in proximity of centroids for both 1999 and 2022 surveyed years in the ordination space (**Figure 14, 15**). This suggests that at most sites on those two transects, species composition in 2022 was very similar to the composition during the 1999 survey.

On these two transects, vegetation change patterns are also reflected in changes in importance values (IV) of major species (Mean IV > 2.0%) over the study period. As expected, the IV of sawgrass (*Cladium jamaicense*) increased when the sites were getting drier but then decreased after the E3 (2011) survey (**Figure 16a, 17a; Appendix 3a**). There was no significant

difference (Wilcoxon Paired Test: p-value = 0.733 & 0.463 for M1 & M2, respectively) in sawgrass importance values between E0 (1999) and E6 (2022) surveys. On transect M1, the mean sawgrass importance values were 33.1% and 34.7% during the E0 (1999) and E6 (2022) surveys, while on M2, the sawgrass IV were 37.2% and 35.2%, respectively, during those two surveys. Likewise, during the E0 (1999) and E6 (2022) surveys, the mean importance values (IV) of spikerush (*Eleocharis cellulosa*) were 11.8% and 16.7% on M1, while that were 15.9% and 15.3% on M2, respectively. In contrast, Importance Value (IV) of *Utricularia* species on both M1 and M2, and IV of maidencane (*Panicum hemitomon*) on M2, were the lowest during E2 and/or E3 surveys (**Figure 16c, d; 17c, d, e**), when the slough portion of those transects was relatively dry (**Figures 2, 3**). However, IV of these species significantly (Wilcoxon Paired Test: p-value <0.05) increased between the E3 (2012) and E6 (2022) surveys. Also, the mean importance value of lemon bacopa (*Bacopa caroliniana*), an indicator species of wetness, on Transect M1 was higher during the E6 survey than it was two decades ago.

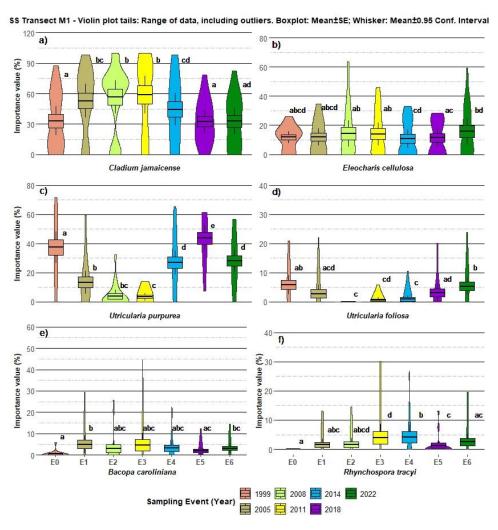


Figure 16: Violin plots of major species' importance value (IV) in the slough portion of Transect M1 for the 1999 survey and all six surveys (E1-E6) done between 2005 and 2022. Different letters represent significant (Wilcoxon test; p < 0.05) differences in species cover between different surveys.

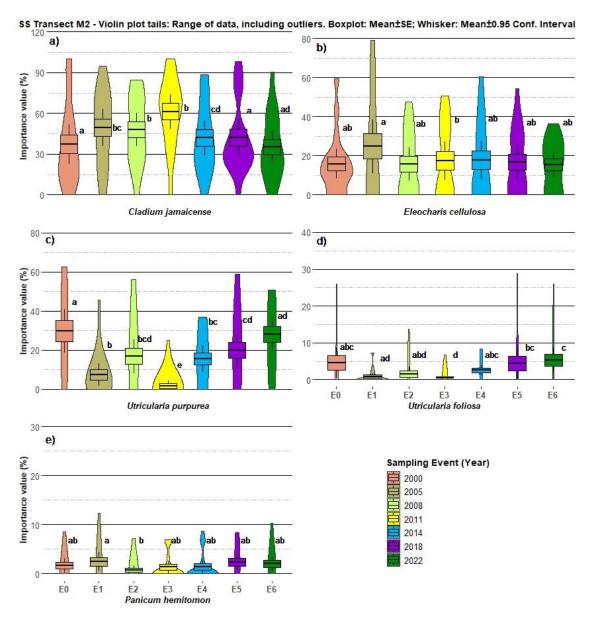


Figure 17: Violin plots of major species' importance value (IV) in the slough portion of Transect M2 for the 2000 survey and all six surveys (E1-E6) done between 2005 and 2022. Different letters represent significant (Wilcoxon pairwise t-test; p < 0.05) differences in species cover between different surveys.

In the slough portion of transect M3 in central SRS, the direction of plant compositional change was towards drier vegetation through E2 (2009) (**Figure 18**). While between 2009 and 2015 the slough sites on this transect were tracking the fluctuations in water conditions, after 2015, the shift in vegetation composition was towards the wetter type, and the magnitude of changes between 2019 and 2023 was much higher than the change between 2015 and 2019. However, trajectory analysis results revealed that among the sites that were sampled once in the late 1990s and six times between 2006 and 2023, vegetation composition at 82% of sites was still drier in 2023 than in 1999, though the shift in the ordination space towards the drier type was significant at only 29% of sites (**Appendix 2**). In contrast, the shift in vegetation

composition at 18% of sites was towards the wetter type, of which the shift was significant at 20% of sites.

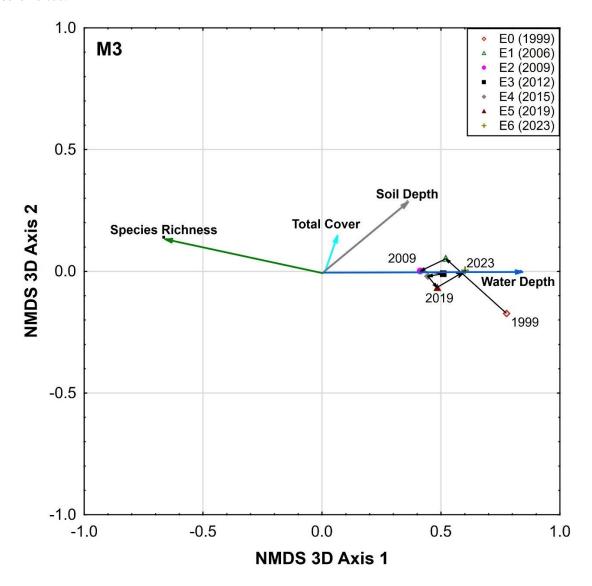


Figure 18: NMDS ordination biplots of the trajectory of centroids, calculated using the Axis scores of sites on slough portions of the Transect M3, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected seven times between 1999 and 2023 on this transect. The initial point of the trajectory represents 1999 whereas the end point of the trajectory is 2023.

In concurrence with changes in hydrologic condition within central SRS, where the transect M3 is located, the relative abundance of major species (Mean IV > 2.0%) on its slough sites changed significantly over the study period. Mean IV of sawgrass (*C. jamaicense*) and spikerush (*E. cellulosa*) increased significantly from that in E0 (1999) over the next five sampling events, i.e., until E5 (2019) when the area was relatively dry (**Figures 19a; Figures 2, 3**). However, the IV of both species significantly decreased between E5 (2019) and E6 (2023), and their IVs in E6 were not significantly different (Wilcoxon Paired Test: p-value = 0.264 & 0.065) from the values in E0 (1999). During the 1999 and 2023 surveys, the mean IV of

sawgrass were 27.8% and 32.8% and that of spikerush were 10.19% and 13.88%, respectively (**Appendix 3b**). In contrast with the trend observed for sawgrass and spikerush, the mean IV of bladderwort species (*Utricularia spp.*) decreased significantly between E0 and E4, but not between E0 and E3. While the IV of both *U. purpurea and U. foliosa* later increased after E4, the IV values of *both species* during the E6 (2023) survey were still lower than the values during E0, although IV of *U. foliosa* during E6 was not significantly different from the IV during E0.

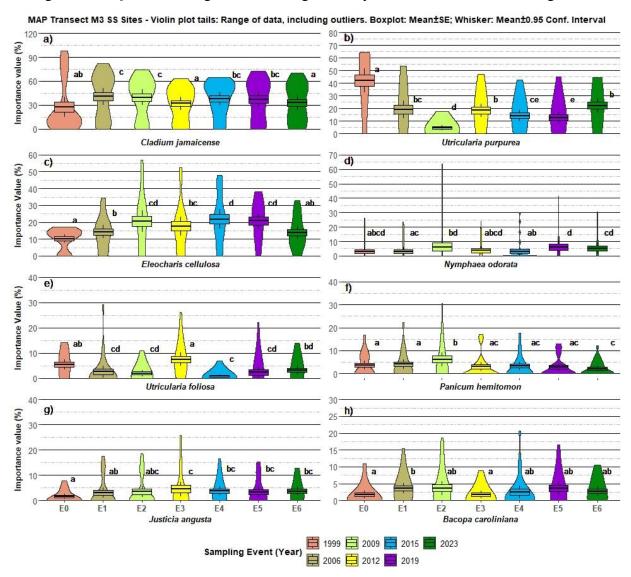


Figure 19: Violin plots of major species' importance value (IV) in the slough portion of Transect M3 for the 1999 survey and all six surveys (E1-E6) done between 2006 and 2023. Different letters represent significant (Wilcoxon test; p < 0.05) differences in species cover between different surveys.

In the slough portion of the transect M4 located in south central SRS, the direction of plant compositional change was towards drier vegetation until E1 (2007) (**Figure 20**). However, during the subsequent 2010 survey (E2), M4 vegetation trajectory reversed as slough sites shifted towards more hydric type, staying the same during the 2013 (E3) survey and showing minimal change towards a drier type after that (**Figure 20**). Trajectory analysis results also revealed that

among the sites that were sampled once in the late 1990s and five times between 2007 and 2020, vegetation composition at 77.8% of sites in 2020 was still drier than in 1999, however such differences in vegetation over 13 years, as represented by the shift in position of the sites in ordination space, was significant at only 41.7% of sites (**Appendix 2**).

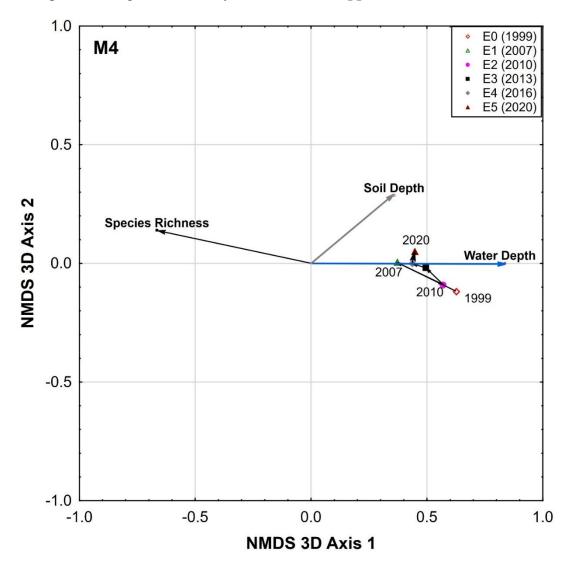


Figure 20: NMDS ordination biplots of the trajectory of centroids, calculated using the Axis scores of sites on slough portions of the Transect M4, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected seven times between 1999 and 2020 on this transect. The initial point of the trajectory represents 1999, whereas the end point of the trajectory is 2020.

In concurrence with changes in hydrologic condition within south central SRS, where the slough portion of M4 is also located, the relative abundance (IV) of some of the most abundant species (Mean IV > 2.0%) changed significantly (**Figure 21**). The drier conditions during E1-E4 (2007-2017) compared to E0 (1999) resulted in an increase in the relative abundance of sawgrass (*C. jamaicense*) and spikerush (*E. cellulosa*) and a decrease in the abundance of bladderworts (*Utricularia* spp.) and lemon bacopa (*B. caroliniana*). In this portion of slough, the IV of

sawgrass did not differ between E4 (2016) and E5 (2020) surveys, whereas IV of sawgrass during these two surveys was significantly higher than in three (E0, E2 and E3) of the previous four surveys (**Figure 21a; Appendix 3b**). In contrast, the mean IV of spikerush during E5 (2020) decreased by 5.3% since the last survey in 2016 (IV value: 18.9 ± 17.0 and 24.2 ± 19.5 , respectively), though the difference was not significant between E5 and all previous surveys. The IV of the bladderwort species (*U. purpurea*) varied greatly over the study period (**Figure 21c**). Between E4 and E5 surveys, while IV of *U. purpurea* significantly increased, the IV of *U. foliosa* decreased, a trend also observed for the IV of lemon bacopa (*B. caroliniana*) (**Figure 21d, e**).

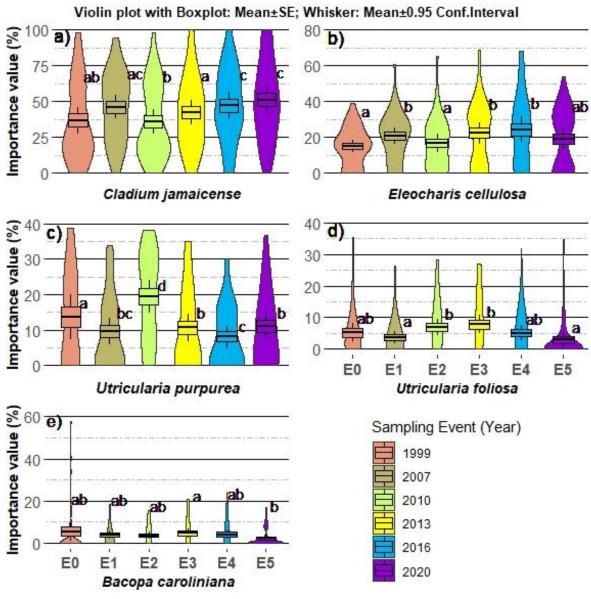


Figure 21: Violin plots of major species' importance value (IV) in the slough portion of Transect M4 for the 1999 survey and all five surveys (E1-E5) done between 2007 and 2020. Different letters represent significant (pairwise t-test; p < 0.05) differences in species cover between different surveys.

Across the slough sites in all four transects which cross through shark river slough (M1, M2, M3 and M4), the mean importance values of sawgrass and spikerush were the lowest during the 1999 survey, when the sites were much wetter (hydroperiod >360 days), and the mean water depth at three of four transects (except M1) was higher than the most recent survey (E5 or E6). While their mean importance values during the next five surveys (E1-E5) were significantly higher than that during the E0 due to drier conditions in comparison to the late 1990s, there was no significant difference in their IV between E0 and E6 (**Figure 22a, b**). In contrast, the IV of eastern purple bladderwort, *Utricularia purpurea*, was significantly lower in all surveys, including even E6, than its IV in 1999 (**Figure 22c**). The IV of other major hydric species (*U. purpurea*, *B. caroliniana* and Maidencane, *Panicum hemitomon*) varied over the years, but the values were not significantly different among seven surveys between 1999 and 2023 (**Figure 22, d, e, f**).

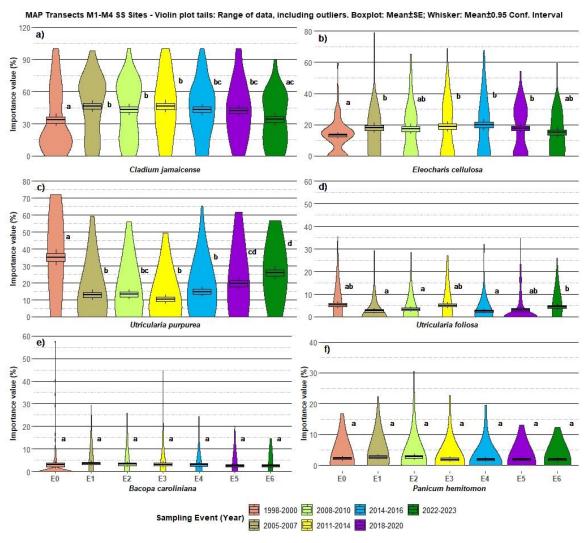


Figure 22: Violin plots of major species' importance value (IV) in the slough portion of transects, averaged across all four (M1-M4) transects for each survey. After the 1999 survey, the sites in the slough portion of M1 and M2 were last surveyed for the sixth time in 2022 and that of M3 in 2023, while sites on M4 were surveyed for the fifth time in 2020. Different letters represent significant (Wilcoxon test; p < 0.05) differences in species cover between different surveys.

3.3.2 Vegetation change in Marl Prairie (2006-2024)

Transect M1 and M2E

On Transect M1, where marl prairie sites were surveyed six times between 2006 and 2023, the vegetation change pattern differed between the periods before and after 2015, i.e., when the enhancement in water delivery into ENP kicked off under the recent restoration efforts (**Figure 23**). Before 2015, while species composition shifted towards a drier type, as evidenced by the threefold increase in the abundance of muhly grass (*Muhlenbergia capillaris*) and 62% decrease in the abundance of Lemon bacopa (*B. caroliniana*) (**Appendix 4a**).

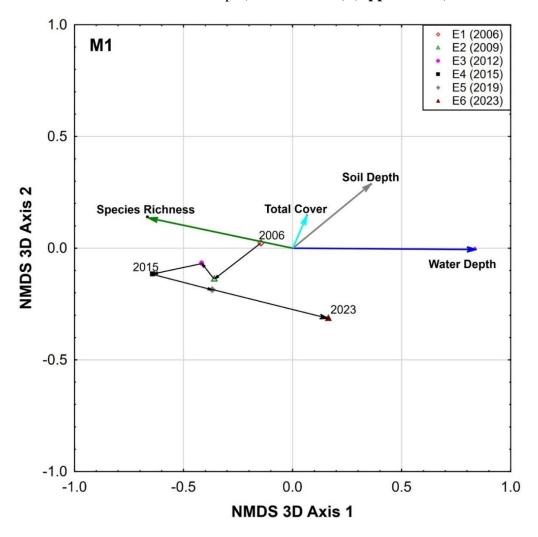


Figure 23: NMDS ordination biplots of the trajectory of centroids, calculated using the Axis scores of sites on marl prairie portions of the transects M1, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected 6 times between 2006 and 2023 on Transect M1. The initial and end points of the trajectory represent 2006 and 2023, respectively.

After 2015, vegetation composition shifted towards a wetter type, and such a shift continued until the most recent survey in 2023 (**Figure 23**), when marl prairie sites on transect M1 were much wetter than during the E1 (2006) survey (**Figure 4**; **Appendix 1a**). A similar

pattern, i.e., a shift in vegetation composition towards the wetter type, was also observed on M2E, which was surveyed in 2015 for the first time (**Figure 24**), primarily responding to an increase in mean hydroperiod and water depth since 2015 (**Figure 4a, b**).

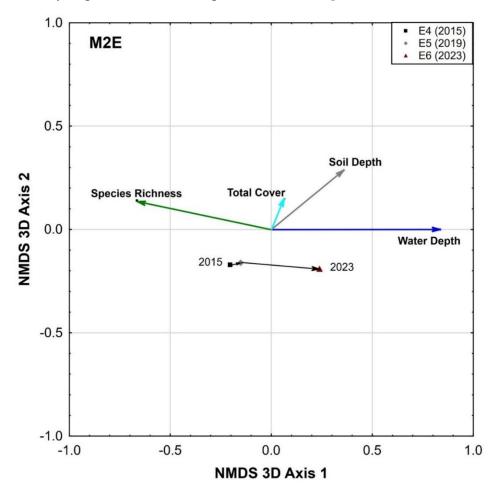


Figure 24: NMDS ordination biplots of the trajectory of centroids, calculated using the Axis scores on marl prairie portions of the transects M2E, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected 3 times between 2015 and 2023 on Transect M1. The initial and end points of the trajectory represent 2015 and 2023, respectively.

The wetter condition of marl prairie sites on M1 and M2E in 2023 than in 2006 and 2015, respectively, were also evident in an increase in vegetation-inferred hydroperiod (**Figures 25**, **26**). In the marl prairie portion of M1, the mean vegetation-inferred hydroperiod was 45 days longer in 2023 than in 2006. However, the pattern of change in inferred-hydroperiod differed between before and after 2015. In fact, the mean inferred hydroperiod was the lowest during the E4 (2015) survey (Sah et al. 2020). However, after 2015, the mean inferred-hydroperiod showed an increasing trend, resulting in the inferred hydroperiod at most sites in 2023 higher than the inferred hydroperiod during E1 (2006) (**Appendix 5**). During the E6 (2023) survey, the inferred hydroperiod values on M1 and M2E were 70 days and 40 days higher than the values during the E4 (2015) survey (**Figure 26 a, b**). The same pattern is observed between the last two surveys E5 (2019) and E6 (2023) (**Figure 26 c, d**).

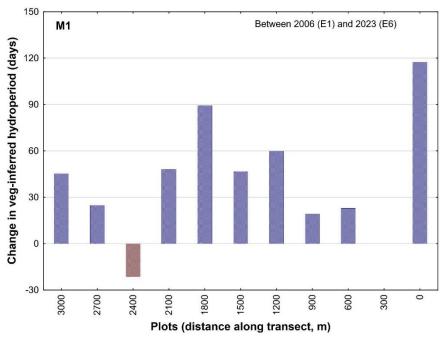


Figure 25: Change in vegetation-inferred hydroperiod between E1 (2006) and E6 (2023) at the vegetation monitoring sites in prairie portions of the Transect M1.

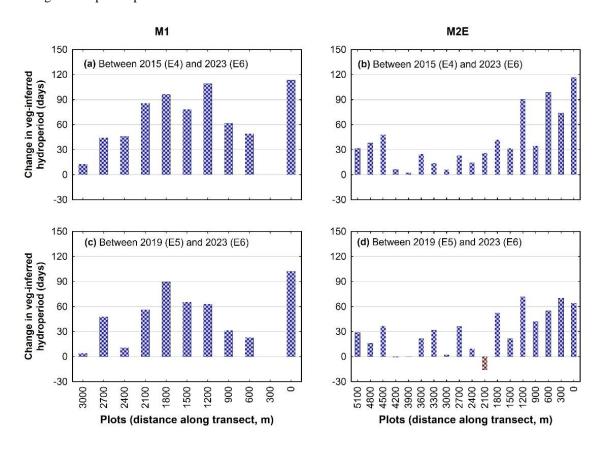


Figure 26: Change in vegetation-inferred hydroperiod between (a) E4 (2015) and E6 (2023) and (c) E5 (2019) and E6 (2023) at the vegetation monitoring sites in prairie portions of the Transect M1 and between (b) E4 (2015) and E6 (2023) and (d) E5 (2019) and E6 (2023) for M2E.

In concurrence with the changes in hydrologic conditions in the prairie portion of the M1 transect, the abundance of representatives of both prairie and hydric major species (Mean IV > 3.5%) also changed over time. However, the pattern of change in abundance of those species differed between the first few surveys and the most recent surveys, especially after 2015. For instance, between 2006 and 2012, the mean importance value (IV) of sawgrass (*C. jamaicense*) and panic grass (*Coleataenia tenera*) did not change much (**Appendix 4a**), while the IV of those species slightly decreased in recent years (**Figure 27a, e**). Likewise, a significant decrease (Wilcoxon Paired Test: p = 0.008) in IV of beakrush (*Rhynchospora tracyi*) between E5 and E6, and in IV of multy grass (*M. capillaris*) between E4 and E6 are in tandem with the wetting trend observed in recent years. The mean IV of multy grass and spadeleaf (*Centella asiatica*) had peaked at 7.9% and 4.6%, respectively, during the E4 (2015) survey but both species did not occur during the 2023 survey at any of M1 prairie sites (**Appendix 4a**). In contrast, the mean IV of spikerush (*E. cellulosa* and *Utricularia purpurea*), both indicator species of wetness in marl prairies, significantly increased (Wilcoxon Paired Test: p = 0.005) between E4 (2015) and E6 (2023).

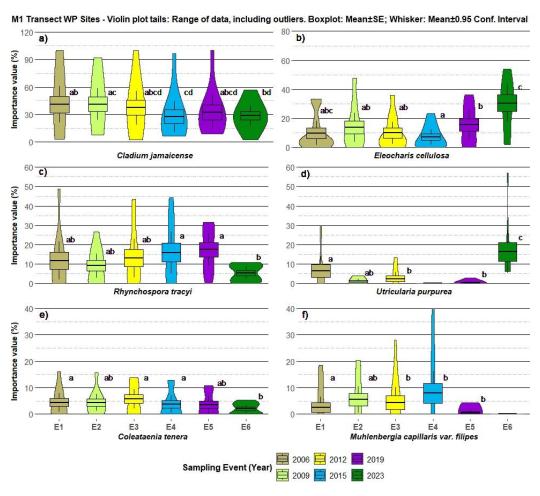


Figure 27: Violin plots of major species' importance value (IV) in the marl prairie portions of Transect M1 averaged across sites for the first (E1) and sixth (E6) survey.

On Transect M2E, the sites have become increasingly wetter since 2015 (**Figure 4**) but the mean importance values of two major species (Mean IV > 4.0%), sawgrass (*C. jamaicense*) and spikerush (*E. cellulosa*), did not change much (Wilcoxon Paired Test: p = 0.0.38 and 0.35, respectively) (**Figure 28**). However, the mean IV of purple bladderwort (*U. purpurea*), an indicator species of wetness along prairie-marsh gradients, significantly increased (Wilcoxon Paired Test: p < 0.001) from 0% in 2015 to 16.6% in 2023. In contrast, the mean IV of muhly grass, not a major species on the transect M2E (mean IV <4.0%), decreased from 3.6% in 2015 to 0.4% in 2023 (**Appendix 4a**). The changes in IV of the other two major species, lemon bacopa (*B. caroliniana*) and beakrush (*R. tracyi*) were not significant.

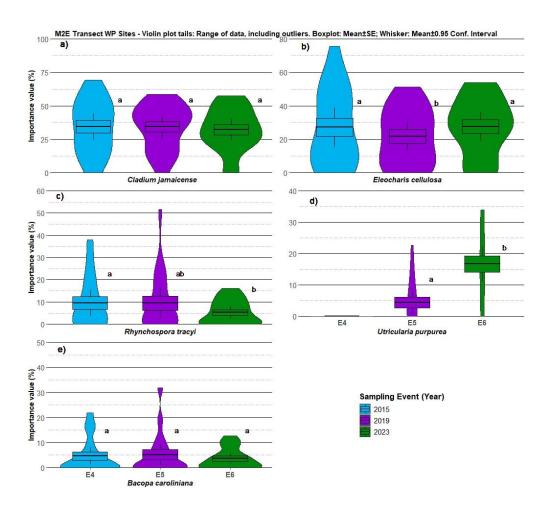


Figure 28: Violin plots of major species' importance value (IV) in the marl prairie portions of Transect M2 (M2E) averaged across sites for the fourth (E4), fifth (E5) and sixth (E6) surveys.

Transect M3

On the transect M3, where marl prairie sites on both sides of SRS were surveyed four times (E1-E4) between 2007 and 2016 and each time in the same year, the vegetation change pattern differed between eastern and western prairies (**Figure 29**). During that period, while

species composition in western prairies shifted towards a drier type, as evidenced by the 90% increase in the abundance of bluestem (*Schizachyrium rhizomatum*) and decrease in the abundance of beakrush (*R. tracyii*) by the same magnitude (**Appendix 4b**), the direction of change in vegetation composition in the eastern prairie sites showed a mixed pattern, as evidenced in the trajectory analysis results (**Figure 29**).

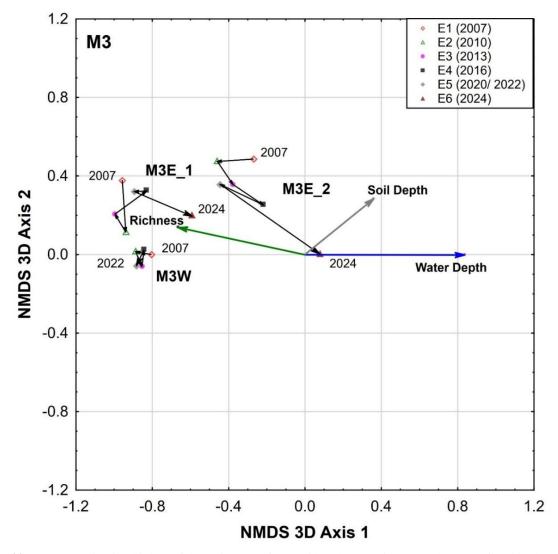


Figure 29: NMDS ordination biplots of the trajectory of centroid and the environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected between 2006 and 2024 in the prairie portion of the Transect M3. Sites on the eastern portion (M3E) of the transect were surveyed six times, while those on western portion (M3W) were surveyed five times. M3E_1 and M3E_2 include eastern portions of marl prairies from 0 m to 7000m and from 7000 m to 12000 m, respectively. For all three M3E_1, M3E_2 and M3W portions, the initial point is represented by 2007, while the end of the trajectory is 2022 for M3W, and the 2024 survey for both M3E_1 and M3E_2.

During the current sampling cycle (2019-2024), the eastern (M3E) and western (M3W) marl prairies were not sampled in the same year. They were sampled for the fifth time in the spring of 2020 and 2022, respectively, and then in 2024, only the sites on M3E were resampled for the sixth time. The differences in trend in vegetation shift between both sides of SRS were

consistent with that observed until 2016. However, between two surveys, E4 (2016) and E5 (2020), the magnitude of change towards a wetter vegetation type was less evident along the eastern boundary of ENP. In contrast to our expectation, vegetation composition was of a drier type in 2020 than in 2016 (**Figure 29**), primarily because of the differences in hydrologic conditions in the field at the time of surveys during those years. Due to unusual flooding during the spring of 2016, the vegetation survey was done late in the season. Even at the time of the survey in 2016, there was up to 68 cm deep standing water in the field. In contrast, standing water depths during the 2020 survey varied between 0 and 44 cm, mostly <20 cm. Nevertheless, in the eastern marl prairie of M3, the shift in vegetation composition towards the wetter type was of greater magnitude during the most recent surveys, i.e., between E5 (2020) and E6 (2024) (**Figure 29**), mainly due to a significant increase in hydroperiod and mean annual water depth (**Figure 7a, b**) resulted from an increased water delivery into ENP after the implementation of COP in 2020 (USACE/ENP/SFWMD 2023).

In the western marl prairie portion of the transect, the vegetation shift over 15 years (2007-2022) toward drier type was prominent (**Figure 30a; Appendix 6**)). In this portion of the transect, the mean vegetation-inferred hydroperiod was 20 days shorter in 2022 than in 2007. In contrast, in the eastern portion of the transect, the change in vegetation-inferred hydroperiod between 2007 and 2020 showed a mixed pattern. However, the vegetation-inferred hydroperiod at almost all the eastern sites were higher during the 2024 survey than those in 2007 (**Figure 30b**). However, much of that change occurred between E4 (2016) and E6 (2024) (**Appendix 5**).

In the prairie portion of the M3 transect, the pattern of change in abundance of major species (Mean IV > 4.0%) differed between eastern and western prairies, and even between M3E_1 and M3E_2, primarily due to differences in hydrologic changes among them. In the eastern marl prairie portion of M3, the mean importance value (IV) of sawgrass (*C. jamaicense*) significantly (Wilcoxon Paired Test: p = 0.01) decreased between E1 and E3, when the sites experienced a drying trend, but the difference in its IV between E1 and E6 was not significant (**Figure 31a**). In contrast, the IV of muhly grass (*Muhlenbergia capillaris*) did not differ among the first five surveys but significantly decreased between E5 (2020) and E6 (2024) due to the increase in wetness (**Figure 31b**).

In M3W there was a significant decrease (Wilcoxon Paired Test: p = 0.017) in IV of beakrush (*R. tracyi*) and an increase (Wilcoxon Paired Test: p = 0.017) in IV of bluestem (*S. rhizomatum*) between E1 and E5 (**Figure 32b, d**), and that were in tandem with the drying trend observed in that region. Likewise, an increase in mean IV of beakrush (*R. tracyii*) from 0.01% to 10.8% on M3E_1 and that of bladderworts (*U. purpurea*) from 0% to 13.7% on M3E_2 during E1 and E6 surveys, respectively (**Appendix 4b**) were due to an increase in water depth in those areas in recent years (**Figure 7b**). Nevertheless, the differences in mean IV of some species which are indicators of wetness in marl prairies including spikerush (*E. cellulosa*) on M3E and other species on M3W (e.g., *B. caroliniana, Panicum virgatum*, etc.) were not significant between E1 and E6 and between E1 and E5, respectively.

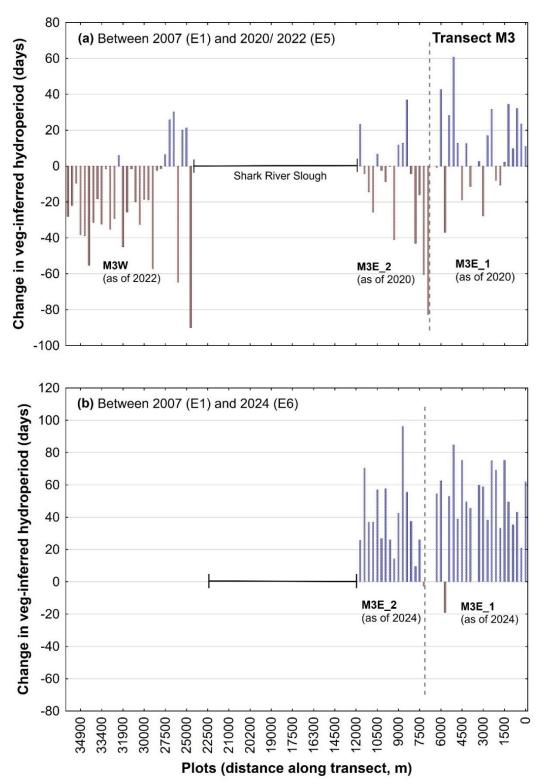


Figure 30: Change in vegetation-inferred hydroperiod between (A)E1 (2007) and E5 (2020/2022) surveys at the vegetation monitoring plots in both eastern and western marl prairie portions of the Transect M3, and between (B) E1 (2007) and E6 (2024 surveys at the vegetation monitoring plots on the eastern marl prairie portion of the Transect M3.

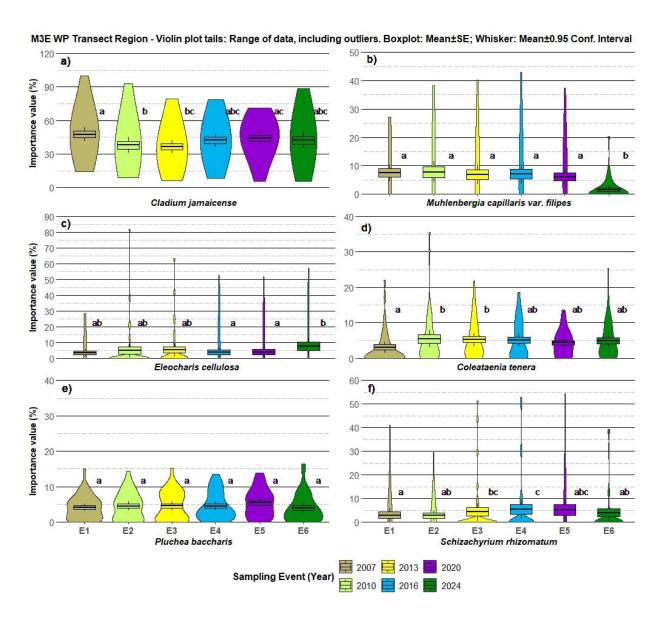


Figure 31: Violin plots of major species' importance value (IV) in the eastern marl prairie portion of Transect M3 from the first (E1) to the sixth (E6) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species' importance value between the surveys.

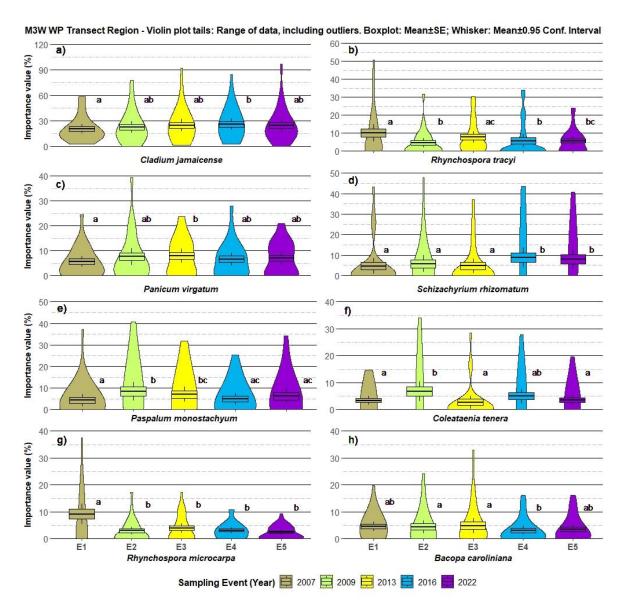


Figure 32: Violin plots of major species' importance value (IV) in the western marl prairie portion of Transect M3 from the first (E1) to the sixth (E6) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species' importance value between the surveys.

Transect M4

On M4, which has marl prairie sites located on both sides of SRS, there was a noticeable change in prairie vegetation composition over 13 years (2008-2021). During this period, vegetation composition at most prairie sites showed a wetting trend (**Figure 33, 34**). However, the magnitude and direction of the shift in vegetation composition at these sites were not the same throughout the study period. For instance, the vegetation composition during the 2014 (E3) survey was drier than in the 2011 (E2) survey at the M4E_1 and M4E_2 sites. In contrast, the sites west of the slough (M4W) continued to shift towards a wetter type (**Figure 33**). Despite a minor deviation in vegetation change pattern in some portions of the transect, the long-term shift

in prairie vegetation on M4 was primarily towards increasing wetness, as evidenced by the position of 2008 and 2021 centroids in the ordination (**Figure 33**), and by an increase in vegetation-inferred hydroperiod at >90% of the prairie sites on this transect (**Figure 34a**; **Appendix 7**). Over 13 years, the mean increase in inferred-hydroperiod in all three regions (M4E_1, M4E_2 & M4W) of the prairie portion of the transect were almost the same. However, between two recent surveys, 2017 (E4) and 2021 (E5), the mean increase in inferred-hydroperiod was significantly higher in the M4E_1 and M4W portions of the transect (26 and 39 days, respectively) than in the M4E_2 portion (7 days) (**Figure 34b**).

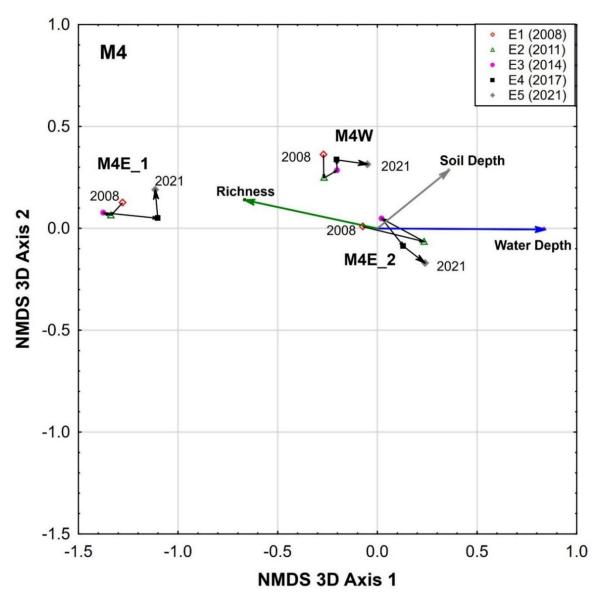


Figure 33: NMDS ordination biplots of the trajectory of centroid and the environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected five times between 2008 and 2021 in the prairie portion of the Transect M4. The initial point and the end of the trajectory represent the 2008 and 2021 survey, respectively. Transect M4 is separated into east (M4E) and west (M4W) based on location of sites on both sides of the Shark River Slough. The eastern marl prairie sites are further separated into east (M4E_1) and west (M4E_2) of the Main Park Road.

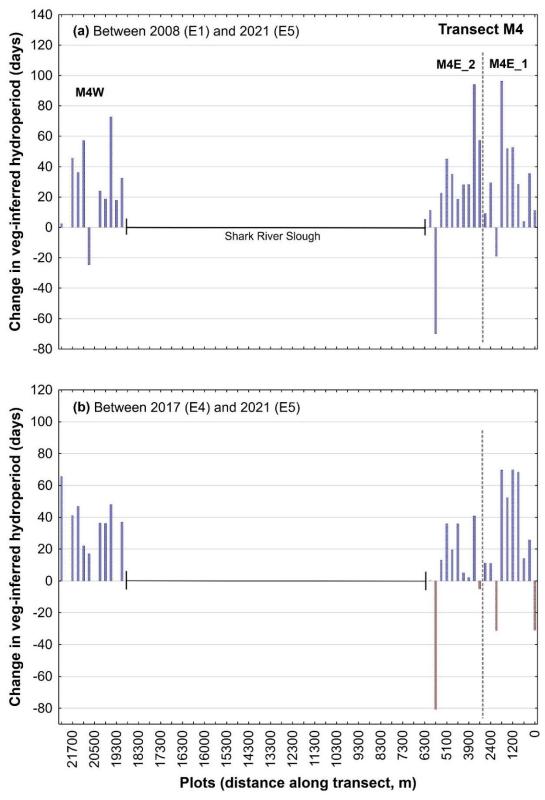


Figure 34: Change in vegetation-inferred hydroperiod between (a) E1 (2008) and E5 (2021) surveys and (b) E4 (2017) and E5 (2021) at the vegetation monitoring plots on the eastern and western marl prairie portions of the Transect M4.

In the prairie portion of the M4 transect, the abundance of representatives of both prairie and hydric major species (Mean IV > 4.0%) changed over time. Between 2008 and 2017, mean importance value (IV) of sawgrass (*C. jamaicense*) increased across all marl prairie segments of the transect, and this increase was significant on M4E_1 (east of the Main Park Road) and M4W (west of the Slough) portions of the transect (**Figure 35a, 37a**). Since the 2017 survey, sawgrass cover decreased in these areas. In 2021, at the M4W sites located west of SRS, the mean sawgrass cover was only 38% in comparison to 54 % during the 2017 survey (**Appendix 4c**), primarily because those sites had partly burned in 2020 (**Table 2**). In the M4E_2 part of the transect, the IV of sawgrass had not changed much. Nevertheless, between 2008 and 2021, the most noticeable increase was in the relative abundance of bladderwort on M4E_2 and that of spikerush (*E. cellulosa*) on M4W (Figure **36f, 37b**), an indication of the wetting trend in the marl prairies of those areas (**Figure 9**).

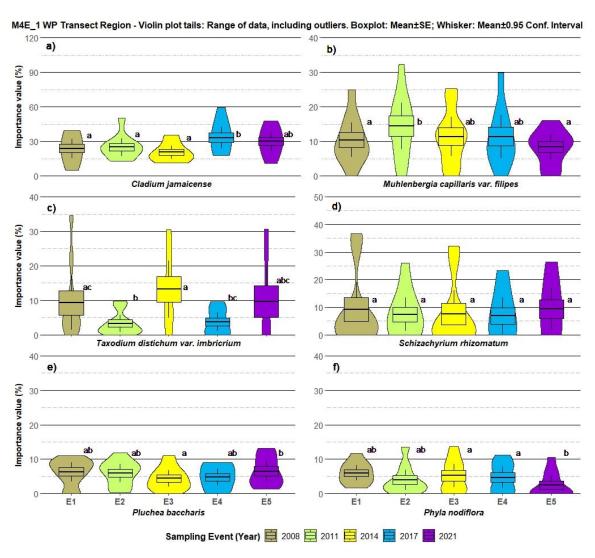


Figure 35: Violin plots of major species' importance value (IV) in the eastern marl prairie portion east of Main Park Road of Transect M3 from the first (E1) to the fifth (E5) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species' importance value between the surveys.

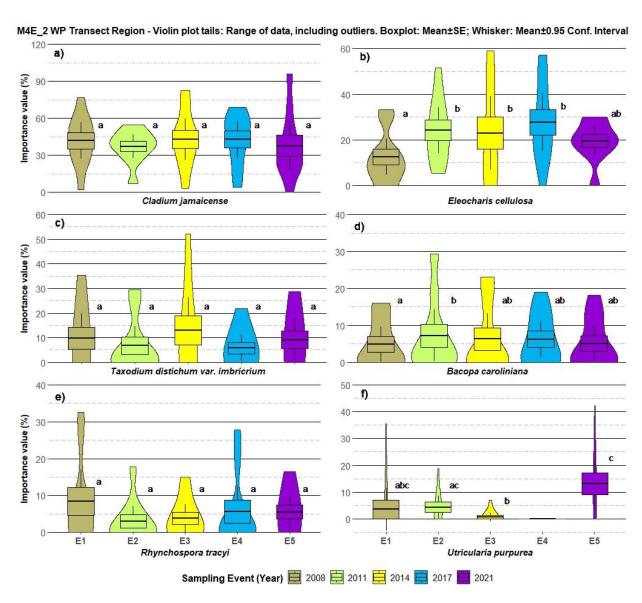


Figure 36: Violin plots of major species' importance value (IV) in the eastern marl prairie portion west of Main Park Road of Transect M3 from the first (E1) to the fifth (E5) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species' importance value between the surveys.

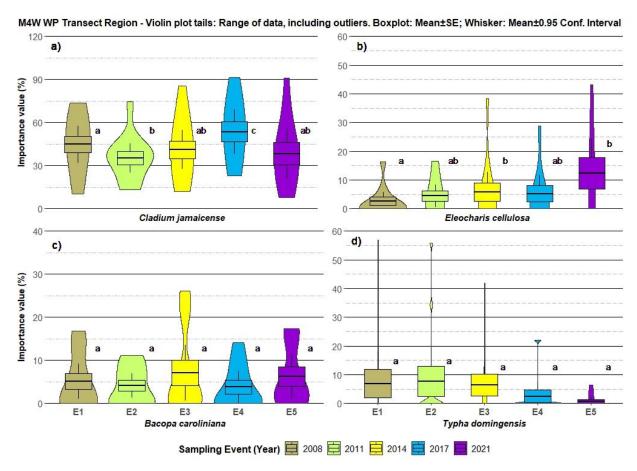


Figure 37: Violin plots of major species' importance value (IV) in the western marl prairie portion of Transect M3 from the first (E1) to the fifth (E6) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species' importance value between the surveys.

Transect M5

Transect M5, which consists mainly of marl prairie sites, is divided into sections M5W (west of the Main Park Road) and M5E (east of the Main Park Road), and in general, M5W is wetter than M5E (**Figures 11, 12**). Over the study period (2008-2022), an increase in four-year average hydroperiod and mean annual water depth have resulted in a shift in species composition towards a wetter type in both M5E and M5W sections of the transect (**Figure 38**). Together with the shift in species composition as revealed by the trajectory analysis, higher vegetation-inferred hydroperiod during the E5 (2022) survey than E1 (2008) at all sites along the transect except few sites west of Main Park Road also showed that vegetation in these areas have shifted towards a wetter character (**Figure 39; Appendix 7**). In the eastern portion of M5, the mean vegetation inferred hydroperiod during the E5 survey was 21 days higher than inferred hydroperiod during the E1 survey. However, such difference was only 8 days in the western portion of the transect. Moreover, between 2018 (E4) and 2022 (E6), 67% of western sites exhibited either minimal change or showed a shift in vegetation composition towards a drier type.

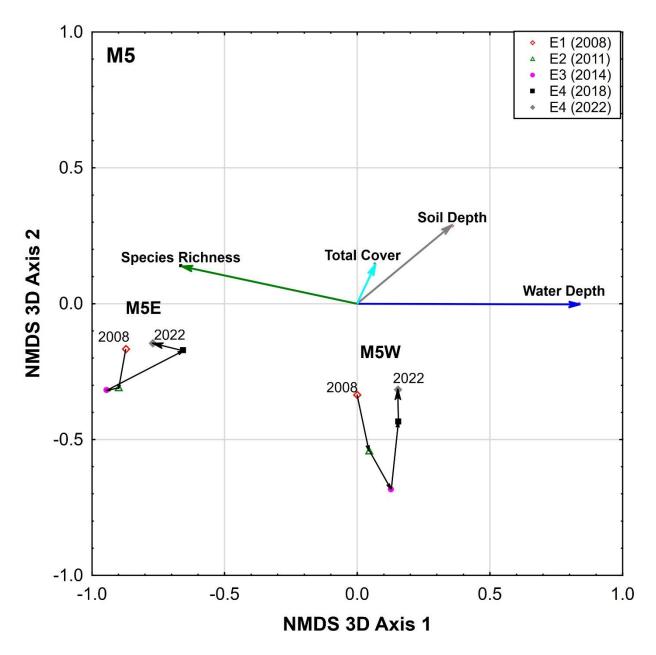


Figure 38: NMDS ordination biplots of the trajectory of centroid, calculated using the Axis scores of sites, and the community characteristics/environmental vectors fitted in the ordination space. The ordination is based on species abundance data collected five times between 2006 and 2022 in the prairie portion of the Transect M5. The initial and end points of the trajectory represent the 2006 and 2022 surveys for both M5E and M5Wportions of the transect. Mangrove portion (M5R) is not shown in the figure.

Over the 14-year period (between E1 and E5), there was a marked increase in abundance of species indicative of wet conditions. Such changes in major species' abundance (Mean IV > 4.0%) were more uniform at sites on the eastern portion of the transect (4500-9000) (**Figure 40**; **Appendix 4d**). For instance, at the sites on M5E, the mean IV of spikerush (*E. cellulosa*) significantly (Wilcoxon Paired Test: p = 0.008) increased from 2.5% to 6.5% in 14 years. In contrast, the mean IV of muhly grass (*M. capillaris* var. *filipes*) and bluestem (*S. rhizomatum*),

both indicators of relatively dry conditions of marl prairies, decreased from 15% to 7.7%, and from 13.2% to 10.1%, respectively (**Figure 40b, c**).

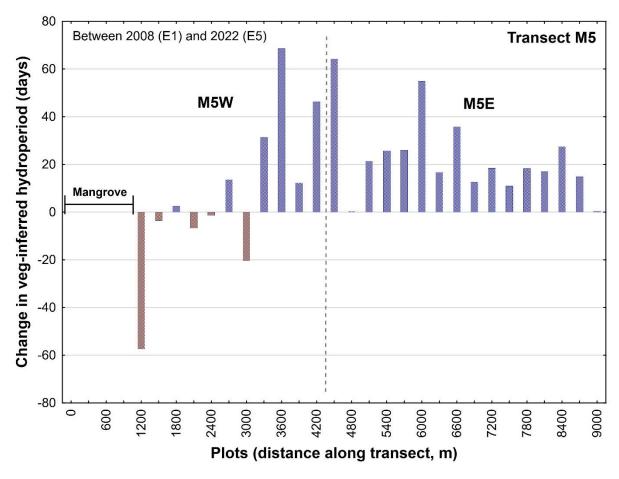


Figure 39: Change in vegetation-inferred hydroperiod between E1 (2008) and E5 (2022) at the vegetation monitoring sites on Transect M5.

In the M5W section, the most abundant species (Mean IV > 3.5%) were sawgrass (*C. jamaicense*) and spikerush (*E. cellulosa*). While the vegetation composition at >50% of sites in this area also shifted towards a wetter type between E1 and E5 (**Figure 39**), the changes in abundance (IV) of these two major species were not significant (**Figure 41a, b**). Though the mean IV of beakrush (*R. tracyi*), which is also an indicator of wet conditions, increased from 2.6% to 6.66% (**Appendix 4d**). Moreover, the westernmost part of transect M5 runs into an area which transitions from freshwater marsh to mangroves. The sites on the first 900 m of the transect from the west are classified as mangroves (M5R) (Sah et al. 2015a). In this portion of the transect, the importance value (IV) of red mangrove ranged between 46.7% and 52.1%. On the first 3,300 m of western portion of the transect M5, there was an increase in both frequency and cover of mangroves in 14 years. For instance, west of the Main Park Road (M5R&W), the frequency of occurrence of red mangrove increased from 53% to 67%, and its mean importance value (IV) increased from 16.6% to 23.2% between 2008 and 2022.

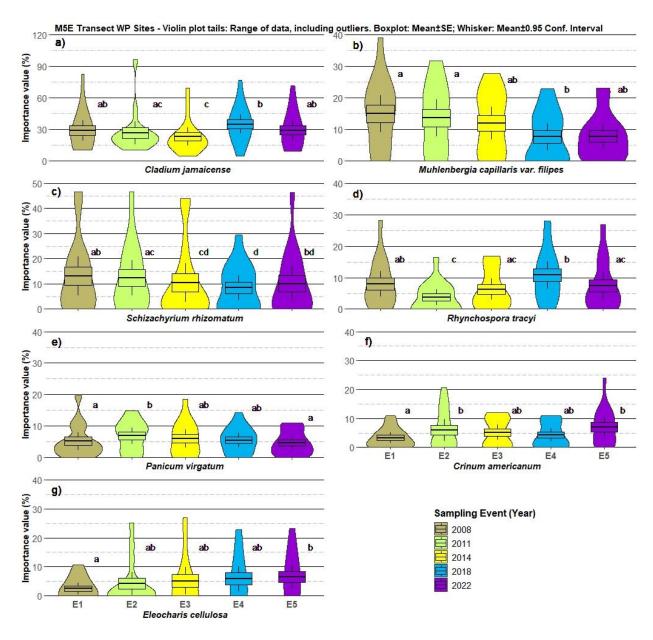


Figure 40: Violin plots of major species' importance value (IV) in the eastern marl prairie portion of Transect M5, averaged across sites from the first (E1) to the fifth (E5) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species' importance value (IV) between surveys.

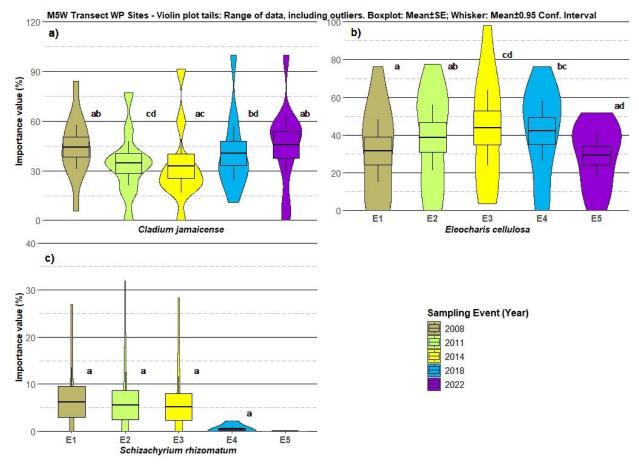


Figure 41: Violin plots of major species' importance value (IV) in the eastern marl prairie portion of Transect M5, averaged across sites from the first (E1) to the fifth (E5) survey. Different letters represent significant (Wilcoxon Paired Test: p < 0.05) differences in species importance values between surveys.

Species richness in marl prairies

In the marl prairie portion of the MP&S gradient, in concurrence with changes in species composition in response to hydrologic changes, species richness also varied over the study period. For instance, on transect M1, the mean species richness was significantly lower during the E1 (8.3 \pm 4.5 species/plot) and E2 (10.1 \pm 4.9 species/plot) surveys than during the next three surveys (E3-E5). (Paired t-tests: p = <0.001, < 0.001 and 0.04, respectively). Between E5 and E6, mean species richness at those sites decreased, due to increase in wetness in that area. However, the species' richness in 2023 was not significantly different from any of previous surveys, including E1 and E2 (**Figure 42**). Higher richness during E3 (2012) and E4 (2015) surveys could be related to dry conditions during those years.

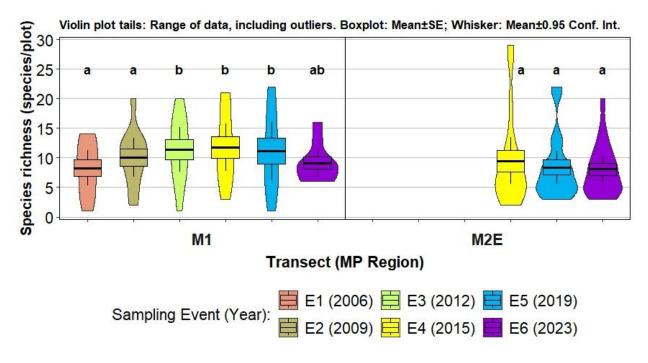


Figure 42: Plant species richness (species/plot) at the sites in the marl prairie portion of the transects M1 and M2E. Different letters represent significant (pairwise t-test; p < 0.05) difference in species richness between surveys on each section of the transect.

Species richness at the sites on M2E did not differ much among the three sampling events. However, as sites got wetter in recent years, a decreasing trend in species richness was observed. The mean (±SD) species richness on this transect were 9.4±8.0, 8.3±5.6 and 8.1±4.5/plot in E4, E5 and E6, respectively (**Figure 42**). Also, with an increase in wetness over time (E4-E6), variation in species richness among the sites on the transect, represented by coefficient of variation (CV), showed a decreasing trend. The CV was 84.2% in 2015 but decreased to 55.6% in 2023.

The change pattern in species richness on M3 differed between the eastern and western portions of the transect, which were surveyed six and five times, respectively, since 2007. On the eastern portion of M3, species richness did not differ much among the first five sampling events but declined significantly during the last year (**Figure 43**). In contrast to the trend observed in eastern prairies, species richness in the western prairies was significantly higher during the E4 and E5 surveys (Paired T-test; p < 0.002 and p < 0.001, respectively) than the previous two surveys (**Figure 43**), possibly because of the drying trend in that area. In this portion of the transect, species richness (18 species /plot) during the most recent survey (E5) was the highest among all sampling events.

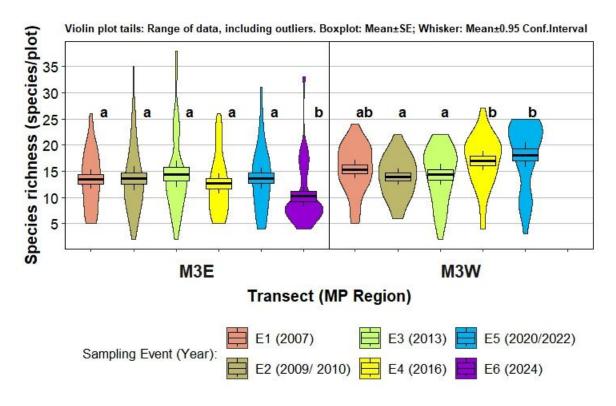


Figure 43: Plant species richness (species/plot) at the sites in the marl prairie portion of the transect M3. Transect M3 extends within the marl prairies on both sides (M3E and M3W) of Shark River Slough. Different letters represent significant (pairwise t-test; p < 0.05) difference in species richness between surveys on each section of the transect.

The change pattern in species richness on M4 also differed between the eastern and western portions of the transect. On the eastern portion of M4, species richness was lower in M4E_2 through all sampling periods compared to M4E_1. Species richness values in the western prairies were intermediate between those in the eastern sections (**Figure 44**). On the western marl prairie sites, species richness was not significantly different between any two surveys, while at the M4E_1 sites, mean species richness during the 2021 (E5) survey was significantly lower than previous surveys. In contrast, at the M4E_2 sites, mean species richness was lower during the E3 and E4 surveys, possibly because of the wetter conditions during those surveys than the prior surveys. However, the mean richness observed during the E5 survey was not significantly different from any of the previous surveys.

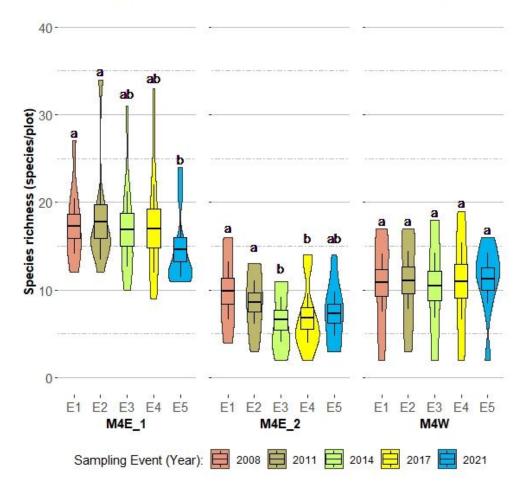


Figure 44. Plant species richness (species/plot) at the sites in the marl prairie portion of the transect M4. Transect M4 extends within the marl prairies on both sides (M4E and M4W) of Shark River Slough. The eastern marl prairie sites are further separated into east (M4E_1) and west (M4E_2) of the Main Park Road. Different letters represent significant (pairwise t-test; p < 0.05) difference in species richness between surveys on individual sections of the transect.

On transect M5 also, temporal change pattern in species richness differed among three sections of the transect (**Figure 45**). The differences in species richness among five surveys were not statistically significant in M5R and M5W. However, in the eastern (M5E) portion of the transect, a small decrease in species richness was observed between E1 and E4 surveys, corresponding with the increase in wetness of the sites in that area. Though, to our surprise, species richness during the recent (E5) survey was significantly higher than E1, E2 and E4 surveys (Paired T-test: p = 0.034, p = 0.005, and p = 0.017, respectively), and the highest (15 species/Plot) among all the sampling events, despite the fact that hydrologic conditions in that area have become much wetter.

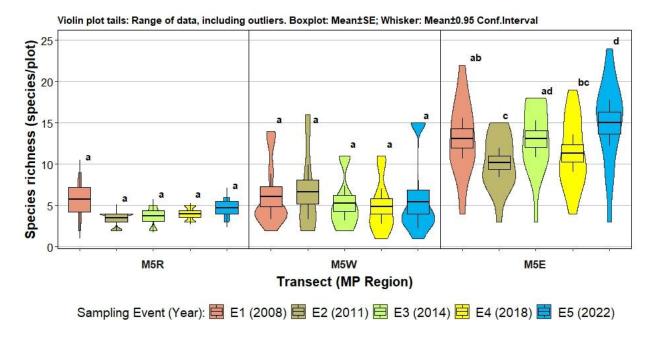


Figure 45: Plant species richness (species/plot) at the sites in the marl prairie portion of the transect M5. Transect M5 extends within the marl prairies on both sides Main Park Road, and westernmost portion (0-900 m) of the transect is dominated by red mangroves. Different letters represent significant (pairwise t-test; p < 0.05) difference in species richness between surveys on each section of the transect.

Change in Vegetation height, Cover and Biomass

In marl prairies, hydrologic changes not only affect vegetation composition, but also its structure, including vegetation height, cover, and biomass. For instance, over the study period (2006-2023), total cover and absolute green cover changed drastically at the sites on M1 while vegetation height and cover did the same in M2E (**Tables 3, 4**). On transect M1, vegetation cover was similar in the first and last surveys with slightly higher values in the rest of the surveys. The mean cover value was the highest (33.1±18.1) during the E4 (2015) survey. The same was true for transect M2E, where the mean (± SD) cover value was 29.5±19.4% in 2015, higher than the cover in 2019 and 2023, suggesting that mean vegetation cover decreased with an increase in hydroperiod and mean annual water depth. On Transect M1, the mean green cover was the lowest during the E1 (2006) survey. However, the percentage of green vegetation increased between the E1 and E4 surveys, then decreased. But the green percent cover in the last two surveys (E5 & E6) was still higher than the green cover in 2006.

Vegetation height on transect M1 showed the opposite trend over the study period. Mean vegetation height was the lowest (49.7±32.7 cm) in 2015. However, on M2E, the vegetation height was the lowest (21.1±10.7 cm) during the most recent survey, E6 (2023). On both transects (M1 and M2E), above ground biomass did not change much over the study period (**Table 3, 4**).

Table 3: Mean (\pm SD) vegetation height (cm), total cover (%), absolute green cover (%), and biomass (g m⁻²) on marl prairie portions of Transect M1 (n = 10) measured during six sampling events between 2006 and 2023. E1 = 2006, E2 = 2009, E3 = 2012, E4 = 2015. E5 = 2019 and E6 = 2023. One site (M1-00300) was not sampled during E5 and E6, thus was excluded from the analysis.

Structural	Sampling events							
variables	E1 (2006)	E2 (2019)	E3 (2012)	E4 (2015)	E5 (2019)	E6 (2023)		
Vegetation height (cm)	57.4 ± 33.9	53.8±29.7	52.6±26.3	49.7±32.7	61.1±28.7	59.8±24.5		
Total cover (%)	19.4±17.2	30.0±26.2	28.1±21.9	33.1±18.1	31.3±23.8	24.0±18.0		
Absolute Green Cover (%)	6.2±4.9	8.5±9.8	8.5±7.5	14.8±7.4	12.1±8.1	12.8±8.4		
Biomass (g m ⁻²)	405±313	509±438	463±310	499±330	542±365	435±224		

Table 4: Mean (\pm SD) vegetation height (cm), total cover (%), absolute green cover (%), and biomass (g m⁻²) on marl prairie portions of Transect M2 (i.e. M2E) measured during three sampling events between 2015 and 2023. E4 = 2015. E5 = 2019 and E6 = 2023. This portion of transect M2 was surveyed for the first time in 2015. However, the sampling events are numbered in accordance with the Transect M1.

S441	Sampling events				
Structural variables	E4 (2015)	E5 (2019)	E6 (2023)		
Vegetation height (cm)	50.4±19.0 ^a	55.9±16.8a	21.1±10.7 ^b		
Total cover (%)	29.5±19.4a	21.7±10.9a	21.1±10.7 ^a		
Absolute Green Cover (%)	14.6±11.9	9.8±4.5	10.9±5.3		
Biomass (g m ⁻²)	455±247a	396±158a	459±157a		

Over the study period (2007-2024), vegetation height and cover changed significantly on both M3E and M3W portions of Transect M3 (**Table 5**). On the eastern portion of the transect, where all but three plots burned in the Mustang Corner Fire of 2008, vegetation cover during the E2 survey, two years after the fire, was significantly lower (GLMM, Tukey test: p<0.001) and only half of what it had been during E1. Mean (\pm SD) cover during E1 and E2 was 45.8 \pm 19.8% and 23.2 \pm 16.0%, respectively. In this portion of M3, vegetation cover recovered in three years, but by the time of E3, it was still only 72% of the initial cover. Since then, the cover has not changed much, but rather has decreased slightly, primarily in response to the increase in wetness of the sites. Vegetation height showed a similar trend over the study period. In contrast to the trend observed in M3E, mean vegetation height in M3W was significantly higher (GLMM, Tukey test: p = 0.004) during the most recent (E5) survey (67.0 \pm 25.6 cm) than during the first (E1) survey (59.7 \pm 16.9 cm). The mean vegetation cover increased in 15 years, though the difference in percentage cover between E1 and E5 was not significant.

Table 5: Mean (\pm SD) vegetation height (cm), total cover (%), absolute green cover (%), and biomass (g m⁻²) on M3E and M3W marl prairie portions of Transect M3 measured during five sampling events between 2007 and 2024. E1 = 2007, E2 = 2010, E3 = 2013, & E4 = 2016 for both M3E and M3W. E5 = 2020 and 2022 for M3E and M3W. E6 = 2024 for M3E.

Structural	Transect (Regions)	Sampling events							
variables		E1 (2007)	E2 (2010)	E3 (2013)	E4 (2016)	E5 (2020/22)	E6 (2024)		
Vegetation	МЗЕ	80.1 ± 23.1 ^a	52.7 ± 18.3^{b}	57.6 ± 20.0^{bc}	70.3 ± 20.8^{ac}	60.5 ± 17.2^{bc}	75.3 ± 24.4^{a}		
height (cm)	M3W	59.7 ± 16.9^{a}	62.0 ± 25.3^{ab}	$61.1 \pm 40.2^{\circ}$	58.1 ± 23.3^{a}	67.0 ± 25.6^{bc}			
Total agram (9/)	МЗЕ	45.8 ± 19.8^{a}	23.2 ± 16.0^{b}	33.1 ± 19.6^{ab}	29.2 ± 20.3^{b}	32.1 ± 16.3^{b}	26.8 ± 20.1^{b}		
Total cover (%)	M3W	37.9 ± 15.2^{a}	44.9 ± 19.3 ^a	45.5 ± 23.5^{a}	40.1 ± 20.8^{a}	44.0 ± 23.8^{a}			
Absolute Green	МЗЕ	18.5 ± 11.0^{a}	10.6 ± 10.1^{b}	13.1 ± 8.8^{bc}	12.9 ± 12.2^{bc}	12.9 ± 6.9^{bc}	13.2 ± 11.2^{c}		
Cover (%)	M3W	14.2 ± 8.0^{ab}	12.3 ± 7.7^{a}	23.2 ± 15.1^{b}	19.1 ± 14.0^{b}	18.5 ± 10.1^{b}			
Biomass (g m ⁻²)	МЗЕ	757 ± 325^{a}	402 ± 195^{b}	518 ± 270^{bc}	538 ± 276^{bc}	509 ± 220^{bc}	$541 \pm 310^{\circ}$		
	M3W	540 ± 206^{a}	620 ± 295^{ab}	672 ± 517^{b}	566 ± 273^{a}	638 ± 351 ^{ab}			

In correspondence with vegetation cover and height, aboveground biomass also changed over the study period. In general, since above ground plant biomass is a function of both vegetation height and cover (Sah et al. 2007), the change in biomass over time showed a similar trend as was observed for height and cover on this transect. On the eastern portion of the transect, plant biomass during the E2 survey, two years after the fire, was significantly low (GLMM, Tukey test: p<0.001) and only half of what it had been during E1 (**Table 5**). Mean (± SD) biomass during E1 and E2 was 757 ± 325 g m⁻¹ and 402 ± 195 g m⁻¹, respectively. In this portion of M3, biomass recovered in three years, but by the time of E3, it was still only twothirds of the initial biomass. In the next seven years, biomass increased slightly, but the mean biomass during E4 (538 \pm 276 g m⁻¹), E5 (509 \pm 220 g m⁻¹) and E6 (541 \pm 310 g m⁻¹) surveys were not significantly different from the biomass during E3 ($518 \pm 270 \text{ g m}^{-1}$). In contrast, in the western marl prairie (M3W), biomass showed an increasing trend during the first three surveys (E1-E3) but decreased significantly (GLMM, Tukey test: p = 0.04) between the E3 (2013) and the E4 (2016) surveys, primarily in response to increase in wetness. In the next four years, biomass increased slightly, and was higher than it was 15 years ago, but still lower than the biomass during the 2013 (E3) survey.

Vegetation height, total and absolute green cover attributes across the M4 transect exhibited distinct temporal and spatial patterns between 2008 and 2021 (**Table 6**). In M4E_1, vegetation height remained relatively stable, showing a modest but significant increase by 2017 and persisting through 2021. However, the absolute green cover experienced a peak in 2011 followed by a consistent and significant decline, indicating a reduction in photosynthetically active vegetation despite stable total cover. M4E_2 displayed more variable trends: vegetation peaked in 2014, while green cover surged in 2011 but declined notably in subsequent years. Still, total cover remained statistically unchanged throughout the study period. In contrast, M4W showed the most dynamic changes, with vegetation height and total cover significantly

increasing by 2017 before plummeting in 2021 — patterns that mirrored trends in absolute green cover. These shifts in vegetation structure on M4W reflect disturbance impacts such as fire (*see below*), whereas the eastern regions exhibited more structural consistency but lower overall cover and height due to changes in hydrologic conditions.

Mean above ground plant biomass varied differently across different portions of the transect. In general, mean (± SD) aboveground biomass at the western prairie sites (M4W) was 2-3 times higher than biomass at the eastern prairie sites. Moreover, mean biomass at the easternmost portion of the transect (M4E_1) e.g., east of the Main Park Road, remained almost stable over the 15-year study period. Biomass at the sites west of the park road (M4E_2) also showed minimal change, despite wetter hydrologic conditions during the 2021 (E5) survey compared to earlier years. In both eastern sections, aboveground biomass decreased from the 2014 (E3) to 2021 (E5) surveys, although the decline was not statistically significant. In the western portion of the transect, no differences in biomass were observed during the first three survey periods. While mean biomass during 2017 (E4) was significantly higher than previous years, a significant reduction in biomass was observed during the most recent survey (E5), primarily because most sites on this portion of the transect had burned in 2020, one year prior to sampling in 2021. In this portion of the transect, mean (± SD) biomass in 2021 (E5) was 577 g m⁻², which was only 37% of the biomass recorded during the 2017 (E4) survey.

Table 6: Mean (\pm SD) vegetation height (cm), total cover (%), absolute green cover (%), on M4E and M4W marl prairie portions of Transect M4 measured during five sampling events between 2008 and 2021. E1 = 2008, E2 = 2011, E3 = 2014, E4 = 2017 and E5 = 2021.

Structural	Transect (Regions)	Sampling events						
variables		E1 (2008)	E2 (2011)	E3 (2014)	E4 (2017)	E5 (2021)		
Vegetation height (cm)	M4E_1	51.5±9.1ab	40.6±11.3a	52.2±8.3ab	59.7±12.2b	57.5±12.3b		
	M4E_2	74.6±22.0ab	66.4±22.7a	86.2±47.7b	70.3±17.1ab	78.7±45.0ab		
	M4W	108.5±57.1a	121.1±62.4a	113.5±69.3a	135.6±51.8b	84.9±17.9a		
Total cover (%)	M4E_1	26.6±10.5a	30.5±7.7a	27.3±11.0a	24.7±11.2a	28.0±13.8a		
	M4E_2	33.9±19.8a	43.8±14.5a	39.1±23.4a	35.1±16.4a	31.1±22.6a		
	M4W	72.5±21.8ab	61.0±22.4a	72.1±22.5ab	81.9±15.5b	30.8±13.3c		
Absolute Green Cover (%)	M4E_1	12.6±3.1a	19.53±5.7b	12.2±4.9ac	7.8±3.1cd	6.6±3.8d		
	M4E_2	14.8±7.5ab	25.7±13.1c	24.4±17.5ac	11.3±4.7b	12.7±15.2b		
	M4W	35.1±18.1ab	40.6±22.4b	48.8±24.6b	35.8±17.8b	17.1±8.5a		
Biomass g m ²	M4E_1	413.8±113a	416±119a	420±114a	432±145a	455±138a		
	M4E_2	593.3±315a	663±250a	754±682a	557±176a	610±540a		
	M4W	1286±681a	1218±694a	1315±836a	1559±604b	577±83c		

On Transect M5, while vegetation composition on both sides of Main Park Road was quite different, there was no significant difference in structural variables between M5E and

M5W sites. Thus, the data were pooled together to analyze structural variables, including vegetation height, cover, green cover, and biomass. On this transect, vegetation height and green percent cover did not change much in 14 years (2008-2022) (**Table 7**). However, both vegetation cover and mean total aboveground biomass during the recent (E5) survey were significantly higher (GLMM, Tukey test: p = 0.005 and p = 0.031, respectively) than the cover and biomass during the first survey. Total cover and biomass during the E5 survey were 30% and 19% higher than the cover and biomass, respectively, during the E1 survey.

Table 7: Mean (\pm SD) vegetation height (cm), total cover (%), absolute green cover (%), and biomass (g m⁻²) on marl prairie portion of Transect M5 measured during five sampling events between 2008 and 2022. E1 = 2008, E2 = 2011, E3 = 2014, E4 = 2018 and E5 = 2022 for both M5E and M5W. Five sites in the western portion of the transect that are dominated by *Rhizophora mangle* are excluded from the analysis.

Structural variables	E1 (2008)	E2 (2011)	E3 (2014)	E4 (2018)	E5 (2022)
Vegetation height (cm)	56.7 ± 14.7^{a}	56.7 ± 13.9^{a}	55.0 ± 15.3^{a}	69.6 ± 17.6^{b}	58.3 ± 19.6^{a}
Total cover (%)	29.3 ± 15.2 ^a	39.4 ± 15.3^{b}	33.2 ± 12.5^{ab}	31.2 ± 13.4^{ab}	38.0 ± 18.9^{b}
Absolute Green Cover (%)	14.9 ± 9.9^{abc}	19.6 ± 13.8^{ab}	13.2 ± 6.9^{ac}	$10.0 \pm 7.5^{\circ}$	16.9 ± 9.4^{b}
Biomass (g m ⁻²)	454 ± 174^{a}	541 ± 168^{b}	473 ± 131^{ab}	521 ± 188^{b}	541 ± 263^{b}

3.3.3 *Vegetation type change* (2005-2024)

Based on the vegetation data collected during the four most recent sampling years (2021-2024; *also see Table 1*) on all five transects (M1-M5), 18 vegetation types were identified through the classification procedure (**Appendix 2**). There were four vegetation types more than the those identified based on E1 (2005-2008) vegetation data (Sah et al. 2015a). Those types were Beakrush-Spikerush (*Rhynchospora-Eleocharis*) Marsh and Spikerush-Beakrush (*Eleocharis-Rhynchospora*) Marsh, and two other types: Cattail (*Typha*) Marsh and Bayhead which were not identified by Sah et al. (2015a), since the sites were removed as outliers.

All vegetation types (except Bayhead) identified at the sites along MP-S Gradients can be categorized into two broad categories: Wet Prairie (WM) and Marsh (M), as were identified based on the data collected throughout the marl prairie landscape (Ross et al. 2006). Over the two decades, vegetation type changed at almost half (48.6%) of the sites. However, at most (83.0%) of those sites, vegetation type changed from one type to another only within the broad category of WP or M (**Figure 46a**). At the rest of the sites (n = 22), vegetation type changed from WP to M type. Half of those sites were in the eastern marl prairie portion of M3 (i.e., M3E_1), three sites were on M1, and two sites were on the eastern portion of M4 (**Figure 46b**). Only one site in the western portion of M4 changed from WP-M while all the WP sites in the western portion of M3 either did not change or changed only from one WP to another WP type.

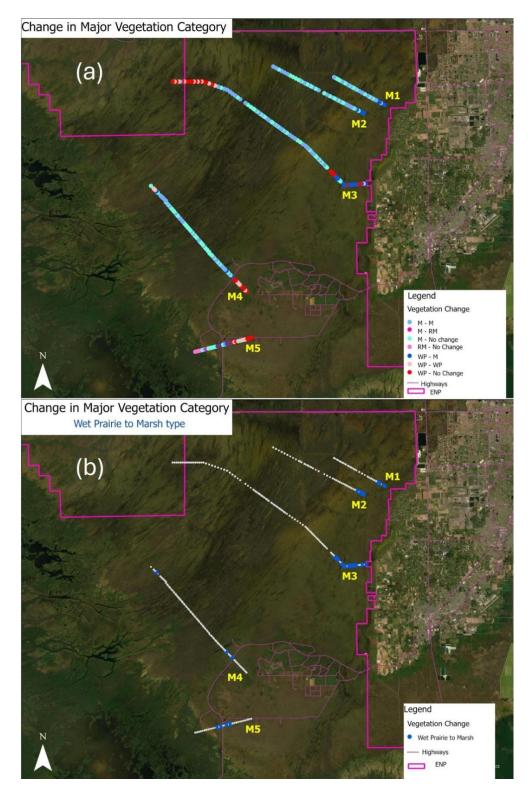


Figure 46: Change in vegetation types at the sites on Map Transects M1-M5 between E1 (2005-2008) and E5 or E6 (2021-2024) and on Transect M2E between E4 (2015) and E6 (2021-2023). (a) All types: M-M = One marsh veg type to another marsh type. M-RM = Marsh vegetation to Mangrove; WP-WP = One wet-prairie to another wet-prairie type; WP-M = Wet prairie to marsh vegetation type. All three types (M, WP, RM) with 'no change" indicates same vegetation type during both sampling. (b) Change in vegetation from Wet Prairie to Marsh Vegetation type.

Interestingly, at four sites on the transect M2E, which were sampled in 2015 for the first time, vegetation type changed from WP to M within 8 years, i.e., between 2015 and 2023, a period during which both hydroperiod and annual mean water depth in that area increased significantly. Across all the transects, none of the marsh (M) sites changed to the prairie (WP) type.

3.3.4 Carbon isotopic signature of plants and change in C_3 and C_4 cover

In the Everglades, spatial variation in vegetation composition along marl prairie-slough gradient correlates with changes in the relative abundance of C_4 and C_3 species. Among 152 species recorded on five transects (M1-M5) during the E1 (2005-2008) survey, we identified 11.8% of species as C_4 (Sah et al. 2020). On these transects, C_4 : C_3 ratio (cover value log-transformed) was negatively correlated with 4-year hydrology (**Figure 47**). Variability in relative proportion of C_4 and C_3 species in short hydroperiod (<240 days) marl prairie sites was much higher than the slough sites (hydroperiod > 300 days) which were primarily dominated by C_3 species. (Sah et al. 2020).

On the transects (M1-M5), an increase in hydroperiod and mean annual water depth over two decades (between E1 (2005-2008) and E5 or E6 (2021-2023)) disproportionately affected C_4 and C_3 cover. The overall change in C_4 cover was negatively correlated with the increase in mean annual water depth ($r^2 = 0.39$, p <0.001) whereas the relationship between change in water depth and C_3 cover the study period was not significant (p = 0.595) (**Figure 48**).

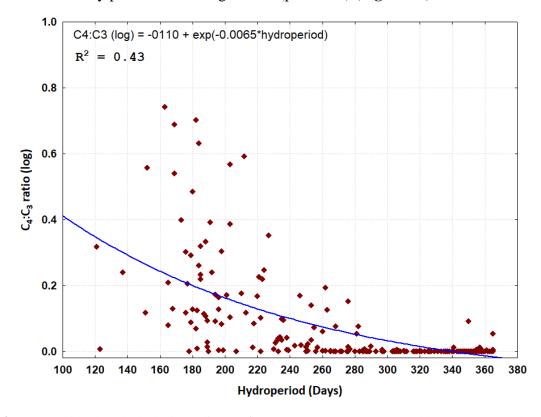


Figure 47: C₄:C₃ ratios along hydrologic gradient on five transects (M1-M5) surveyed between 2005 and 2008.

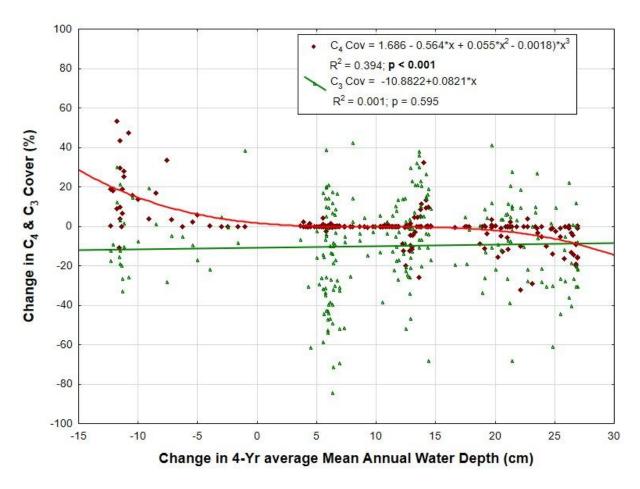


Figure 48: Change in C₄ and C₃ species' cover in relation to change in mean annual water depth between E1 (2005-2008) and E5 or E6 (2021-2024) surveys. All five transects (M1-M5) were sampled during the E1 survey, while most recently, transects M1, M2 and M3 (except its western marl prairie portion) were sampled for the sixth time (E6) whereas transects M4, M5 and the western marl prairie portion of M3 were sampled for the fifth time (E5).

4. Discussion & Conclusion

In the Everglades, the relationship between hydrologic regime and vegetation distribution is dynamic. Along the marl prairie-slough (MP&S) gradient, vegetation shift was influenced by periodic fluctuations in water conditions, caused by both rainfall and water management activities (Cortez 2024; and previous years' SFER Reports), and by fire that usually interacts with pre- and post-fire hydrologic conditions affecting the vegetation recovery after fire. In general, the sensitivity of vegetation to short-term changes in hydrologic conditions observed along MP&S gradients which have been studied every 3-4 years is in accordance with earlier findings that in Everglades prairies and marshes, discernible change in species composition can occur in periods as short as 3-4 years (Armentano et al. 2006; Zweig and Kitchens 2008; Sah et al. 2014; Gann and Richards 2015).

Periodic fluctuations in annual mean water level were reflected in the four-year average hydroperiods and water levels that we used to examine the vegetation responses to both the short term and decadal changes in hydrologic regimes. At the slough sites of four (M1-M4) transects which were surveyed for the first time in 1999, a drying trend was maintained until the E3 (2011-2013) survey (Figures 2 & 3), primarily due to drought conditions observed in 2007/2008 and 2011. However, both four-year average hydroperiod and water levels before the next two surveys (E4 (2014-2016) and E5 (2018-2021)) at all four transects and before three surveys (E4, E5, and E6 (2022)) on M1, M2 and M3 were higher than those before the E3 survey, suggesting a trend in increasing water level in the SRS resulted from the restoration efforts associated with MOD and COP projects aimed at delivering more water into ENP. In concurrence with the observed trend in hydrology over the study period, vegetation composition in the slough portions of these transects also showed a similar trend, i.e., first a shift toward drier types, and then toward wetter types (Sah et al. 2020, 2021, 2022, 2023, 2024a). However, since not all transects were surveyed in the same year, the annual variation in water conditions might have also affected the magnitude and direction of vegetation change on these transects. For instance, conditions in 2014, the year before the E4 (2015) survey, on Transect M3 were very dry, which caused an aberrant shift in vegetation at slough sites on M3 in comparison to that on M1 and M2 transects (Sah et al. 2020, 2021).

On transects M1, M2 and M3, the trend of shift in vegetation towards wetter types observed between E4 (2014-2015) and E5 (2018-2019) continued through E6 (2022-2023). In fact, this shift in composition was much more pronounced than during previous surveys, primarily due to an increase in water delivery into ENP. Interestingly, the vegetation composition in the northern portion of SRS (the location of M1 and M2) in 2022 was similar to the composition in 1999 (**Figures 14 & 15**), suggesting that the effects of dry conditions recorded in SRS and adjoining prairies during the first decade of this century are now mitigated to some extent by the increased water delivery into ENP since 2015 (USACE/ENP/ SFWMD 2023). In the central-southern SRS, the change in vegetation composition toward a wetter type was not of similar magnitude (**Figure 18**) or showed minimal change, especially after E4 (2015

and 2016 on transects M3 and M4, respectively) (**Figure 20**). The reason could be the effects of significantly lower water depth during the E6 (2023) survey than in 1999 (e.g., in the location of M3). In addition, vegetation might have been still recovering from the fires that burned one-third of slough sites on M4 in two years 2019 and 2020, i.e., one year before, or same year of, vegetation sampling (**Table 2**).

In the Everglades, the relative abundance of sawgrass and other hydric species such as spikerush, bladderwort and water lily are considered indicators of water conditions in the ridge and slough landscape (Ross et al. 2003; Zweig and Kitchens 2008; Gann and Richards 2015; Ross et al. 2016). In north-central SRS, where M1 and M2 are located, mean sawgrass abundance (Importance Value, IV) showed an increasing trend until 2011, a period when the slough was drier than in the late 1990s. In contrast, the mean importance value of bladderworts showed an opposite trend. During the E4 and E6 surveys, a decreasing trend in sawgrass abundance (IV) and an increasing trend in IV of bladderworts in response to an increase in water level were as per our expectations, confirming the earlier findings that vegetation composition in ridge and slough landscape can change in 3-4 years (Zwieg and Kitchens 2008). In concurrence with similar hydrologic conditions between the late 1990s and in recent years (Figure 2, 3), the IV of both sawgrass and bladderworts during the E6 survey were also not statistically different from their IV in 1999.

In central-southern SRS, where M3 and M4 transects are located, mean sawgrass abundance (Importance Value, IV) showed an increasing trend until E2 (2009 and 2010, respectively), a period when the slough was drier than in the late 1990s. In contrast, the mean importance value of bladderwort showed an opposite trend. During the most recent survey (E6, and E5 for M3 and M4, respectively), a decrease in sawgrass accompanied by an increase in bladderwort relative abundance since the last survey was not a surprise, especially when the hydrologic condition in that region was wetter than it was during the previous surveys. In fact, in central SRS, IV of both sawgrass and bladderwort were not statistically different between the most recent survey and 1999—results also observed on transects M1 and M2; *see previous paragraph*—which suggests that the recent hydrological conditions in that part of SRS are like those in the 1990s when water levels were relatively high in ENP (SFWMD 1999). However, in the southern central SRS (i.e., location of M4), a corresponding change in IV of sawgrass was not observed. On that transect an increase in IV of sawgrass was surprising to us. This discrepancy can be to some extent because sawgrass has a wide range of hydrologic tolerance.

The short-term changes in sawgrass cover observed during the last twenty-five years in SRS support the longer-term dynamics described for the post-drainage era in the Everglades by Bernhardt and Willard (2009). Several researchers have reported an expansion of sawgrass and other emergent species, such as spikerush, in the R&S landscape when hydrologic conditions become relatively dry (Busch et al., 1998; Zweig and Kitchens, 2008, 2009; Nungesser 2011). Such expansion may occur within 3-4 years, especially when a relatively low water level is maintained beneath the peat surface of the sloughs for three consecutive dry seasons (Zweig and

Kitchens 2009). In contrast, the extended wet seasons that occur intermittently can reverse the process. In the slough portions of the studied transects, wetter conditions after the E3 survey had the reverse trend of what was observed until the E3 survey, and the observed changes in vegetation composition suggest that an increase of even 5-10 cm mean annual water depth in SRS can rapidly shift the vegetation toward types more characteristic of sloughs.

The deviation in trajectories of vegetation shift observed in the slough portion is also affected by fire. Several slough sites on these transects burned over the study period. In the slough portion of M3, while only a few sites (<20%) burned in 2006 and 2008, a majority (>65%) of sites burned in 2012, and again in 2018. Likewise, 33% of slough sites on transect M4 burned over two years (2019 and 2020) had also burned a few months to one year prior to the E5 (2021) survey. In the Everglades wetlands, including the peat-dominated ridge and slough landscape, post-fire vegetation recovery depends on several factors, such as the season of fire, and hydrologic conditions at the time of fire as well as in the post-fire period (Ruiz et al. 2013; Sah et al. 2015b; Oli 2021). When fire occurs in a dry season while the slough has little standing water and water is deep below the ground surface, a significant amount of peat may be consumed (Benscoster et al. 2022), affecting post-fire vegetation recovery, causing elevation loss and an increase in mean annual water depth, and ultimately resulting in a vegetation shift toward wetter types. This was observed at 5 sites on Transect M1 burned in Mustang Fire in 2008 (Sah et al. 2020). In contrast, wet season fires in sloughs are generally patchy. Post-fire vegetation at those sites usually recovers rapidly and shows a minimal change in composition, as observed on sites burned in 2012 (Sah et al. 2020). On the M4 transect, 18 slough sites burned over two years, 2019 and 2020. However, at those burned sites, the mean vegetation cover in 2020 (i.e. a few months to one-year after the fire) was even higher than vegetation cover in 2016, suggesting that vegetation at some locations was incompletely burned or unburned. A similar pattern was observed on M1 and M2 slough sites that burned in 2021 or 2022 and were sampled in 2022, i.e., a few months to one year after fire, respectively. At the slough sites on those two transects, the mean total species cover was 93% and 88% of the cover recorded on those sites in 2018, respectively. Even though the sites on those transects burned during the dry season, the amount of standing water at the time of the burn might have caused a patchy burn with variable effects on vegetation composition. Moreover, sites were considered burned if they were within the fire boundaries provided by ENP. Fires within the R&S landscape have been patchy, and many survey plots on these transects did not show any sign of burning in their respective surveys in 2022. A detailed mapping of burned patches, possibly using satellite imagery data, followed by an analysis of vegetation responses to hydrology and fire interaction can help to explain the vegetation dynamics in this area more precisely.

On the MP&S gradients, short-hydroperiod marl prairies are flooded annually for varying periods while remaining dry for extended portions of the year. Marl prairie sites on all transects (M1-M5) have increasingly become wetter since 2015 than the previous years (Sah et al. 2021, 2022, 2023, 2024a), affecting the marl prairie vegetation composition throughout the region, especially east of SRS. However, several sites in the western marl prairie, especially along

transect M3, showed a drying trend, a result also reported in another study (Sah et al. 2024b, 2025).

Generally, in seasonally flooded ecosystems, like the Everglades marl prairies, differences in optimum flooding tolerances of species present in the vegetation mosaic form the basis for variation in vegetation composition (Ross et al. 2006). Hence, the change in vegetationinferred hydroperiod on the prairie portion of studied transects reflects the amount and direction of change in vegetation (Armentano et al. 2006). An increase in vegetation-inferred hydrology observed in the prairie portions of M1, M2 and eastern M3 since E4 (2015-2016) surveys can be attributed to the change in water management that resulted in increased water flow through NESRS (USACE 2020, USACE/ENP/SFWMD 2023). Other studies have also shown that hydrologic conditions in the NESRS region have changed since 2015 due to the Increment Field Tests associated with the Modified Water Delivery (MOD) followed by the full implementation of the Combined Operation Plan (COP) in August 2020 (Sarker et al. 2020; USACE, 2020; USACE/ENP/ SFWMD 2023; Nocentini et al. 2024). Sarker et al. (2020) have reported that hydroperiod in NESRS increased by 87 days between water year (WY) 2016 and WY2019. Likewise, Nocentini et al. (2024) have recorded that hydroperiod increased by 52 days between WY2015 and WY2021. However, the increase in hydroperiod varied in space. In our study, 4year average hydroperiod on the transects M1 and M2E also increased by 70 and 46 days respectively, between the E4 (2015) and E6 (2023) surveys. Over the same period (2016-2024), hydroperiod increased by 69 days on the eastern portion of M3. While the western portion of M3 was not studied in 2024, the hydroperiod decreased by 33 days between 2016 and 2020 (Figure 7). This discrepancy in the hydrologic pattern on both sides of SRS has also caused differences in the vegetation change pattern between eastern and western marl prairies along the MP&S gradients.

Water management operations are the main driver for the difference in vegetation change patterns observed in the eastern and western prairies on M3. Water conditions in the prairies west of SRS are influenced by the regulatory schedules for the S-12 structures along Tamiami Trail, initially implemented under the operational objectives of the Interim Structural and Operation Plan (ISOP)/Interim Operational Plan (IOP) but have so far continued in modified form under current management plans, including COP (USACE 2020; USACE/ENP/ SFWMD 2023; NASEM 2024). Together with the management efforts to regulate water deliveries from the S-12 structures, a consistently low water level has been maintained at water recorder NP-205 since 2002 (USFWS 2016). This has caused the vegetation composition in western marl prairies (e.g., western portion of M3) to shift toward a drier type over the last two decades (2003-2022). In contrast, water management aimed at hydrating prairies in the rocky glades of eastern ENP by operating a series of pump stations (e.g., S332B, S332C) along the L-31N canal and increasing water delivery into ENP through NESRS seem responsible for the vegetation shift in the eastern marl prairie toward a wetter type. Thus, a shift in vegetation towards wetter types indicates that the management goal is being achieved, at least in part. However, regular monitoring is essential to detect the magnitude and rate of vegetation shift in that region from the marl prairie to marl

marsh type. In fact, all the wet prairie sites identified on M1 and M2E during E1 (2005 and 2015, respectively) have already changed to marsh type. This is in concurrence with the goal of restoration, especially in the NESRS region. Likewise, on the easternmost (M3E_1) portion (up to 6.3 km from the retention pond levee), 12 (i.e., 63%) of 19 WP sites have changed to marsh vegetation type (**Figure 46b, Appendix 2**). In fact, in this part of the transect, Muhly grass cover IV values decreased from 12.1% to 2.5% while that of beakrush (*R. tracyi*) increased from 0.01 to 10.8% (**Appendix 4b**).

The magnitude of an increase in vegetation-inferred hydroperiod, which is a measure of hydrology-mediated change in vegetation composition, was not the same across all three marl prairie portions of the transect M4 (i.e. M4E_1, M4E_2 and M4W). Our results revealed that the shift towards wetness was higher at the M4E_1 and M4W sites than the M4E_2 sites. Since M4E_2 and M4W are located on both sides of the SRS, the greater shift in wetness at the MRE_1 than M4E_2 in the last four years was a surprise. In fact, between E4 and E5 surveys, the differences in 4-year average hydroperiod and mean annual water depth at the M4E_1 sites were higher than at the M4E_2 sites (**Figure 6**). Moreover, while differences in hydroperiod and water depths at the M4W sites were not as high as those at the eastern prairie sites, almost all M4W sites had burned in 2020 (**Table 2**), which also impacted the vegetation change at those sites. The most obvious impact of fire was on total plant cover and above ground plant biomass. During the 2021 survey, mean above ground biomass at M4W sites was a little more than half of the biomass in 2017 (**Figure 18**).

In addition to the positive outcome of the operations of water pumps and detention ponds and increased water deliveries through NESRS, the impact of such management efforts on prairie vegetation needs to be interpreted cautiously, because water flow from detention ponds and through bridges and culverts along Tamiami Trail into ENP may have adverse consequences as well. For instance, periphyton near inflow structures along the eastern boundary had elevated phosphorus in comparison to adjacent marl prairie sites to the west, suggesting an increase in Ploading due to long-term exposure of the canal-side sites to seepage (Gaiser et al. 2014). Sah et al. (2014) also concluded that vegetation in the upper Taylor Slough basin followed a significant trajectory along the vector representing the phosphorus gradient, possibly due to the influence of seepage water from the detention ponds. Nocentini et al. (2024) also observed P enrichment at some sites close to the canal, which was attributed to the internal legacy P loading (Sarker et al. 2020). Thus, increasing water levels resulting from inputs either from the canal through detention ponds or delivered into ENP through NESRS continue to influence vegetation in the eastern marl prairies, the water quality issue may need to be addressed so that the affected marl prairies do not shift to another stable state more adapted to P-enriched soil (Hagerthey et al. 2008).

A shift in vegetation composition in response to changes in an environmental driver is the result of changes in relative abundance of species. In the marl prairie portion of MP&S gradients, where the sites have become wetter in recent years, on both transects M1 and M2E, the

vegetation shift towards a wetter type is marked by an increase in importance values of hydric species, including bladderworts (*Utricularia* species), and a decrease in IV of prairie species like muhly grass (Muhlenbergia capillaris). In fact, in the NESRS regions, Nocentini et al. (2024) have also recorded that abundance of macrophyte species which are indicators of shorthydroperiod prairies decreased in six years (2016 – 2021), while abundance of long-hydroperiod species, such as E. cellulosa, increased in the same period. In addition, they have recorded an increase in cattail (Typha domingensis) in patches in some areas. On Transect M1, one of 11 surveyed sites has had dense cattail mixed with sawgrass since the E1 survey. However, at that site, the cattail has become more dominant than before and so dense that the site has become inaccessible. Thus, we were unable to study vegetation composition in that plot during the most recent two surveys, E5 (2019) and E6 (2023). In fact, an increase in cattail abundance in NESRS has also been noticed in the vicinity of a tree island located downstream of the Tamiami 1-mile bridge (Sah et al. 2024b). Moreover, along with the MP&S gradient, species richness is inversely proportional to the wetness (Sah et al. 2015). On both M1 and M2E, species richness decreased with an increase in wetness in recent years, especially after 2015. With a management goal of wetting the prairies in NESRS and the rocky glades along the eastern Park boundary, a decrease in species richness might be an outcome that cannot be avoided.

Despite the prevalence of more naturally driven hydrologic conditions, the influence of water management activities on the western section of the transect M4 cannot be ruled out. In the western part of the prairie west of Shark River Slough, high-water level persisted in the midto late 2000s, mainly because the hydrologic conditions in this area were influenced by flows through the culvert and bridges on Tamiami Trail and Loop Road (Kotun et al. 2009). However, the current water management goal of moving water from west to east seems to reverse the trend. Moreover, sea level rise (SLR) also might have an impact on the southwestern portion of the marl prairie. This is the case on transect M5, which at its western end transitions from freshwater to mangroves; a portion of the transect is primarily dominated by red mangrove (*Rhizophora mangle*). Over fourteen years (2008-2022), the mean frequency and cover of red mangrove has increased in the western portion of M5, suggesting the increasing influence of SLR driven saltwater intrusion in that area, as has been observed by researchers in the southern coastal region of the Everglades (Ross et al. 2024).

The distribution of C_3 and C_4 plants varies along hydrologic gradients, and in general, C_3 species increase in importance as wetness increases (Mozeto et al. 1996; Kotze and O'Connor 2000). In the Everglades also, we observed a decrease in C_4 abundance with an increase in wetness. These carbon isotope trends could indicate decreased $\delta^{13}C$ discrimination by plants with decreased water availability or values for plant $\delta^{13}C$ ratio could also be indicative of the proportion of C_3 or C_4 plants present, with C_3 plants having values of -32 to -22‰ and C_4 plants from -17 to -9‰ (Boutton et al. 1998). In fact, in a detailed study of soil and plant carbon isotopes on a subset of prairie and slough sites on the transect M3, the mean value of both plant and soil $\delta^{13}C$ decreased with an increase in wetness (Sah et al. 2020). Moreover, there was a small variation in $\delta^{13}C$ values (small standard error and narrow confidence interval) in ridge and

slough area, where mostly C₃ plants were present, while in the eastern marl prairie and transitional portions of the transect, variation was high due to the presence of varied proportions of C₃ and C₄ plants. The relationship between species composition and soil organic characteristics along the gradient suggests that the species traits, such as C₄/C₃ ratio, and their relative abundance can be used as indicators of soil organic matter turnover rates in this area, since C₃ and C₄ differ significantly in organic carbon production (Still et al. 2003). In concurrence with the distribution pattern of the relative abundance of C₄ and C₃ species along hydrologic gradient on the transects (M1-M5) studied, a significant decrease in C₄ cover over two decades was not surprising, because the sites on those transects have become much wetter during that period (Appendix 1).

In summary, regional differences in hydrologic regimes resulting from alternative management strategies have caused temporal changes in vegetation composition in Shark River Slough and adjacent marl prairies. The occurrence of these changes coincided with alterations in hydrologic regime during the past two decades. A recent increase in wetness together with the vegetation shift toward a more hydric type at both the slough and eastern marl prairie sites of the studied transects (M1-M5) suggest that restoration activities aimed at increased water delivery into ENP, especially in the eastern prairies along the Park boundary and in the NESRS region, are on track to achieve restoration goals. However, a shift in marl prairie vegetation from species-rich wet prairie type to species-poor marsh vegetation might be an outcome which may need to be closely monitored, as that will have an adverse impact on the marl prairie habitat quality. Finally, our results provide feedback that can be used for the adaptive management of Everglades wetland ecosystems along the marl prairie-slough gradient.

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Data Report

Vegetation data collected on MP&S Gradients Transects during first four years (Year 1-4) of the reporting period (2019-2024: CA # W912HZ-19-2-0031) is in the file **W912HZ1920031_MP&S_2019-2024** (**Yr_1_5)_ALL_Data.xlsx** at the location of monitoring data for this project **on RECOVR Share Point.** Once the Share Point is accessible, Year-5 data to be uploaded.

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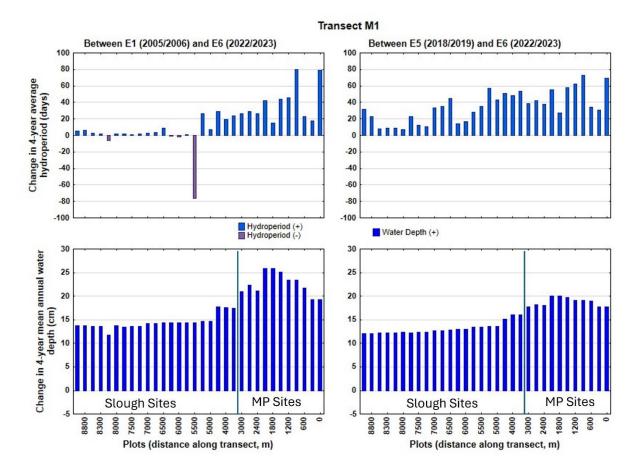
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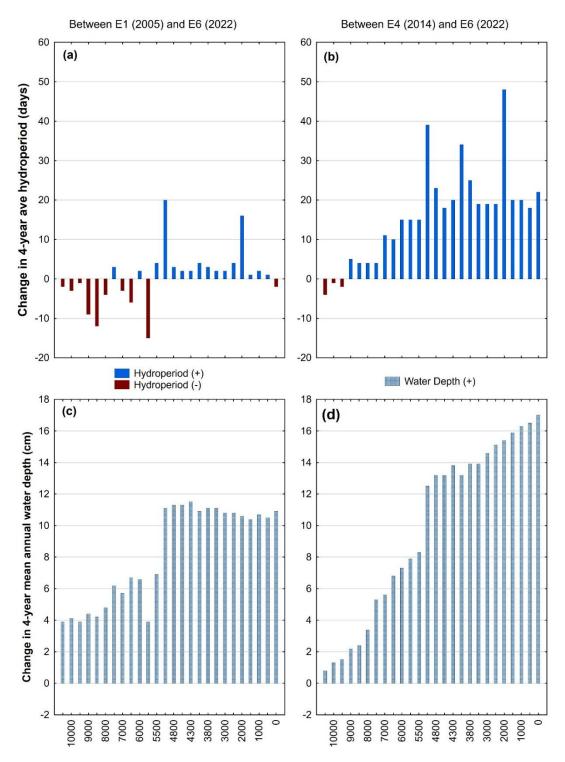
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Appendices

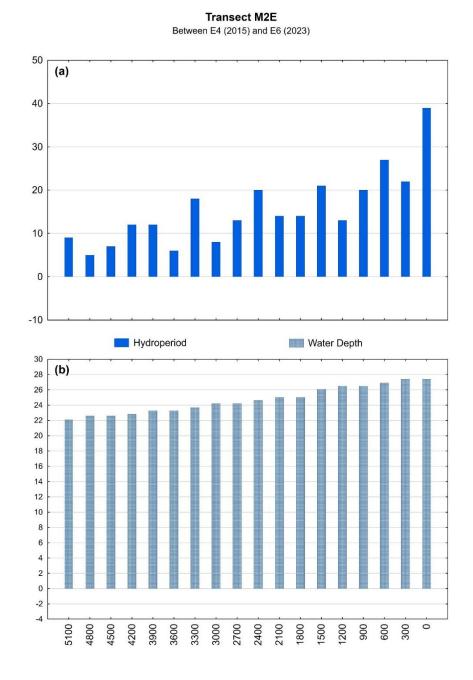


Appendix 1a: Change in four year-average hydroperiod and annual mean water depths prior to vegetation survey at sites of Transect M1 (including both MP and Slough sites) between E1 (2005/2006) and E6 (2022/2023) surveys. The site M1-5500 is in the tail of a small tree island and thus is drier than other slough sites on M1.

Transect M2



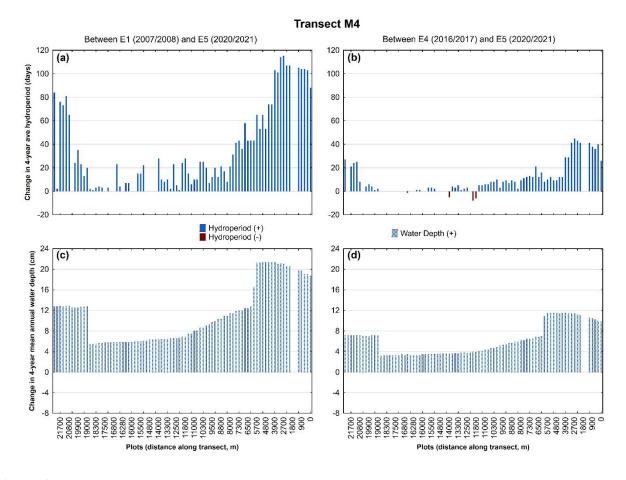
Appendix 1b: Change in four year-average hydroperiod and annual mean water depths prior to vegetation survey at sites of Transect M2 (Slough sites) between E1 (2005) and E6 (2022) surveys.



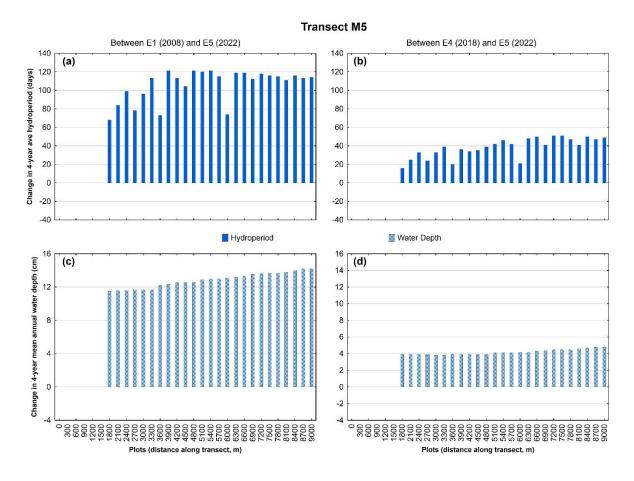
Appendix 1c: Change in four year-average hydroperiod and annual mean water depths prior to vegetation survey at sites of Transect M2E between E4 (2015) and E6 (2023) surveys.

Transect M3 Between E4 (2015/ 2016) and E6 (2023/ 2024) Between E1 (2007) and E5 (2022) Between E1 (2006/ 2007) and E6 (2023/ 2024) 180 180 180 (b) Change in 4-year ave hydroperiod (days) 160 (a) 160 160 (c) 140 140 140 120 120 120 100 100 100 80 80 80 60 60 60 M3W 40 40 40 20 20 20 0 0 0 -20 -20 -20 M3 SS МЗЕ M3E M3 SS -40 -40 -40 -60 -60 -60 -80 -80 -80 Hydroperiod (+) Hydroperiod (-) Water Depth (+) Water Depth (-) 26 26 26 (e) (f) Change in 4-year mean water depth (cm) (d) 22 22 22 18 18 18 14 14 14 10 10 10 6 6 6 2 2 2 -2 -2 -2 -6 -6 -6 -10 -10 -10

Appendix 1d: Change in four year-average hydroperiod and annual mean water depths prior to vegetation survey at both slough (SS) and eastern marl prairie sites of Transect M3 between E1 (2006/2007) and E6 (2023/2024) surveys, and at M3W sites between E1 (2007) and E5 (2022) surveys.



Appendix 1e: Change in four year-average hydroperiod and annual mean water depths prior to vegetation survey at both slough (SS) and marl prairie sites of Transect M4 between E1 (2007/2008) and E5 (2020/2021) surveys, and between E4 (2016/2017) and E5 (2020/2021) surveys.



Appendix 1f: Change in four year-average hydroperiod and annual mean water depths prior to vegetation survey at both slough (SS) and marl prairie sites of Transect M5 between E1 (2008) and E5 (2022) surveys, and between E4 (2018) and E5 (2022) surveys.

Appendix 2: Results (delta and slope values) of trajectory analysis and change in vegetation types. Trajectory analysis was done using 3-d ordination of the sites on slough and marl prairie portion of transects (M1-M5) along 4-year average mean water depth vector. N1 and N2 are the number of survey years during Marl prairie-Slough gradient study (2005-202). P-values <0.1 are in color showing the significant shift (blue = towards the wetter type; red = towards the drier type). The base year for trajectory of a subset of slough sites was 1999/2000 study, while marl prairie sites on M1, M3, M4 and M5 were 2006-2008 sampling event (E1), and those on M2E was 2015. Vegetation types identified at Transect (M1-M5) sites are compared between E1 (2005-2008) and E5 or E6 (2001-2004). Vegetation types based on E5 or E6 (2021-2024) vegetation data were identified using the same method as were done based on E1 (2005-2008) vegetation data by Sah et al. (2012). (*Full name of vegetation type are given below the table.)

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M1	M1-00000	1	5	1.6047	0.000	0.070	0.001	2006	2023	CWP	CMM
M1	M1-00300	1	3	-0.2243	0.346	-0.020	0.614	2006		TM	-
M1	M1-00600	1	5	0.0553	0.388	0.002	0.438	2006	2023	CEM	ECM
M1	M1-00900	1	5	0.1701	0.288	0.010	0.227	2006	2023	CWP	CMM
M1	M1-01200	1	5	0.9830	0.020	0.046	0.029	2006	2023	OWP	EM
M1	M1-01500	1	5	0.3646	0.176	0.019	0.169	2006	2023	CMM	EM
M1	M1-01800	1	5	0.0762	0.364	0.012	0.216	2006	2023	CM	CEM
M1	M1-02100	1	5	0.2384	0.264	0.0000	0.475	2006	2023	CMM	CMM
M1	M1-02400	1	5	-0.2036	0.210	-0.0057	0.687	2006	2023	EM	CEM
M1	M1-02700	1	5	0.0913	0.382	0.0032	0.427	2006	2023	ECM	ECM
M1	M1-03000	1	5	0.2866	0.113	0.0209	0.043	2006	2023	CMM	ECM
M1	M1-03500	1	5	0.0473	0.455	0.0156	0.163	2005	2022	EM	EM
M1	M1-04000	1	5	0.1199	0.298	0.0142	0.090	2005	2022	CM	CEM
M1	M1-04500	1	5	0.0364	0.439	0.0055	0.331	2005	2022	CM	CEM
M1	M1-05000	1	6	-0.3245	0.244	-0.0061	0.652	2005	2022	CM	CM
M1	M1-05300	1	5	-0.1340	0.277	-0.0011	0.558	2005	2022	CEM	ECM
M1	M1-05500	1	6	-0.7407	0.038	-0.0206	0.890	2005	2022	EM	EM
M1	M1-05800	1	5	-0.6510	0.026	-0.0232	0.965	2005	2022	EM	EM
M1	M1-06000	1	6	-0.1186	0.387	0.0079	0.314	2005	2022	CM	EM
M1	M1-06300	1	6	-0.2733	0.158	-0.0060	0.707	2005	2022	EM	EM
M1	M1-06500	1	6	-0.5138	0.159	-0.0129	0.757	2005	2022	EM	CM
M1	M1-06900	1	6	-0.0345	0.436	0.0094	0.250	2005	2022	CEM	EM
M1	M1-07000	1	6	0.1703	0.263	0.0140	0.033	2005	2022	CM	CM
M1	M1-07300	1	6	-0.0169	0.458	0.0002	0.504	2005	2022	CM	CM
M1	M1-07500	1	6	-0.1103	0.339	0.0037	0.338	2005	2022	CEM	EM
M1	M1-07800	1	6	0.1652	0.218	0.0145	0.023	2005	2022	CM	CEM
M1	M1-08000	1	6	-0.5281	0.047	-0.0138	0.863	2005	2022	CM	CM
M1	M1-08260	1	5	0.4039	0.013	0.0158	0.041	2007		CM	-
M1	M1-08300	1	6	0.1468	0.341	0.0098	0.204	2005	2022	CM	CM
M1	M1-08500	1	6	0.2233	0.169	0.0102	0.111	2005	2022	CM	CM
M1	M1-08800	1	6	0.0109	0.468	0.0028	0.295	2005	2022	CM	CM

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M1	M1-09000	1	6	-0.4122	0.018	-0.0083	0.868	2005	2022	CM	CEM
M2	M2-00000	1	5	0.3612	0.077	0.0249	0.026	2005	2022	CM	ECM
M2	M2-00500	1	5	-0.4910	0.086	-0.0104	0.699	2005	2022	EM	EM
M2	M2-01000	1	5	-0.0709	0.381	0.0013	0.472	2005	2022	CM	CEM
M2	M2-01500	1	5	-0.0207	0.451	0.0015	0.433	2005	2022	CM	CM
M2	M2-02000	1	3	-0.0949	0.419	0.0004	0.490	2005	2022	ВН	ВН
M2	M2-02500	1	5	-0.0377	0.385	0.0019	0.468	2005	2022	CEM	CM
M2	M2-03000	1	5	0.3964	0.128	0.0299	0.035	2005	2022	CM	CM
M2	M2-03500	1	6	-0.7701	0.019	-0.0255	0.971	2005	2022	EM	CEM
M2	M2-03800	1	6	0.1317	0.337	0.0144	0.113	2005	2022	CM	CM
M2	M2-04000	1	6	-0.3578	0.161	-0.0165	0.887	2005	2022	CM	CM
M2	M2-04300	1	6	-0.3457	0.057	-0.0107	0.891	2005	2022	NOM	CEM
M2	M2-04500	1	6	0.0338	0.443	0.0014	0.434	2005	2022	CM	CM
M2	M2-04800	1	6	0.0142	0.419	-0.0045	0.803	2005	2022	CM	CM
M2	M2-05000	1	5	-0.2808	0.041	-0.0183	0.995	2005	2022	OM	CM
M2	M2-05500	1	6	-0.4140	0.019	-0.0147	0.966	2005	2022	CEM	CEM
M2	M2-05760	1	6	0.7560	0.032	0.0242	0.055	2007	2022	CM	EM
M2	M2-06000	1	6	0.1391	0.524	-0.0052	0.743	2005	2022	CEM	CEM
M2	M2-06500	1	6	0.2788	0.204	0.0228	0.021	2005	2022	CM	CM
M2	M2-07000	1	6	-0.1090	0.305	0.0004	0.495	2005	2022	CM	CM
M2	M2-07500	1	6	-0.2170	0.170	-0.0016	0.560	2005	2022	EM	EM
M2	M2-08000	1	6	-0.0855	0.374	0.0030	0.376	2005	2022	CEM	ECM
M2	M2-08500	1	6	-0.2205	0.189	-0.0092	0.819	2005	2022	EM	ECM
M2	M2-09000	1	6	-0.2039	0.218	-0.0084	0.800	2005	2022	ECM	EM
M2	M2-09500	1	6	0.0863	0.385	0.0070	0.250	2005	2022	ECM	ECM
M2	M2-10000	1	6	0.2303	0.029	0.0100	0.019	2005	2022	CEM	ECM
M2	M2-10500	1	6	0.1828	0.128	0.0058	0.176	2005	2022	CEM	ECM
M2E	M2E-0000	1	2	1.2948	0.000	0.1619	0.000	2023	2023	CMWP	CMM
M2E	M2E-0300	1	2	1.1075	0.002	0.1384	0.002	2023	2023	CMWP	CMM
M2E	M2E-0600	1	2	1.0192	0.004	0.1274	0.004	2023	2023	CMWP	CM
M2E	M2E-0900	1	2	0.2651	0.016	0.0331	0.016	2023	2023	CEM	CEM
M2E	M2E-1200	1	2	0.6497	0.011	0.0812	0.011	2023	2023	CMWP	CM
M2E	M2E-1500	1	2	0.3048	0.000	0.0381	0.000	2023	2023	CRM	CEM
M2E	M2E-1800	1	2	0.2085	0.233	0.0261	0.233	2023	2023	CEM	CEM
M2E	M2E-2100	1	2	0.2151	0.215	0.0269	0.215	2023	2023	CM	CEM
M2E	M2E-2400	1	2	0.0724	0.381	0.0091	0.381	2023	2023	RCM	CEM
M2E	M2E-2700	1	2	0.7266	0.038	0.0908	0.038	2023	2023	RCM	EM
M2E	M2E-3000	1	2	0.0581	0.301	0.0073	0.301	2023	2023	CEM	ECM
M2E	M2E-3300	1	2	0.3029	0.074	0.0379	0.074	2023	2023	RCM	ECM
M2E	M2E-3600	1	2	0.2986	0.002	0.0373	0.002	2023	2023	ECM	ECM

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M2E	M2E-3900	1	2	0.6322	0.080	0.0790	0.080	2023	2023	EM	EM
M2E	M2E-4200	1	2	0.2425	0.110	0.0303	0.110	2023	2023	EM	ECM
M2E	M2E-4500	1	2	0.2145	0.118	0.0268	0.118	2023	2023	ECM	ECM
M2E	M2E-4800	1	2	0.2257	0.084	0.0282	0.084	2023	2023	CEM	ECM
M2E	M2E-5100	1	2	0.1210	0.130	0.0151	0.130	2023	2023	ECM	ECM
M3	M3-00000	1	4	1.0897	0.000	0.0436	0.003	2007	2024	CWP	CM
M3	M3-00300	1	4	0.5494	0.084	0.0279	0.075	2007	2024	MWP	CWP
M3	M3-00600	1	4	0.4550	0.013	0.0208	0.027	2007	2024	CWP	CMM
M3	M3-00900	1	4	0.4983	0.086	0.0305	0.051	2007	2024	SCWP	SCWP
M3	M3-01200	1	4	0.5333	0.026	0.0289	0.019	2007	2024	SCWP	SCWP
M3	M3-01500	1	4	0.4082	0.085	0.0278	0.031	2007	2024	CWP	CMM
M3	M3-01800	1	4	0.6492	0.006	0.0298	0.017	2007	2024	CWP	CM
M3	M3-02100	1	4	-0.1224	0.424	-0.0158	0.722	2007	2024	CWP	RCM
M3	M3-02400	1	4	0.4005	0.182	0.0126	0.266	2007	2024	MWP	RCM
M3	M3-02700	1	4	-0.1430	0.366	-0.0025	0.555	2007	2024	CWP	RCM
M3	M3-03000	1	4	0.1117	0.345	0.0016	0.434	2007	2024	SCWP	SCWP
M3	M3-03300	1	4	0.7021	0.005	0.0266	0.028	2007	2024	CWP	ECM
M3	M3-03600	1	2	0.0396	0.463	0.0066	0.463	2007		CEM	-
M3	M3-03900	1	4	0.5427	0.044	0.0391	0.010	2007	2024	CWP	CMM
M3	M3-04200	1	4	0.7225	0.016	0.0377	0.012	2007	2024	CMM	CMM
M3	M3-04500	1	4	0.3511	0.071	0.0224	0.044	2007	2024	CMM	CMM
M3	M3-04800	1	4	0.4619	0.017	0.0242	0.010	2007	2024	CWP	CMM
M3	M3-05100	1	4	0.3690	0.117	0.0261	0.043	2007	2024	CWP	CM
M3	M3-05400	1	4	0.6954	0.049	0.0481	0.008	2007	2024	CWP	CMM
M3	M3-05700	1	4	0.3552	0.050	0.0132	0.108	2007	2024	CWP	CWP
M3	M3-06000	1	4	0.0281	0.447	0.0050	0.369	2007	2024	CWP	CWP
M3	M3-06300	1	4	0.3614	0.089	0.0180	0.079	2007	2024	CWP	CWP
M3	M3-06600	1	0	*	*	*	*	2007		ВН	-
M3	M3-06900	1	4	0.1947	0.278	0.0256	0.059	2007	2024	ВН	ВН
M3	M3-07200	1	4	0.0631	0.472	0.0257	0.196	2007	2024	CMM	CMM
M3	M3-07500	1	4	0.2597	0.215	0.0248	0.043	2007	2024	CMM	CMM
M3	M3-07800	1	4	0.5265	0.024	0.0160	0.125	2007	2024	CMM	CM
M3	M3-08100	1	4	0.6729	0.008	0.0404	0.000	2007	2024	CMM	CM
M3	M3-08400	1	4	0.1460	0.344	0.0124	0.255	2007	2024	CMM	CMM
M3	M3-08700	1	4	0.7890	0.044	0.0269	0.125	2007	2024	CM	CEM
M3	M3-09000	1	4	0.1465	0.309	0.0163	0.123	2007	2024	CMM	CMM
M3	M3-09300	1	4	0.4140	0.159	0.0267	0.097	2007	2024	CMM	CM
M3	M3-09600	1	4	0.0707	0.451	-0.0082	0.682	2007	2024	CM	CM
M3	M3-09900	1	4	0.1507	0.344	0.0154	0.228	2007	2024	CMM	CMM
M3	M3-10200	1	4	0.2198	0.199	0.0049	0.379	2007	2024	CEM	ECM

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M3	M3-10500	1	4	0.4759	0.058	0.0235	0.071	2007	2024	CMM	ECM
M3	M3-10800	1	4	0.2119	0.200	0.0167	0.113	2007	2024	CEM	ECM
M3	M3-11100	1	4	0.0716	0.393	0.0094	0.274	2007	2024	CMM	CMM
M3	M3-11400	1	4	0.9690	0.000	0.0398	0.002	2007	2024	CMM	ECM
M3	M3-11700	1	4	0.1891	0.119	0.0041	0.313	2007	2024	CEM	EM
M3	M3-12000	1	3	0.5243	0.096	0.0308	0.098	2007	2023	CM	ECM
M3	M3-12500	1	4	0.4302	0.027	0.0243	0.023	2006	2023	CM	ECM
M3	M3-13000	1	4	0.1950	0.192	0.0035	0.360	2006	2023	CM	CM
M3	M3-13500	1	4	0.3127	0.141	0.0265	0.028	2006	2023	CM	CM
M3	M3-14000	1	4	0.2085	0.165	0.0155	0.057	2006	2023	CM	ECM
M3	M3-14500	1	4	0.3065	0.049	0.0189	0.017	2006	2023	CEM	EM
M3	M3-15000	1	4	0.1759	0.069	0.0096	0.050	2006	2023	CEM	ECM
M3	M3-15500	1	5	-0.2578	0.217	-0.0148	0.899	2006	2023	NOM	NOM
M3	M3-15800	1	5	0.0445	0.426	-0.0110	0.809	2006	2023	NOM	NOM
M3	M3-16000	1	5	-0.4841	0.020	-0.0154	0.963	2006	2023	CM	CEM
M3	M3-16300	1	5	-0.0738	0.398	-0.0073	0.818	2006	2023	CM	CM
M3	M3-16500	1	5	-0.1361	0.275	-0.0015	0.546	2006	2023	CEM	ECM
M3	M3-16800	1	5	-0.2115	0.105	-0.0040	0.709	2006	2023	CM	CEM
M3	M3-17000	1	5	-0.3416	0.043	-0.0120	0.944	2006	2023	CM	ECM
M3	M3-17300	1	5	-0.5092	0.053	-0.0177	0.949	2006	2023	CM	CM
M3	M3-17500	1	5	-0.3055	0.103	-0.0108	0.894	2006	2023	CEM	ECM
M3	M3-17800	1	5	0.5738	0.024	0.0178	0.043	2006	2023	NOM	NOM
M3	M3-18000	1	5	-0.4252	0.013	-0.0126	0.975	2006	2023	CM	CEM
M3	M3-18300	1	5	-0.2431	0.140	-0.0044	0.712	2006	2023	NOM	NOM
M3	M3-18500	1	5	-0.2511	0.157	-0.0068	0.776	2006	2023	CEM	CEM
M3	M3-19000	1	5	-0.0797	0.324	-0.0037	0.688	2006	2023	EM	NOM
M3	M3-19300	1	5	-0.3605	0.088	-0.0193	0.971	2006	2023	ECM	CEM
M3	M3-19500	1	5	0.1652	0.182	0.0089	0.142	2006	2023	EM	NOM
M3	M3-19800	1	5	-0.1754	0.144	-0.0071	0.858	2006	2023	CM	CM
M3	M3-20000	1	5	-0.1652	0.239	-0.0074	0.817	2006	2023	ECM	ECM
M3	M3-20200	1	5	0.0461	0.391	0.0024	0.339	2007	2023	CM	CM
M3	M3-20300	1	5	-0.3289	0.035	-0.0128	0.975	2006	2023	CEM	CM
M3	M3-20500	1	5	-0.4605	0.016	-0.0144	0.965	2006	2023	CEM	CEM
M3	M3-20700	1	5	0.1000	0.171	0.0051	0.168	2007	2023	CM	CM
M3	M3-20800	1	5	-0.1811	0.195	-0.0065	0.816	2006	2023	CEM	CM
M3	M3-21000	1	5	-0.3903	0.041	-0.0123	0.936	2006	2023	EM	ECM
M3	M3-21300	1	5	-0.2316	0.167	-0.0100	0.885	2006	2023	EM	EM
M3	M3-21500	1	5	0.0066	0.501	0.0015	0.425	2006	2023	CM	CEM
M3	M3-21800	1	5	-0.0543	0.303	-0.0011	0.608	2006	2023	CM	CM
M3	M3-22000	1	5	-0.1643	0.173	-0.0062	0.857	2006	2023	CM	CM

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M3	M3-22500	1	4	-0.0292	0.480	0.0085	0.163	2006	2023	EM	EM
M3	M3-23000	1	4	0.1340	0.058	0.0053	0.063	2006	2023	ECM	ECM
M3	M3-23500	1	4	0.4788	0.010	0.0192	0.009	2006	2023	RCM	ERM
M3	M3-24000	1	1	-0.3288	*	-0.1644	0.860	2007		BH	-
M3	M3-24500	1	4	-0.0567	0.444	0.0062	0.349	2007	2022	CMM	CM
M3	M3-25000	1	4	-0.0537	0.434	-0.0068	0.638	2007	2022	CEM	CEM
M3	M3-25500	1	4	0.2053	0.220	0.0150	0.129	2007	2022	RCM	CEM
M3	M3-26000	1	4	-0.0374	0.367	0.0023	0.340	2007	2022	CMM	CM
M3	M3-26500	1	4	0.2544	0.104	0.0158	0.098	2007	2022	CMM	CRM
M3	M3-27000	1	4	-0.0162	0.482	0.0030	0.412	2007	2022	RCM	REM
M3	M3-27500	1	4	0.2473	0.128	0.0129	0.164	2007	2022	RCM	CEM
M3	M3-28000	1	4	-0.1353	0.141	-0.0050	0.733	2007	2022	CMM	CMM
M3	M3-28500	1	4	0.2712	0.094	0.0191	0.062	2007	2022	RCM	CMM
M3	M3-29000	1	4	-0.1696	0.219	-0.0166	0.905	2007	2022	CWP	SCWP
M3	M3-29500	1	4	-0.0617	0.397	0.0024	0.426	2007	2022	CWP	CWP
M3	M3-30000	1	4	0.1033	0.270	0.0097	0.188	2007	2022	MWP	CWP
M3	M3-30500	1	4	-0.1840	0.218	-0.0102	0.755	2007	2022	CWP	CWP
M3	M3-31000	1	4	0.0752	0.291	0.0025	0.378	2007	2022	SCWP	SCWP
M3	M3-31300	1	4	-0.2211	0.161	-0.0278	0.979	2007	2022	CWP	PWP
M3	M3-31600	1	4	-0.0870	0.326	-0.0057	0.690	2007	2022	SCWP	SCWP
M3	M3-31900	1	4	-0.2723	0.087	-0.0201	0.959	2007	2022	CWP	SCWP
M3	M3-32200	1	4	0.0677	0.373	0.0064	0.304	2007	2022	SCWP	SCWP
M3	M3-32500	1	4	-0.1398	0.319	-0.0005	0.541	2007	2022	CWP	SCWP
M3	M3-32800	1	4	-0.0335	0.437	-0.0012	0.545	2007	2022	CWP	CWP
M3	M3-33100	1	4	-0.1902	0.254	-0.0019	0.530	2007	2022	CWP	CWP
M3	M3-33400	1	4	-0.0113	0.479	0.0063	0.359	2007	2022	CWP	CWP
M3	M3-33700	1	4	0.1228	0.265	0.0084	0.251	2007	2022	PWP	PWP
M3	M3-34000	1	4	-0.1742	0.130	-0.0054	0.691	2007	2022	SOWP	PWP
M3	M3-34300	1	4	-0.4374	0.025	-0.0265	0.974	2007	2022	CWP	CWP
M3	M3-34600	1	4	-0.4807	0.012	-0.0217	0.937	2007	2022	RCM	CRM
M3	M3-34900	1	4	-0.1856	0.203	-0.0183	0.918	2007	2022	CWP	SCWP
M3	M3-35200	1	4	-0.1545	0.253	-0.0051	0.653	2007	2022	CWP	CWP
M3	M3-35500	1	4	-0.3095	0.130	-0.0139	0.799	2007	2022	CWP	SCWP
M3	M3-35800	1	4	-0.1974	0.169	-0.0176	0.911	2007	2022	CWP	CWP
M4	M4-00000	1	4	0.4875	0.070	0.0422	0.029	2008	2021	CWP	CWP
M4	M4-00300	1	4	0.4911	0.116	0.0499	0.024	2008	2021	MWP	CWP
M4	M4-00600	1	4	0.1057	0.425	0.0090	0.392	2008	2021	CWP	CWP
M4	M4-00900	1	4	-0.3371	0.095	-0.0160	0.800	2008	2021	CWP	CWP
M4	M4-01200	1	4	-0.2413	0.220	-0.0103	0.680	2008	2021	CWP	CWP
M4	M4-01500	1	4	0.8235	0.012	0.0599	0.007	2008	2021	SCWP	CWP

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M4	M4-01800	1	4	-0.4051	0.137	-0.0214	0.753	2008	2021	CWP	SCWP
M4	M4-02100	1	4	0.5907	0.017	0.0435	0.010	2008	2021	SCWP	CWP
M4	M4-02400	1	4	0.2927	0.137	0.0273	0.092	2008	2021	CWP	CWP
M4	M4-02700	1	4	-0.1651	0.312	-0.0072	0.623	2008	2021	CWP	CWP
M4	M4-03300	1	4	0.7070	0.015	0.0482	0.028	2008	2021	CWP	ECM
M4	M4-03600	1	4	0.3883	0.004	0.0240	0.006	2008	2021	CM	CM
M4	M4-03900	1	4	0.2765	0.161	0.0146	0.232	2008	2021	CM	CEM
M4	M4-04200	1	4	0.1528	0.142	0.0083	0.213	2008	2021	CEM	CEM
M4	M4-04485	1	4	0.3777	0.075	0.0254	0.088	2008	2021	CWP	CEM
M4	M4-04800	1	4	0.3163	0.036	0.0169	0.124	2008	2021	CEM	ECM
M4	M4-05100	1	4	0.4094	0.021	0.0264	0.034	2008	2021	CEM	ECM
M4	M4-05400	1	4	0.4039	0.085	0.0079	0.359	2008	2021	RCM	REM
M4	M4-05700	1	4	0.2915	0.134	0.0069	0.339	2008	2021	CMM	CM
M4	M4-06000	1	4	-0.1991	0.196	-0.0142	0.805	2007	2021	CEM	CEM
M4	M4-06300	1	4	-0.0698	0.376	-0.0075	0.686	2007	2020	RCM	CEM
M4	M4-06500	1	4	0.0956	0.290	-0.0019	0.544	2007	2020	CEM	CEM
M4	M4-06800	1	4	0.3152	0.161	0.0184	0.217	2007	2020	RCM	ERM
M4	M4-07000	1	5	0.1531	0.218	0.0081	0.166	2007	2020	CEM	ECM
M4	M4-07300	1	5	-0.1009	0.336	-0.0004	0.525	2007	2020	CEM	CEM
M4	M4-07500	1	5	-0.1584	0.057	-0.0046	0.856	2007	2020	CM	CEM
M4	M4-07800	1	5	-0.3781	0.074	-0.0121	0.851	2007	2020	ECM	ECM
M4	M4-08000	1	5	-0.1445	0.171	-0.0063	0.820	2007	2020	ECM	ECM
M4	M4-08300	1	5	-0.4526	0.005	-0.0182	0.993	2007	2020	CEM	CEM
M4	M4-08500	1	5	-0.4394	0.069	-0.0198	0.938	2007	2020	CM	CM
M4	M4-08800	1	5	-0.1487	0.179	-0.0054	0.753	2007	2020	CM	CM
M4	M4-09000	1	5	-0.3748	0.022	-0.0160	0.974	2007	2020	CEM	CEM
M4	M4-09300	1	5	-0.1012	0.349	-0.0018	0.541	2007	2020	CM	CM
M4	M4-09500	1	5	-0.6034	0.003	-0.0258	0.996	2007	2020	CM	CM
M4	M4-09800	1	5	-0.2434	0.202	-0.0074	0.750	2007	2020	EM	ECM
M4	M4-10000	1	5	-0.0456	0.286	-0.0003	0.546	2007	2020	CM	CM
M4	M4-10300	1	5	-0.3746	0.019	-0.0171	0.982	2007	2020	CEM	CEM
M4	M4-10500	1	5	-0.3809	0.039	-0.0180	0.968	2007	2020	CM	CM
M4	M4-10800	1	5	-0.5033	0.069	-0.0193	0.921	2007	2020	CEM	CEM
M4	M4-11000	1	5	-0.3689	0.044	-0.0136	0.928	2007	2020	CEM	CM
M4	M4-11300	1	5	-0.0978	0.322	-0.0086	0.823	2007	2020	CM	CTM
M4	M4-11500	1	5	-0.8246	0.019	-0.0363	0.982	2007	2020	CEM	CEM
M4	M4-11800	1	2	0.1981	0.197	0.0160	0.184	2007	2020	CM	CM
M4	M4-12000	1	2	-0.0426	0.387	-0.0047	0.632	2007	2020	CM	CM
M4	M4-12300	1	4	-0.0863	0.344	-0.0120	0.766	2007	2020	EM	NOM
M4	M4-12500	1	4	0.0859	0.333	-0.0041	0.638	2007	2020	CEM	CEM

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M4	M4-12800	1	4	0.2144	0.224	-0.0023	0.534	2007	2020	CEM	CM
M4	M4-13000	1	4	-0.0124	0.495	-0.0088	0.762	2007	2020	CEM	CEM
M4	M4-13300	1	4	-0.0076	0.476	-0.0064	0.708	2007	2020	CM	CM
M4	M4-13500	1	4	-0.2235	0.080	-0.0182	0.944	2007	2020	CEM	CEM
M4	M4-13800	1	4	0.0616	0.325	-0.0009	0.521	2007	2020	CM	CM
M4	M4-14000	1	4	-0.0180	0.222	-0.0012	0.760	2007	2020	CM	CM
M4	M4-14300	1	4	0.2593	0.230	0.0168	0.257	2007	2020	EM	EM
M4	M4-14500	1	4	-0.0890	0.285	-0.0134	0.915	2007	2020	CM	CM
M4	M4-14800	1	4	-0.1411	0.171	-0.0173	0.963	2007	2020	CEM	CM
M4	M4-15000	1	4	0.1038	0.257	0.0005	0.478	2007	2020	ECM	EM
M4	M4-15300	1	4	-0.0596	0.430	-0.0187	0.787	2007	2020	EM	TM
M4	M4-15500	1	3	0.1137	0.239	0.0073	0.276	2007	2020	CEM	CM
M4	M4-15700	1	4	-0.2491	0.162	-0.0081	0.742	2007	2020	CEM	CM
M4	M4-15800	1	5	-0.2671	0.127	-0.0155	0.948	2007	2020	CEM	CM
M4	M4-16000	1	5	0.0558	0.377	0.0036	0.357	2007	2020	EM	EM
M4	M4-16100	1	4	-0.0061	0.463	0.0017	0.377	2007	2020	CM	CM
M4	M4-16260	1	4	-0.2000	0.068	-0.0086	0.911	2007	2020	CM	CM
M4	M4-16280	1	4	-0.1171	0.165	-0.0054	0.835	2007	2020	CM	CM
M4	M4-16300	1	5	0.2715	0.032	0.0102	0.059	2007	2020	CM	CM
M4	M4-16500	1	5	0.0601	0.443	0.0122	0.323	2007	2020	RCM	CTM
M4	M4-16800	1	5	-0.3241	0.072	-0.0172	0.965	2007	2020	CEM	CEM
M4	M4-17000	1	5	-0.0711	0.408	-0.0068	0.679	2007	2020	CM	CM
M4	M4-17300	1	5	0.4796	0.051	0.0301	0.010	2007	2020	EM	EM
M4	M4-17500	1	5	-0.1548	0.229	-0.0086	0.801	2007	2020	ECM	ECM
M4	M4-17800	1	5	0.3590	0.043	0.0107	0.119	2007	2020	CM	CM
M4	M4-18000	1	5	0.3102	0.031	0.0139	0.020	2007	2020	CEM	ECM
M4	M4-18300	1	5	-0.5530	0.003	-0.0252	0.999	2007	2020	ECM	ECM
M4	M4-18500	1	5	-0.3643	0.009	-0.0156	0.989	2007	2020	CEM	CM
M4	M4-18800	1	5	-0.0984	0.301	-0.0104	0.909	2007	2020	ECM	ECM
M4	M4-19000	1	4	0.4881	0.003	0.0323	0.002	2008	2021	CMM	CM
M4	M4-19300	1	3	0.0295	0.441	0.0013	0.487	2008	2021	CEM	ECM
M4	M4-19600	1	4	0.3626	0.060	0.0175	0.162	2008	2021	CMM	ECM
M4	M4-19900	1	4	-0.0924	0.285	-0.0015	0.549	2008	2021	CMM	CM
M4	M4-20200	1	4	0.3552	0.137	0.0311	0.070	2008	2021	CM	CMM
M4	M4-20500	1	2	0.0395	0.134	0.0066	0.134	2008		TM	-
M4	M4-20800	1	4	0.2456	0.001	0.0183	0.001	2008	2021	CM	CM
M4	M4-21100	1	4	0.6088	0.003	0.0437	0.001	2008	2021	CWP	EM
M4	M4-21400	1	4	0.4245	0.038	0.0340	0.016	2008	2021	SCWP	CWP
M4	M4-21700	1	4	0.4747	0.008	0.0378	0.002	2008	2021	SCWP	CWP
M4	M4-22000	1	3	-0.0057	0.482	-0.0003	0.525	2008		CM	-

Tran- sect	Site ID	N1	N2	Delta	p-value	Slope	p-value	Samp-1 (E1)	Samp-2 (E5E6)	E1_VEG- ID*	E56_VEG- ID*
M4	M4-22300	1	4	0.3086	0.095	0.0360	0.018	2008	2021	CM	CM
M5	M5-00000	1	4	-0.1007	0.032	-0.0066	0.966	2008	2022	RM	RM
M5	M5-00300	1	4	0.3671	0.282	0.0247	0.274	2008	2022	RM	RM
M5	M5-00600	1	4	0.1924	0.111	0.0145	0.072	2008	2022	RM	RM
M5	M5-00900	1	4	-0.0848	0.271	-0.0072	0.810	2008	2022	RM	RM
M5	M5-01200	1	4	-0.1283	0.165	-0.0143	0.969	2008	2022	CM	CM
M5	M5-01500	1	4	0.0023	0.472	-0.0023	0.761	2008	2022	ECM	CEM
M5	M5-01800	1	4	0.2894	0.165	0.0115	0.274	2008	2022	EM	RM
M5	M5-02100	1	4	0.0096	0.405	-0.0012	0.637	2008	2022	CEM	CEM
M5	M5-02400	1	4	0.1781	0.095	0.0098	0.088	2008	2022	CEM	CEM
M5	M5-02700	1	4	0.1931	0.186	0.0098	0.248	2008	2022	ECM	ECM
M5	M5-03000	1	4	-0.1825	0.110	-0.0094	0.842	2008	2022	CEM	CEM
M5	M5-03300	1	4	0.1943	0.138	0.0197	0.030	2008	2022	CEM	CEM
M5	M5-03600	1	4	0.6343	0.006	0.0435	0.004	2008	2022	CWP	CEM
M5	M5-03900	1	4	0.0178	0.466	0.0189	0.165	2008	2022	CWP	CWP
M5	M5-04200	1	4	0.1958	0.293	0.0152	0.237	2008	2022	CWP	RCM
M5	M5-04500	1	4	0.2071	0.079	0.0128	0.079	2008	2022	CM	CM
M5	M5-04800	1	4	0.1980	0.182	0.0203	0.065	2008	2022	RCM	CEM
M5	M5-05100	1	4	0.0481	0.417	0.0110	0.227	2008	2022	CWP	CRM
M5	M5-05400	1	4	-0.1720	0.150	0.0000	0.528	2008	2022	CWP	CWP
M5	M5-05700	1	4	0.1712	0.260	0.0219	0.098	2008	2022	CWP	CM
M5	M5-06000	1	4	0.0860	0.417	0.0215	0.177	2008	2022	CWP	CWP
M5	M5-06300	1	4	-0.0677	0.409	0.0093	0.306	2008	2022	CWP	SCWP
M5	M5-06600	1	4	0.2290	0.126	0.0307	0.009	2008	2022	CWP	CWP
M5	M5-06900	1	4	0.1914	0.144	0.0203	0.026	2008	2022	MWP	CWP
M5	M5-07200	1	4	0.0320	0.472	0.0071	0.391	2008	2022	CMM	CMM
M5	M5-07500	1	4	-0.0079	0.474	-0.0011	0.548	2008	2022	CWP	SCWP
M5	M5-07800	1	4	0.0454	0.437	0.0150	0.233	2008	2022	SCWP	CWP
M5	M5-08100	1	4	0.2187	0.230	0.0217	0.112	2008	2022	CWP	MWP
M5	M5-08400	1	4	0.0871	0.348	-0.0070	0.681	2008	2022	SCWP	SCWP
M5	M5-08700	1	4	0.4932	0.055	0.0382	0.009	2008	2022	CWP	CWP
M5	M5-09000	1	4	-0.1328	0.199	-0.0102	0.849	2008	2022	MWP	MWP

^{*} MWP = Muhlenbergia Wet Prairie (WP); SCWP = Schizachyrim WP; CWP = Cladium WP; PWP = Paspalum WPCM = Cladium Marsh; CMM = Cladium Mixed Marsh; CRM = Cladium-Rhynchospora Marsh; RCM = Rhynchospora-Cladium Marsh: CEM = Cladium-Eleocharis Marsh; ECM = Eleocharis-Cladium Marsh, EM = Eleocharis Marsh; ERM = Elecharis-Rhynchospora Marsh; REM = Rhynchospora-Eleocharis Marsh; CTM = Cladium-Typha Marsh; TCM = Typha-Cladium Marsh; TM = Typha Marsh; Nymphaea Open Marsh; RHIMAN = Red mangrove; BH = Bayhed.

Appendix 3a: Importance value index (IV) of species that were present at the slough sites of transect M1 and M2. Slough sites on both transects were surveyed for the first time in 1999/2000, and then six times (2005, 2008, 2011, 2014, 2018 & 2022) between 2005 and 2023.

SPP	SPCODE	Species name				M1							M2			
No.	SECODE	Species name	1999	2005	2008	2011	2014	2018	2022	2000	2005	2008	2011	2014	2018	2022
1	ACRDAN	Acrostichum danaeifolium										0.66	0.83	0.65	0.02	
2	AESPRA	Aeschynomene pratensis		0.16	0.36	0.04	0.18	0.19	0.33	0.02	0.41	0.40	0.22	0.51	0.13	0.57
11	ANNGLA	Annona glabra											0.31	0.02		0.34
24	BACCAR	Bacopa caroliniana	0.48	4.92	3.19	4.91	3.16	1.99	3.31	2.60	2.49	2.30	0.95	2.16	2.26	1.41
28	BLESER	Blechnum serrulatum								0.79	0.61	0.86	0.62	0.46	0.45	0.50
29	BOECYL	Boehmeria cylindrica											0.06			
35	CEPOCC	Cephalanthus occidentalis								0.10	1.29	0.31	1.13	0.57	0.48	0.26
37	CHRICA	Chrysobalanus icaco										0.36	0.13			0.02
39	CLAJAM	Cladium jamaicense	33.12	52.89	59.99	62.38	44.49	32.38	34.70	37.16	49.48	47.87	61.22	42.04	41.98	35.19
43	CRIAME	Crinum americanum	2.72	1.90	2.46	1.43	3.18	2.82	1.29	2.37	1.89	2.85	2.78	3.23	1.72	1.48
44	CYNBLO	Metastelma blodgettii								0.23						
45	CYNXX1	Cynanchum sp.										0.18				
56	ELECEL	Eleocharis cellulosa	11.79	11.85	15.05	14.78	10.76	11.40	16.67	15.91	24.80	15.79	17.46	17.75	16.80	15.31
57	ELEELO	Eleocharis elongata														0.72
59	ELEINT	Eleocharis interstincta														0.12
79	HYDCOR	Hydrolea corymbosa	0.04													
80	HYMLAT	Hymenocallis latifolia	0.49							0.49						
81	HYMPAL	Hymenocallis palmeri		0.03					0.03		0.90	0.28	0.56	0.74	1.33	0.59
82	HYPALA	Hyptis alata														
86	IPOSAG	Ipomoea sagittata											0.98	0.95	1.10	0.39
87	IVAMIC	Iva microcephala			0.06											
90	JUSANG	Justicia angusta	0.08	0.57	0.96	0.90	1.14	0.57	0.51	1.21	2.18	3.12	2.26	4.56	1.94	1.45
92	LEEHEX	Leersia hexandra			0.54			0.22	0.39	0.70	0.10	0.13	_	0.56	0.21	0.82
95	LUDALA	Ludwigia alata									0.10					
96	LUDCUR	Ludwigia curtissii													0.02	
97	LUDMIC	Ludwigia microcarpa											0.18			

SPP	SPCODE	Cu actas mama				M1							M2			
No.	SPCODE	Species name	1999	2005	2008	2011	2014	2018	2022	2000	2005	2008	2011	2014	2018	2022
98	LUDREP	Ludwigia repens			0.08							0.18				
102	MELQUI	Melaleuca quinquenervia	0.65	0.76	0.16	0.14										
104	MIKSCA	Mikania scandens												0.02		
106	MORCER	Morella cerifera				0.63							0.54			
107	MUHCAP	Muhlenbergia capillaris var. filipes												0.68		
109	NYMAQU	Nymphoides aquatica				0.18	0.20	0.18	0.62			0.16		0.45	0.15	0.38
110	NYMODO	Nymphaea odorata	1.88	0.86	0.57	0.09	0.20	0.16		0.06	2.00	1.67	0.75	0.41	0.49	0.90
111	OXYFIL	Oxypolis filiformis											0.22	0.14		0.02
113	PANHEM	Panicum hemitomon	3.64	2.59	1.91	2.01	1.53	0.23	1.10	1.70	2.48	0.74	1.38	1.44	2.37	2.03
115	PANTEN	Coleataenia tenera			0.32		0.30	0.03			0.16		0.24			0.14
116	PANVIR	Panicum virgatum			0.06								0.25			
119	PASGEM	Paspalidium geminatum	1.24	1.95	0.94	0.86	0.87	0.82	1.98	0.66	0.31	0.13	0.18	0.32	0.49	0.99
122	PELVIR	Peltandra virginica	0.05	0.70	0.05	0.04		0.19	0.08	0.32	1.68	0.92	0.19	1.03	0.32	0.11
123	PERBOR	Persea borbonia											0.13			
137	PERHYD	Polygonum hydropiperoides				0.25							0.71	0.14		
124	PERSET	Persicaria setacea													0.53	
134	PLUROS	Pluchea baccharis											0.02	0.24		
138	PONCOR	Pontederia cordata		1.91	2.22		0.11	0.78	0.60	0.48	0.05	0.74	0.36	0.78	2.00	1.99
149	RHYINT	Rhynchospora intermedia														0.09
150	RHYINU	Rhynchospora inundata			0.25									0.28		
151	RHYMIC	Rhynchospora microcarpa		0.05								0.13				
152	RHYMIL	Rhynchospora miliacea			0.06											
153	RHYTRA	Rhynchospora tracyi		1.54	4.32	6.47	4.16	1.26	2.63	0.75	0.12	0.57	1.18	0.78	0.50	0.96
158	SAGLAN	Sagittaria lancifolia	0.59	1.24	2.30	0.75	0.20		0.04	0.23	0.80	1.33	1.06	0.58	0.54	
159	SALCAR	Salix caroliniana												0.24		
161	SARCLA	Funastrum clausum										0.18	1.18	0.27		
179	THEINT	Thelypteris interrupta											0.07			

SPP	SPCODE	Species name				M1							M2			
No.	SPCODE	Species name	1999	2005	2008	2011	2014	2018	2022	2000	2005	2008	2011	2014	2018	2022
189	TYPDOM	Typha domingensis											0.06			
234	UTRCOR	Utricularia cornuta	0.05				1.49									
235	UTRFOL	Utricularia foliosa	5.82	2.74		0.62	0.86	3.09	5.60	4.56	0.80	1.50	0.37	2.51	4.36	5.26
236	UTRGIB	Utricularia gibba					0.22		0.28							
237	UTRPUR	Utricularia purpurea	37.37	13.34	4.15	3.51	26.98	43.69	29.85	29.67	7.34	16.69	1.43	15.48	19.78	27.94

Appendix 3b: Importance value index (IV) of species that were present at the slough sites of transect M3 and M4. Slough sites on both transects were surveyed for the first time in 1999/2000, and then between 2005 and 2023 they were surveyed six and five times, respectively. The sites on M3 were surveyed in 2006, 2009, 2012, 2015, 2019 & 2023, while those on M4 were surveyed in 2007, 2010, 2013, 2016 & 2020.

SPP	SPCODE	Encoing name				М3						M	[4		
No.	SPCODE	Species name	1999	2006	2009	2012	2015	2019	2023	1999	2007	2010	2013	2016	2020
2	AESPRA	Aeschynomene pratensis		0.34	0.57	0.48	1.19	0.59	0.14		0.67	0.37	0.68	0.09	0.20
11	ANNGLA	Annona glabra		0.26	0.10	0.02	0.06		0.09		0.11	0.02			
24	BACCAR	Bacopa caroliniana	1.74	3.64	3.67	1.74	2.46	3.54	2.72	5.37	3.52	3.42	4.50	3.88	2.20
28	BLESER	Blechnum serrulatum	0.03	0.02	0.13	0.24	0.01	0.11	0.15	0.54		0.01			
35	CEPOCC	Cephalanthus occidentalis	0.60	0.96	1.27	2.18	0.15	0.29	0.89	0.03	0.26	0.28	0.13		0.21
37	CHRICA	Chrysobalanus icaco	0.12												
39	CLAJAM	Cladium jamaicense	27.82	40.85	39.79	31.94	38.13	37.10	32.76	36.63	45.91	35.87	42.17	47.08	50.96
42	CONERE	Conocarpus erectus						0.04							
43	CRIAME	Crinum americanum	1.05	1.40	0.96	1.76	1.43	1.47	1.57	0.46	0.51	0.52	0.65	0.50	0.44
46	CYPHAS	Cyperus haspan				0.02	0.10					0.03			
56	ELECEL	Eleocharis cellulosa	10.19	14.25	20.62	17.64	21.80	20.77	13.88	14.96	20.47	16.66	22.23	24.24	18.94
57	ELEELO	Eleocharis elongata					0.68	0.53	1.08			1.97		0.48	
71	FUIBRE	Fuirena breviseta		0.18			0.17		0.11		0.02	0.06	0.01	0.08	
80	HYMLAT	Hymenocallis latifolia	0.02							0.02					
81	HYMPAL	Hymenocallis palmeri				0.22	0.08	0.37	0.29		0.21	0.09	0.10	0.57	0.30
82	HYPALA	Hyptis alata		0.07											
86	IPOSAG	Ipomoea sagittata	0.31	0.45	0.65	0.82	0.62	0.95	0.87	0.29		0.05	0.05	0.08	0.14
90	JUSANG	Justicia angusta	1.53	3.07	3.46	4.53	3.73	3.28	3.64	1.28	1.15	1.13	1.31	0.48	1.39
92	LEEHEX	Leersia hexandra		0.34	0.34	0.28	0.39	0.42	0.49		0.77	0.03	0.15		
95	LUDALA	Ludwigia alata	0.03	0.03		0.02	0.11	0.18							
96	LUDCUR	Ludwigia curtissii		0.03											
97	LUDMIC	Ludwigia microcarpa			0.22									0.08	
98	LUDREP	Ludwigia repens					0.02				0.15	0.04			
99	LUDXX1	Ludwigia sp.					0.09								
100	MAGVIR	Magnolia virginiana	0.09	0.09		0.17									
105	MITPET	Mitreola petiolata			0.02										

SPP	SPCODE	Curanian manua				M3						M	1 4		
No.	SPCODE	Species name	1999	2006	2009	2012	2015	2019	2023	1999	2007	2010	2013	2016	2020
109	NYMAQU	Nymphoides aquatica	0.04	0.79	2.01	0.39	1.63	2.37	2.46	0.01	0.02	0.01	0.07	0.08	0.44
110	NYMODO	Nymphaea odorata	2.83	3.06	6.21	3.71	3.13	6.04	5.20		0.03	0.08	0.03		
111	OXYFIL	Oxypolis filiformis									0.37				0.08
113	PANHEM	Panicum hemitomon	3.64	4.12	6.26	3.02	3.33	2.85	2.13	0.66	1.71	1.37	1.48	1.11	1.92
115	PANTEN	Coleataenia tenera												0.25	
119	PASGEM	Paspalidium geminatum	1.07	0.68	1.26	1.04	1.31	1.50	1.91	1.36	0.56	0.49	0.28	0.79	0.50
122	PELVIR	Peltandra virginica	1.17	1.21	1.74	0.65	0.74	0.94	1.30	1.40	1.25	0.53	0.66	0.52	0.50
123	PERBOR	Persea borbonia		0.04	0.14										
137	PERHYD	Polygonum hydropiperoides				0.09									
134	PLUROS	Pluchea baccharis			0.12	0.21									
138	PONCOR	Pontederia cordata	0.03	0.37	0.09		0.16	0.22	0.32	0.02	1.86	2.75	2.15	1.57	1.84
139	POTILL	Potamogeton illinoensis								0.01	0.35	0.67	0.02	0.54	0.30
140	PROPAL	Proserpinaca palustris			0.02		0.02			0.12					
150	RHYINU	Rhynchospora inundata		0.16	0.75	0.26	0.33		0.10		1.01	1.26	0.21		0.01
151	RHYMIC	Rhynchospora microcarpa		0.29	0.54	0.34	0.42								
153	RHYTRA	Rhynchospora tracyi	0.10	0.30	0.74	0.78	0.86	0.60	0.16	0.22	3.37	1.32			0.87
158	SAGLAN	Sagittaria lancifolia	0.22	0.75	1.02	0.87	0.87	0.67	1.00	0.14	0.54	0.33	0.31	0.88	0.56
159	SALCAR	Salix caroliniana			0.06	0.02				0.03					
161	SARCLA	Funastrum clausum		0.15	0.06										
166	SCITAB	Schoenoplectus tabernaemontani									0.05				
189	TYPDOM	Typha domingensis		0.37	0.61	0.76	0.83	0.25	0.68		0.71	1.43	3.24	3.55	2.28
201	UNKX18	Unknown sp18					0.02								
209	UNKX26	Unknown sp26													0.08
223	UNKX40	Unknown sp40							0.09						
224	UNKX41	Unknown sp41							0.02						
234	UTRCOR	Utricularia cornuta									0.01				
235	UTRFOL	Utricularia foliosa	5.38	2.61	1.98	7.46	0.79	2.28	3.17	5.17	3.63	6.79	7.80	5.06	2.93

SPP	SPCODE	Species name				M3						M	I 4		
No.	SECODE	Species name	1999	2006	2009	2012	2015	2019	2023	1999	2007	2010	2013	2016	2020
236	UTRGIB	Utricularia gibba		0.03							0.11				
237	UTRPUR	Utricularia purpurea	41.98	19.10	4.60	18.36	14.33	12.66	22.27	31.26	10.69	22.42	11.76	8.09	12.92
240	UTRXX1	Utricularia sp.							0.52						

Appendix 4a: Importance value index (IV) of species that were present at the marl prairie sites of Transect M1 and M2E. Between 2005 and 2024, the transect M1 was surveyed six times (2006, 2009, 2012, 2015, 2019 & 2023) and M2E was surveyed three times (2015, 2019 & 2023).

CDDCNO	GDGGDE	G . N			M	I 1				M2E	
SPPSNO	SPCODE	Species Name	2006	2009	2012	2015	2019	2023	2015	2019	2023
2	AESPRA	Aeschynomene pratensis	0.805	1.522	0.062	2.192	1.437	1.210	0.487	0.676	1.982
3	AGALIN	Agalinis linifolia		0.463						0.021	
7	ANDGLO	Andropogon glomeratus var. glomeratus									0.018
8	ANDVIR	Andropogon virginicus	0.686	1.050	2.429	0.235	0.034		0.138	0.159	
11	ANNGLA	Annona glabra	0.417		0.177	0.153	0.170	0.303	0.446	0.443	
13	ARIPUR	Aristida purpurascens			0.378				0.766		
15	ASCLAN	Asclepias lanceolata							0.027	0.080	0.342
17	ASTADN	Symphyotrichum adnatum							0.068		
18	ASTBRA	Symphyotrichum bracei				2.941			0.923	0.613	
20	ASTDUM	Symphyotrichum dumosum				0.475					
22	ASTTEN	Symphyotrichum tenuifolium	1.747	1.170	3.087		1.075				
24	BACCAR	Bacopa caroliniana	3.942	1.143	1.501	4.946	4.711	4.361	4.654	5.144	3.620
26	BACHAL	Baccharis halimifolia		0.044							
28	BLESER	Blechnum serrulatum							0.068	0.129	0.095
34	CENASI	Centella asiatica	2.773	3.001	3.558	4.634	3.538		1.544	1.871	0.127
35	CEPOCC	Cephalanthus occidentalis				0.169		0.077			
36	CHIPAR	Chiococca parvifolia							0.292		
39	CLAJAM	Cladium jamaicense	40.940	41.350	37.419	27.650	32.521	28.887	34.492	34.258	32.170
43	CRIAME	Crinum americanum		0.315	0.539	0.328		0.424	0.229	0.234	0.359
46	CYPHAS	Cyperus haspan			0.064						
49	DICACI	Dichanthelium aciculare			0.037				0.112		
50	DICDIC	Dichanthelium dichotomum				0.165	0.211		0.058	0.079	0.018
51	DICXX1	Dichanthelium sp.							0.334		
53	DYSANG	Dyschoriste angusta							0.112		
55	ELEBAL	Eleocharis baldwinii			0.044						
56	ELECEL	Eleocharis cellulosa	9.880	13.720	9.908	7.136	15.451	30.485	27.149	21.713	27.592

CDDCNO	CDCODE	C N			M	1				M2E	
SPPSNO	SPCODE	Species Name	2006	2009	2012	2015	2019	2023	2015	2019	2023
57	ELEELO	Eleocharis elongata								0.166	
58	ELEGEN	Eleocharis geniculata				0.059					0.055
60	ERAELL	Eragrostis elliottii	0.271		0.842	0.165			0.072		
64	EUPCAP	Eupatorium capillifolium		0.358	0.037						
65	EUPLEP	Eupatorium leptophyllum				0.261	0.034				
66	EUPMIK	Eupatorium mikanioides		0.294	0.037	0.212	0.175				
71	FUIBRE	Fuirena breviseta	0.071		0.207	0.029	0.090		0.058		0.189
77	HELPOL	Heliotropium polyphyllum							0.197	0.025	
86	IPOSAG	Ipomoea sagittata		1.201	0.035	0.712	0.410	0.389	0.482	0.707	0.131
87	IVAMIC	Iva microcephala			0.585	0.775	0.222		0.403	0.320	
90	JUSANG	Justicia angusta	0.897	0.958	1.333	1.444	1.251	0.854	0.467	0.326	0.274
92	LEEHEX	Leersia hexandra	0.209	0.777	0.355	0.190		0.185			
95	LUDALA	Ludwigia alata				0.333	0.041		0.058	0.111	
96	LUDCUR	Ludwigia curtissii				0.297			0.030	0.361	
97	LUDMIC	Ludwigia microcarpa	0.218	0.059	0.935	0.044	0.725				
98	LUDREP	Ludwigia repens		1.381					0.058		0.095
99	LUDXX1	Ludwigia sp.								0.025	
102	MELQUI	Melaleuca quinquenervia		0.219							
104	MIKSCA	Mikania scandens	0.271		0.177				0.068	0.159	0.127
105	MITPET	Mitreola petiolata			0.229				0.197		
106	MORCER	Morella cerifera	0.124			0.068			0.153		0.037
107	MUHCAP	Muhlenbergia capillaris var. filipes	2.461	5.419	4.321	7.904	0.421		3.173	2.060	0.401
109	NYMAQU	Nymphoides aquatica									0.320
111	OXYFIL	Oxypolis filiformis	0.501	0.135	0.088	0.091	0.270		0.040	0.136	0.291
113	PANHEM	Panicum hemitomon	0.209		0.074	1.165	1.528	0.919	1.377	0.762	0.928
115	PANTEN	Coleataenia tenera	4.380	4.348	5.744	3.655	3.515	1.974	1.446	1.804	1.522
116	PANVIR	Panicum virgatum		0.612	0.035	0.330			0.413		
119	PASGEM	Paspalidium geminatum				0.167	0.366	0.204	1.549	0.209	1.343

CDDCNO	GDGODE	G • N			M	T 1				M2E	
SPPSNO	SPCODE	Species Name	2006	2009	2012	2015	2019	2023	2015	2019	2023
122	PELVIR	Peltandra virginica	0.738	1.163	0.207	0.061	0.370	0.426		0.032	0.032
127	PHYCAR	Phyllanthus caroliniensis							0.054		
128	PHYNOD	Phyla nodiflora	1.388	0.505	0.443	2.664	2.024		1.076	0.874	0.095
129	PHYSTO	Phyla stoechadifolia		0.737	0.473	0.894	0.832	0.408	0.604	0.602	0.518
134	PLUROS	Pluchea baccharis	1.615	2.670	1.550	2.784	3.260	2.330	1.092	1.295	1.364
135	POLBAL	Polygala balduinii							0.068		
137	POLHYD	Polygonum hydropiperoides		0.794	0.745	0.060			0.185		
138	PONCOR	Pontederia cordata	0.269	0.575	0.271	0.334	0.209	0.036			
139	POTILL	Potamogeton illinoensis									0.786
140	PROPAL	Proserpinaca palustris		0.724	0.188	0.068					
148	RHYDIV	Rhynchospora divergens				0.029			1.111	0.159	
150	RHYINU	Rhynchospora inundata	0.253		1.119	1.351	1.369	0.560	0.647	1.967	0.355
151	RHYMIC	Rhynchospora microcarpa	0.052		1.348	0.441	1.550		1.759	2.611	0.234
152	RHYMIL	Rhynchospora miliacea		1.559							
153	RHYTRA	Rhynchospora tracyi	11.800	9.085	13.116	15.891	17.387	5.404	9.566	9.458	5.237
156	SABPAL	Sabal palmetto							0.031	0.030	
157	SACGIG	Saccharum giganteum		0.180	0.223	0.602	0.386				0.018
158	SAGLAN	Sagittaria lancifolia				0.153	0.336	0.597	0.164	0.498	0.642
159	SALCAR	Salix caroliniana	0.209	0.219	0.320	0.328					
160	SAMEBR	Samolus ebracteatus							0.054		
164	SCHRHI	Schizachyrium rhizomatum		0.147	0.236				0.112		
165	SCHTER	Schinus terebinthifolius							0.011		
168	SETPAR	Setaria parviflora			0.691	1.585	3.736		0.371	0.561	
173	SOLSTR	Solidago stricta		0.028	0.134				0.389	0.584	
177	TEUCAN	Teucrium canadense							0.011	0.030	
189	TYPDOM	Typha domingensis	6.343	0.940	1.838	3.823					
199	UNKX16	Unknown sp16							0.209		
206	UNKX23	Unknown sp23								0.241	
207	UNKX24	Unknown sp24								0.159	

SPPSNO	SPCODE	Charles Name			M	[1				M2E	
SPPSNO	SPCODE	Species Name	2006	2009	2012	2015	2019	2023	2015	2019	2023
208	UNKX25	Unknown sp25								0.129	
234	UTRCOR	Utricularia cornuta					0.051	1.706	0.342	3.665	1.028
235	UTRFOL	Utricularia foliosa	0.048	0.091	0.507			1.356		0.200	1.053
236	UTRGIB	Utricularia gibba						0.595			
237	UTRPUR	Utricularia purpurea	6.486	1.043	2.356		0.293	16.310		4.314	16.600

Appendix 4b: Importance value index (IV) of species that were present at the marl prairie sites of Transect M3. Between 2005 and 2023, the sites in the eastern portion of M3 (M3E_1 & M3E_2) were surveyed six times (2007, 2010, 2013, 2016, 2020 & 2024) while those on western portion of the transect were surveyed five times (2007, 2010, 2013, 2016 & 2022).

SPP-	SPCODE	C(ITIC)	TIS) M3_E1 M3_E2 2007 2010 2013 2016 2020 2024 2007 2010 2013 2016 20													I	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
2	AESPRA	Aeschynomene pratensis		0.02		0.13	0.01	0.45				0.11			0.79	0.56	0.48	1.29	0.92
3	AGALIN	Agalinis linifolia		0.33	0.18	0.34	0.09	0.65		0.03	0.23	0.18			0.15	0.07	0.54	0.87	0.37
4	AGAXX1	Agalinis sp.			0.08														
5	ALEBRA	Aletris bracteata		0.03	0.09					0.01	0.06	0.12							
6	AMBART	Ambrosia artemisiifolia				0.07													
7	ANDGLO	Andropogon glomeratus var. glomeratus	0.02					0.11				0.12							
8	ANDVIR	Andropogon virginicus		0.35	0.27	0.46	0.27		0.04	0.62	0.53		0.20		0.34	0.46	0.06	0.23	1.83
9	ANEADI	Anemia adiantifolia	0.19																
10	ANGBER	Angadenia berteroi	0.17	0.08	0.08	0.15	0.02	0.02		0.01			0.01						
11	ANNGLA	Annona glabra	0.11		0.12		0.13		0.04	0.13	0.04	0.15	0.10	0.31	3.58	1.96	0.81	0.78	1.32
12	ARDESC	Ardisia escallonioides		0.01	0.01	0.03	0.08	0.07											
13	ARIPUR	Aristida purpurascens	0.07	1.09	0.61	0.92	0.19	0.14		0.75	1.67	0.98	0.44	0.03	0.02	0.13	0.59	0.29	0.43
14	ARISTR	Aristida stricta							0.05										
15	ASCLAN	Asclepias lanceolata	0.12	0.12	0.02	0.08	0.11	0.29	0.21				0.07		0.03	0.16	0.47	0.23	0.68
16	ASCLON	Asclepias longifolia											0.01				0.22	0.04	0.12
18	ASTBRA	Symphyotrichum bracei				1.64						2.57			0.33			1.19	
20	ASTDUM	Symphyotrichum dumosum	0.01		0.15	0.67		0.12		0.18				0.18	0.64	2.23	1.24	1.04	1.14
21	ASTSUB	Symphyotrichum subulatum	0.55						1.44										
22	ASTTEN	Symphyotrichum tenuifolium		4.03	3.37	0.11	0.85	1.00		6.28	3.47	0.11	2.44	0.54	0.06	2.54	2.00	0.36	2.29
23	ASTXX1	Aster sp.	0.09						0.07										
24	BACCAR	Bacopa caroliniana	2.25	2.34	2.68	1.00	0.44	4.00	2.30	1.41	1.31	1.49	3.04	2.80	4.64	4.43	4.86	3.11	3.44
25	BACGLO	Baccharis glomeruliflora				0.23		0.01											
26	BACHAL	Baccharis halimifolia	0.19		0.15		0.19												

SPP-	SPCODE	G (MEXA)			M3_	_E1					M3_	E2				I	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
27	BACMON	Bacopa monnieri													0.04	0.48			
28	BLESER	Blechnum serrulatum	1.01	0.18	0.43	0.48	0.18	0.10											
30	BUCFLO	Buchnera americana	0.02			0.08												0.11	
31	CAPBIF	Capraria biflora			0.01														
32	CASFIL	Cassytha filiformis	1.20	0.51	0.24	0.19	1.00	1.80			0.16	0.18	0.20	0.03	3.81	0.59	1.86	1.37	1.48
34	CENASI	Centella asiatica	4.99	0.75	3.10	0.27	2.56	0.62	0.85	0.63	1.15	0.02	1.33	0.02	3.04	4.64	5.07	2.85	2.46
35	СЕРОСС	Cephalanthus occidentalis									0.05		0.04	0.04	0.01		0.02	0.01	0.15
36	CHIPAR	Chiococca parvifolia	0.07			0.09													
37	CHRICA	Chrysobalanus icaco										0.15	0.17						
38	CIRHOR	Cirsium horridulum		0.08	0.02	0.02													
39	CLAJAM	Cladium jamaicense	35.48	30.22	29.82	38.65	38.89	41.80	64.64	48.60	45.56	47.12	51.34	43.14	20.38	22.39	24.67	25.86	24.38
40	COERUG	Coelorachis rugosa					0.19						0.25			0.01			
41	CONCOE	Conoclinium coelestinum		0.73			0.06	0.10	١										
43	CRIAME	Crinum americanum				0.02									1.72	1.03	1.43	2.37	1.57
46	CYPHAS	Cyperus haspan	0.01	0.25	0.05														0.07
48	CYPXX1	Cyperus sp.		0.14															
49	DICACI	Dichanthelium aciculare			0.46	0.19	0.07	0.10			0.05	0.09	0.32						
50	DICDIC	Dichanthelium dichotomum	1.79	2.13	0.04	2.83	1.32	0.09	0.16	0.97	0.06	0.37	0.50					0.13	0.25
52	DIOVIR	Diodia virginiana			0.01		0.01												
53	DYSANG	Dyschoriste angusta															0.08		
54	ECHXX1	Echinochloa sp.													0.01				
55	ELEBAL	Eleocharis baldwinii			0.10						0.68			0.11					
56	ELECEL	Eleocharis cellulosa	1.61	2.67	3.23	0.64	0.84	2.11	5.56	8.00	7.72	7.41	8.00	15.12	2.35	2.08	2.57	2.43	3.28
57	ELEELO	Eleocharis elongata								0.18									
60	ERAELL	Eragrostis elliottii	1.31	0.99	0.23	0.27	0.27	0.09	0.24	0.56		0.38	0.56	0.03	0.20	0.32	0.36	0.37	1.75
61	ERICOM	Eriocaulon compressum														0.15		0.04	0.04

SPP-	SPCODE				M3_	<u>E1</u>					M3_	E2]	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
62	ERIQUE	Erigeron quercifolius	0.01	0.12					0.15	0.12	0.19				0.06				
63	EUGAXI	Eugenia axillaris	0.14		0.01														
64	EUPCAP	Eupatorium capillifolium	1.92						0.43										
65	EUPLEP	Eupatorium leptophyllum		0.51	1.53	0.66	1.42			0.45	0.48		0.53						
66	EUPMIK	Eupatorium mikanioides	0.31	0.19	0.05	0.01	0.03	0.07				0.03	0.04	0.04	0.16	0.24	0.40	0.53	0.56
67	EUSPET	Eustachys petraea	0.19		0.17												0.21		
70	FLALIN	Flaveria linearis	0.61																
71	FUIBRE	Fuirena breviseta	0.01	0.59	0.27	0.02		0.07		0.58	0.23	0.25	0.07	0.18	0.01			0.07	
75	HABREP	Habenaria repens														0.07			
76	HELPIN	Helenium pinnatifidum														0.01		0.11	0.15
77	HELPOL	Heliotropium polyphyllum	0.25	0.15	0.02	0.12	0.13					0.09	0.01						
78	HIBGRA	Hibiscus grandiflorus	0.01			0.08		0.18							0.07	0.01		0.08	0.02
79	HYDCOR	Hydrolea corymbosa			0.01														
80	HYMLAT	Hymenocallis latifolia																0.66	
81	HYMPAL	Hymenocallis palmeri	0.29	0.12	0.65	0.73	0.09	1.29							1.16	1.18	2.19	1.46	1.91
82	HYPALA	Hyptis alata	0.40	0.44	0.29	0.48	0.64	0.36	0.35				0.02	0.25	0.04	0.10		0.05	
83	HYPCIS	Hypericum cistifolium		0.12															
84	НҮРНҮР	Hypericum hypericoides			0.04														
86	IPOSAG	Ipomoea sagittata	0.46	0.26	0.81	1.11	1.13	1.09					0.45		0.37	0.34	0.25	0.57	0.74
87	IVAMIC	Iva microcephala	0.24	0.80	1.11	0.21	1.06	0.36											
89	JUNMEG	Juncus megacephalus																0.01	
90	JUSANG	Justicia angusta	0.16	0.51	0.38	0.32	0.37	0.62	0.41	1.72	0.60	2.25	1.30	2.65	0.96	1.56	2.16	1.50	1.70
91	KOSVIR	Kosteletzkya virginica		0.06	0.19		0.11										0.14		
92	LEEHEX	Leersia hexandra		0.28			0.08								0.23	0.70	0.88	1.44	1.03
93	LINMED	Linum medium	0.02	0.03									0.07				0.11	0.11	0.04
94	LOBGLA	Lobelia glandulosa			0.04					0.07	0.06				0.14			0.16	
95	LUDALA	Ludwigia alata	0.06	0.60	0.29	0.21	0.24	0.23			0.02		0.03				0.02		

SPP-	SPCODE	G (MDFG)			M3_	<u>E1</u>					M3_1	E2				I	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
96	LUDCUR	Ludwigia curtissii				0.39	0.09					0.32	0.14						0.03
97	LUDMIC	Ludwigia microcarpa	0.29	0.29	0.55	0.15	0.54	0.34	0.05	1.10	0.70	0.05	1.20		0.06	0.80	0.38	0.19	0.29
98	LUDREP	Ludwigia repens	1.18	0.25	0.10				1.22	1.57	0.55				0.32	0.05			0.15
99	LUDXX1	Ludwigia sp.						0.26				1.01	0.27						
103	METTOX	Metopium toxiferum	0.34				0.19	0.07											
104	MIKSCA	Mikania scandens	2.03	1.92	0.78	1.43	1.40	0.71	0.86	1.73	0.66	0.57	0.69	0.08	0.14	0.14		0.05	0.04
105	MITPET	Mitreola petiolata	0.50		0.02	0.41	0.10		1.01	0.19		0.37	0.36		0.81	0.28	0.74	2.04	1.53
106	MORCER	Morella cerifera	1.06	0.02	0.37	1.13	1.12	0.02			0.01	0.09	0.07		0.06	0.17	0.30	0.09	0.03
107	MUHCAP	Muhlenbergia capillaris var. filipes	12.07	13.38	10.95	10.70	9.78	2.54	1.04	0.11	1.32	2.37	0.99	0.03	0.61	0.39	0.32	0.17	0.58
108	MYRFLO	Myrsine floridana	0.24			0.08													
109	NYMAQU	Nymphoides aquatica	0.02							0.08			0.02		0.07	0.20	0.02	0.18	0.07
110	NYMODO	Nymphaea odorata														0.05			
111	OXYFIL	Oxypolis filiformis		0.18	0.17			0.30	0.27	0.88	0.53	0.22	0.20	0.02	0.16	0.18	0.29	0.21	0.13
112	PANDIC	Panicum dichotomiflorum		1.52			0.09	0.44		1.63									0.10
113	PANHEM	Panicum hemitomon	0.38	1.62	1.03	0.05	0.39	1.28			0.28	0.24	0.46	0.38	2.15	1.54	1.01	0.60	0.64
114	PANRIG	Panicum rigidulum	0.07	0.22	0.71			0.07			1.26				0.04	0.14	0.05		
115	PANTEN	Coleataenia tenera	1.62	4.11	3.70	3.68	3.61	3.81	5.06	7.21	7.18	6.85	5.37	6.38	3.37	6.77	2.76	4.95	3.55
116	PANVIR	Panicum virgatum	0.30	0.27	0.30	1.04	0.39	0.10	1.05				0.57		5.59	7.57	7.95	6.58	6.93
117	PANXX1	Panicum sp.		0.19															0.03
118	PARQUI	Parthenocissus quinquefolia			0.01	0.27	0.06	0.10											
119	PASGEM	Paspalidium geminatum	0.09		0.92	0.22					0.24		0.04		0.14	0.61	0.13	0.28	0.82
120	PASMON	Paspalum monostachyum		0.09	0.14	0.24	0.10	0.22				0.18	0.14		4.29	8.47	7.09	5.02	6.22
121	PASSUB	Passiflora suberosa	_	0.02	0.13														
122	PELVIR	Peltandra virginica	0.02	0.04		0.22		0.04	0.24	0.09	0.36	0.33	0.09	1.53	0.01		0.44	0.06	0.04
123	PERBOR	Persea borbonia	0.34	0.17	0.40	1.31	0.28	0.19				0.03			0.03	0.13	0.04	0.03	
126	PHYAME	Phytolacca americana			0.05														

SPP-	SPCODE	G (TITTO)			M3_	E1					M3_	E2				I	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
127	PHYCAR	Phyllanthus caroliniensis	0.09																
128	PHYNOD	Phyla nodiflora	4.91	1.41	4.86	1.00	4.55	0.79	2.18	0.19	1.19	0.09	1.13	0.18	0.10	0.09			
129	PHYSTO	Phyla stoechadifolia	0.78	0.16	0.17	0.56	2.27	1.22	0.57	0.02	0.03		0.40	0.02					
130	PHYXX1	Phyllanthus sp.															0.05		
131	PINPUM	Pinguicula pumila	0.02																
132	PIRCIS	Piriqueta cistoides ssp. caroliniana															0.07		0.44
133	PLUODO	Pluchea odorata				0.02						0.04							
134	PLUROS	Pluchea baccharis	5.43	4.68	5.55	5.32	5.78	5.28	2.22	4.26	3.20	3.47	4.96	2.19	3.40	3.20	2.75	2.22	1.73
135	POLBAL	Polygala balduinii	0.02																
136	POLGRA	Polygala grandiflora	0.17	0.01	0.10	0.08	0.10			0.07							0.29	0.13	0.03
137	POLHYD	Polygonum hydropiperoides	0.10	0.08	0.26	0.13	0.11		0.61	0.24	0.92	0.04	0.22		0.17	0.09	0.37		
138	PONCOR	Pontederia cordata								0.83	0.05		0.04		0.42	0.41	0.09	0.06	
140	PROPAL	Proserpinaca palustris	0.28	0.18	0.31		0.05	0.23	1.40	1.02	1.00	0.55	0.75		0.30	0.06	0.02	0.16	0.05
141	PSYNER	Psychotria nervosa	0.60			0.02		0.05											
142	PTEAQU	Pteridium aquilinum	0.99	0.59	0.26	0.36	0.11	0.29											
143	QUEXX1	Quercus sp.																0.01	
144	RANACU	Randia aculeata	0.65	0.02	0.29	0.46	0.15	0.22											
146	RHUCOP	Rhus copallinum			0.20	0.15	0.05	0.06											
147	RHYCOL	Rhynchospora colorata	0.01	0.27	0.10	0.01	0.05				0.06				0.13	0.06	0.01	0.07	0.39
148	RHYDIV	Rhynchospora divergens		0.47	0.81		0.32	0.20		1.36	1.65	0.03	0.07	0.03				0.09	1.24
150	RHYINU	Rhynchospora inundata	0.07						0.19			0.21	2.24	0.95	4.66	1.70	0.76	1.31	1.29
151	RHYMIC	Rhynchospora microcarpa	0.60	1.22	0.87	1.45	0.24	0.62	0.82	1.59	2.12	2.27	1.11	0.79	9.21	3.00	3.91	3.16	2.40
153	RHYTRA	Rhynchospora tracyi	0.01	6.16	2.64	3.18	2.65	10.78	1.47	2.35	3.16	2.06	4.54	3.77	10.18	4.70	8.00	5.77	5.77
154	RHYXX1	Rhynchospora sp.							0.05										
155	SABGRA	Sabatia grandiflora	0.10	0.08		0.08	0.08			0.22			0.07		0.12			0.29	0.38
156	SABPAL	Sabal palmetto	0.02	0.03		_									0.01				

SPP-	SPCODE				M3_	<u>E1</u>					M3_	E2				1	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
157	SACGIG	Saccharum giganteum	0.30	0.02	0.13	0.38	0.38	0.80		0.12					0.01	0.07	0.02	0.18	0.12
158	SAGLAN	Sagittaria lancifolia	0.11	0.48	0.30	0.35	0.67	1.17	1.32	0.72	2.78	0.75	1.30	2.36	0.77	1.04	0.46	0.58	0.56
159	SALCAR	Salix caroliniana			1.45	0.05	0.21	0.04	0.19		0.33		0.18	0.24	0.12		0.37	0.36	0.34
160	SAMEBR	Samolus ebracteatus	0.47	0.03		0.16			0.21	0.50	0.20	0.15							
161	SARCLA	Funastrum clausum													0.18	0.38			
162	SCHALB	Schoenolirion albiflorum														0.19	0.16		0.08
163	SCHNIG	Schoenus nigricans	0.02	0.01	0.16	0.01	0.12	0.85							1.24	1.73	1.85	2.21	0.53
164	SCHRHI	Schizachyrium rhizomatum	5.07	4.73	7.40	8.96	8.66	6.72			0.06	0.62	0.24	0.15	4.64	5.71	4.68	8.78	7.88
165	SCHTER	Schinus terebinthifolius	0.13		0.15			0.05			0.06								
167	SCIXX1	Scirpus sp.													0.09				
168	SETPAR	Setaria parviflora	0.55	0.14		0.89	0.67		1.01			0.35	0.18		0.01	0.22			0.05
169	SIDSAL	Sideroxylon salicifolium	0.01	0.09	0.01		0.24												
170	SMILAU	Smilax laurifolia	0.03				0.05	0.05											
172	SOLFIS	Solidago fistulosa		0.28			0.09												
173	SOLSTR	Solidago stricta	0.50	1.11	0.85	0.22	0.16			0.43	0.49	0.29	0.20	0.03	0.17		0.05	0.18	0.04
175	SPIODO	Spiranthes odorata																	0.01
176	TAXDIS	Taxodium distichum var. imbricrium													0.05				
177	TEUCAN	Teucrium canadense		0.49	0.55		0.34	0.12		0.02		0.09	0.18	0.18		0.11			
178	THAGEN	Thalia geniculata								0.08					0.01	0.12	0.09		
180	THEKUN	Thelypteris kunthii	0.01					0.01											
187	TOXRAD	Toxicodendron radicans	0.66	0.11	0.41	1.15	0.46	0.24											
188	TREMIC	Trema micrantha		0.38	0.10	0.03													
189	TYPDOM	Typha domingensis												0.65	0.35	0.67	0.72	0.38	0.02
190	UNKGR1	Unknown gr01				0.09									0.03			0.05	
192	UNKGR3	Unknown gr03																	0.03
200	UNKX17	Unknown sp17										0.05							
217	UNKX34	Unknown sp34																	0.04

SPP-	SPCODE	G (MDIG)			M3_	_E1					M3_	E2				I	M3_W		
SNO	(2024)	Species name (ITIS)	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2020	2024	2007	2010	2013	2016	2022
220	UNKX37	Unknown sp37						0.07											
221	UNKX38	Unknown sp38						0.02											
222	UNKX39	Unknown sp39												0.16					
225	UNKXX1	Unknown sp01													0.06				
226	UNKXX2	Unknown sp02			0.07										0.14				
227	UNKXX3	Unknown sp03			0.07										0.04				
228	UNKXX4	Unknown sp04													0.08				
229	UNKXX5	Unknown sp05													0.05				
230	UNKXX6	Unknown sp06		0.17															
231	UNKXX7	Unknown sp07														0.04			
232	UNKXX8	Unknown sp08													0.05				
234	UTRCOR	Utricularia cornuta															0.10		
235	UTRFOL	Utricularia foliosa	0.14	0.02				0.08			0.05	2.19		0.82		0.02		0.56	0.24
237	UTRPUR	Utricularia purpurea		0.16				1.48			5.20	9.91		13.65		0.42		1.28	1.00
239	UTRSUB	Utricularia subulata														0.01			
240	UTRXX1	Utricularia sp.								0.02									
241	VERBLO	Vernonia blodgettii		0.25	0.07	0.03	0.16			0.02			0.02						
242	VITROT	Vitis rotundifolia	0.27			0.07		0.05											
243	VITSHU	Vitis shuttleworthii						0.05											
244	XYRSPP	Xyris sp.					0.08												

Appendix 4c: Importance value index (IV) of species that were present at the marl prairie sites of Transect M4 which was surveyed five times (2008, 2011, 2014, 2017 & 2021) between 2005 and 2024.

SPP	SPCODE	G (MEXA)			M4_E1					M4_E2	,				M4_W		
SNO	(2024)	Species name (ITIS)	2008	2011	2014	2017	2021	2007	2011	2014	2017	2021	2008	2011	2014	2017	2021
2	AESPRA	Aeschynomene pratensis	0.00					0.47	0.41		0.72	0.20	2.88	1.77	1.29	0.48	0.92
3	AGALIN	Agalinis linifolia		0.18	0.18	0.46	0.62	1.12	0.79	0.26	0.32			0.29			
5	ALEBRA	Aletris bracteata		0.02	0.02	0.15											
9	ANEADI	Anemia adiantifolia	0.02		0.11	0.15											
10	ANGBER	Angadenia berteroi	0.23	0.02	0.28	0.31											
11	ANNGLA	Annona glabra	0.17					0.18					1.05		0.09	0.03	
13	ARIPUR	Aristida purpurascens	0.29	0.40		0.57	0.16										
15	ASCLAN	Asclepias lanceolata	0.03	0.03	0.34		0.03							0.14	0.02		
16	ASCLON	Asclepias longifolia		0.20													
18	ASTBRA	Symphyotrichum bracei	2.27		3.75	0.15		0.12							0.14		
20	ASTDUM	Symphyotrichum dumosum	1.78	2.40	1.07	2.35	0.56	0.20		0.23			0.48	0.76	0.72	0.70	
22	ASTTEN	Symphyotrichum tenuifolium		3.51		3.90	2.88		0.26					0.52	0.34	0.38	0.61
24	BACCAR	Bacopa caroliniana						4.89	7.22	6.32	6.25	5.08	5.11	4.11	7.13	3.80	6.26
27	BACMON	Bacopa monnieri							1.69					1.87			0.55
29	BOECYL	Boehmeria cylindrica												0.11			
32	CASFIL	Cassytha filiformis	1.93	2.11	1.18	1.05	0.53						4.00	5.59	4.80	3.63	
34	CENASI	Centella asiatica	0.55	0.21	0.61	0.27		0.23					1.49	1.85	1.03	0.65	0.05
35	СЕРОСС	Cephalanthus occidentalis												0.35			
36	CHIPAR	Chiococca parvifolia	0.14	0.21	0.40												
37	CHRICA	Chrysobalanus icaco					0.23										
38	CIRHOR	Cirsium horridulum		0.02	0.14												
39	CLAJAM	Cladium jamaicense	23.76	24.94	20.56	33.17	30.03	41.77	37.09	42.91	42.96	37.71	44.82	35.27	41.15	53.62	38.38
42	CONERE	Conocarpus erectus	5.40	1.01	2.29	0.08	0.64										
43	CRIAME	Crinum americanum		_	_								0.92	2.63	2.78	1.30	4.89
46	CYPHAS	Cyperus haspan											0.05		0.03		0.05

SPP	SPCODE	G . (TEXA)			M4_E1					M4_E2					M4_W	7	
SNO	(2024)	Species name (ITIS)	2008	2011	2014	2017	2021	2007	2011	2014	2017	2021	2008	2011	2014	2017	2021
49	DICACI	Dichanthelium aciculare				0.16											
50	DICDIC	Dichanthelium dichotomum	0.57	0.35	0.25	0.60	0.31	0.45									
53	DYSANG	Dyschoriste angusta	1.55	3.76	0.93	1.00										0.59)
56	ELECEL	Eleocharis cellulosa						12.48	24.20	22.99	27.69	19.48	2.62	4.44	5.79	5.23	12.29
60	ERAELL	Eragrostis elliottii		0.33	0.14	0.31	0.23						0.03	0.42			0.03
61	ERICOM	Eriocaulon compressum									0.25						
66	EUPMIK	Eupatorium mikanioides	0.39	0.48	0.45	0.29							0.02	0.33	0.11	0.24	+
68	EVOSER	Evolvulus sericeus		0.14													
69	FICAUR	Ficus aurea											0.05				
71	FUIBRE	Fuirena breviseta	0.02					0.51		0.09					0.03		
72	FUISCI	Fuirena scirpoidea							0.29								
74	GALVOL	Galactia volubilis											0.23				
76	HELPIN	Helenium pinnatifidum		0.40	0.37	0.34	0.52	0.76	0.26	0.35	0.04		0.22	0.05	0.12	0.11	0.58
77	HELPOL	Heliotropium polyphyllum	0.80	0.76	1.20	1.37	0.30										
79	HYDCOR	Hydrolea corymbosa											1.46	1.24	0.05	1.11	
81	HYMPAL	Hymenocallis palmeri	0.17	1.09	0.86	0.51	1.24	0.30	0.71	0.08	1.22	0.56	0.51	0.31	0.40	1.27	0.40
82	HYPALA	Hyptis alata	0.37	0.53	0.14	0.44	0.37						0.33	0.20			
85	ILECAS	Ilex cassine		0.50	0.14		0.19										
86	IPOSAG	Ipomoea sagittata	1.01	0.61	1.40	1.18	1.70	0.04		0.09			0.71	0.36	1.80	0.98	2.50
87	IVAMIC	Iva microcephala	1.10	0.46	1.02	0.94											
88	JACCUR	Jacquemontia curtissii			0.14	0.02											
90	JUSANG	Justicia angusta	0.04			0.17	0.22	,	0.67	0.97	1.65	1.40	1.49	2.68	1.77	1.70	5.04
91	KOSVIR	Kosteletzkya virginica											0.05				
92	LEEHEX	Leersia hexandra]]	0.23	0.39				0.76	0.03	0.16	0.31	
95	LUDALA	Ludwigia alata											0.56	1.12		0.76	0.06
96	LUDCUR	Ludwigia curtissii				0.15											
97	LUDMIC	Ludwigia microcarpa	0.18	0.78			0.18										0.30
98	LUDREP	Ludwigia repens						0.48					1.31	3.48	0.80	0.38	0.30

SPP	SPCODE	G . (TTTG)			M4_E1					M4_E2					M4_W		
SNO	(2024)	Species name (ITIS)	2008	2011	2014	2017	2021	2007	2011	2014	2017	2021	2008	2011	2014	2017	2021
99	LUDXX1	Ludwigia sp.													0.23		
100	MAGVIR	Magnolia virginiana	0.03					0.04				0.14					
101	MELNIV	Melanthera nivea	0.22	1.40	0.33	0.66	0.30										
103	METTOX	Metopium toxiferum				0.06											
104	MIKSCA	Mikania scandens	2.01	2.18	2.55	2.45	1.69			0.09	0.28	0.19			0.73	2.39	0.30
105	MITPET	Mitreola petiolata						0.49	0.27	0.05	0.04				0.11		
106	MORCER	Morella cerifera		0.12	0.36	0.19	1.63										
107	MUHCAP	Muhlenbergia capillaris var. filipes	10.43	14.48	11.41	11.38	8.41								0.14	0.46	
108	MYRFLO	Myrsine floridana	0.31		0.26	0.02											
109	NYMAQU	Nymphoides aquatica								0.20		0.34					0.05
110	NYMODO	Nymphaea odorata						0.04						0.14			
111	OXYFIL	Oxypolis filiformis	0.03		0.21	0.15		0.17	0.49	0.26	1.19	0.33			0.04	0.12	0.16
113	PANHEM	Panicum hemitomon						0.91	0.91		0.40	1.22	1.68	2.37	0.90	0.51	1.26
114	PANRIG	Panicum rigidulum						0.06									
115	PANTEN	Coleataenia tenera	3.63	2.82	1.14	2.37	3.59	0.49		0.30	0.04		1.12	0.86	1.56	1.61	1.38
116	PANVIR	Panicum virgatum	1.85	3.78	3.00	3.47	2.60	0.04		0.82	0.04		2.42	3.23	1.47	1.60	4.94
119	PASGEM	Paspalidium geminatum				0.17				0.41	0.25	0.75					
120	PASMON	Paspalum monostachyum	2.33	2.38	4.60	1.71	1.69						0.12				
121	PASSUB	Passiflora suberosa		0.02													
122	PELVIR	Peltandra virginica					0.19			0.54	0.41	0.24	0.28	0.04	0.27	0.44	0.42
123	PERBOR	Persea borbonia	0.06					0.04	0.09								
128	PHYNOD	Phyla nodiflora	6.00	4.00	5.26	4.74	2.47	0.45	0.06	0.26			0.16	5			
129	PHYSTO	Phyla stoechadifolia	1.17	0.28	0.36	0.45	0.08										
130	PHYXX1	Phyllanthus sp.	0.26														
132	PIRCIS	Piriqueta cistoides ssp. caroliniana		0.02		0.32					_						
134	PLUROS	Pluchea baccharis	6.32	5.98	4.42	4.80	6.51	1.17	1.28	1.58	1.06	0.78	2.54	1.27	1.31	1.37	1.04
136	POLGRA	Polygala grandiflora	0.30	0.14		0.49											

SPP	SPCODE	G (TTTG)			M4_E1					M4_E2					M4_W		
SNO	(2024)	Species name (ITIS)	2008	2011	2014	2017	2021	2007	2011	2014	2017	2021	2008	2011	2014	2017	2021
137	POLHYD	Polygonum hydropiperoides						0.05					0.37		0.33		
138	PONCOR	Pontederia cordata						1.06	0.29	0.09	1.42	0.30	0.51	2.35	1.47	1.14	2.49
140	PROPAL	Proserpinaca palustris	0.03	0.37				0.23	0.88	0.09			0.21	0.74	0.98	0.18	0.06
147	RHYCOL	Rhynchospora colorata	0.02	0.14	0.14		0.27										
150	RHYINU	Rhynchospora inundata						0.68		1.23	0.28		0.46	1.53	1.25	0.92	,
151	RHYMIC	Rhynchospora microcarpa	0.64	2.64	2.82	2.09	0.85	0.82	0.69		0.21		0.62	0.39	0.65		
153	RHYTRA	Rhynchospora tracyi	0.44	0.35	0.48	2.24	1.94	8.40	3.05	3.88	5.70	5.54	4.94	1.68	1.42	1.75	2.11
156	SABPAL	Sabal palmetto		0.23	0.03												
157	SACGIG	Saccharum giganteum					0.04										0.03
158	SAGLAN	Sagittaria lancifolia					0.20	1.80	2.35	1.13	1.22	1.15	0.68	0.82	0.81	1.59	1.22
160	SAMEBR	Samolus ebracteatus	0.12	0.02		0.15											
161	SARCLA	Funastrum clausum											0.05		0.06		
163	SCHNIG	Schoenus nigricans											1.49	1.35	0.91	1.58	
164	SCHRHI	Schizachyrium rhizomatum	9.17	7.40	7.55	6.83	9.29						3.47	3.60	4.28	1.57	2.18
168	SETPAR	Setaria parviflora				0.16	0.15										
171	SMIXX1	Smilax sp.		0.02													
173	SOLSTR	Solidago stricta	0.98	0.29	0.70	0.32	0.03	0.20									
174	SPABAK	Spartina bakeri	1.42	0.31	1.20												
176	TAXDIS	Taxodium distichum var. imbricrium	9.27	3.26	13.18	3.77	13.25	9.87	6.75	12.97	5.78	9.14					
177	TEUCAN	Teucrium canadense	0.12	1.84	1.83	0.47	0.15		0.35								
178	THAGEN	Thalia geniculata											0.42	1.75	3.37	1.33	
181	TILBAL	Tillandsia balbisiana					0.08				0.05	0.13					
182	TILFLE	Tillandsia flexuosa						0.04				0.42					
183	TILPAU	Tillandsia paucifolia	0.07	0.08			1.22	0.33	0.11		0.11	0.88					
184	TILREC	Tillandsia recurvata										0.13					
189	TYPDOM	Typha domingensis											6.94	7.70	6.39	2.46	0.64
191	UNKGR2	Unknown gr02				0.15											

SPP	SPCODE	G · (IDIO)			M4_E1					M4_E2					M4_W	-	
SNO	(2024)	Species name (ITIS)	2008	2011	2014	2017	2021	2007	2011	2014	2017	2021	2008	2011	2014	2017	2021
194	UNKX11	Unknown sp11							0.39								
198	UNKX15	Unknown sp15			0.21												
202	UNKX19	Unknown sp19				0.15											
203	UNKX20	Unknown sp20				0.15											
209	UNKX26	Unknown sp26															0.14
210	UNKX27	Unknown sp27															0.15
211	UNKX28	Unknown sp28					0.22										
212	UNKX29	Unknown sp29					0.20										0.58
213	UNKX30	Unknown sp30					0.27										0.81
214	UNKX31	Unknown sp31					0.13										
215	UNKX32	Unknown sp32					1.29										
216	UNKX33	Unknown sp33					0.04										
233	UNKXX9	Unknown sp09											0.11				
234	UTRCOR	Utricularia cornuta						0.41									0.03
235	UTRFOL	Utricularia foliosa							3.68	1.10	0.41	0.69	0.05	0.26	0.79		4.81
236	UTRGIB	Utricularia gibba						4.16					0.02	0.05			
237	UTRPUR	Utricularia purpurea					0.28	3.60	4.40	0.71		13.18	0.22				1.97
243	VITSHU	Vitis shuttleworthii						0.04									

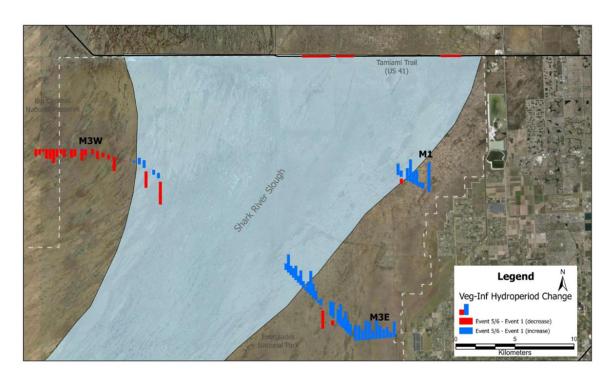
Appendix 4d: Importance value index (IV) of species that were present at the marl prairie sites of Transect M5 which was surveyed five times (2008, 2011, 2014, 2018 & 2022) between 2005 and 2024.

SPP	CDCCDE	G (MING)			M5_E					M5_W					M5_R			M6
SNO	SPCODE	Species name (ITIS)	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2019
2	AESPRA	Aeschynomene pratensis	0.00															3.86
3	AGALIN	Agalinis linifolia				0.30												
8	ANDVIR	Andropogon virginicus	0.02				0.03											
10	ANGBER	Angadenia berteroi				0.13												
11	ANNGLA	Annona glabra	0.16			0.02	0.01				0.03	0.03						0.02
15	ASCLAN	Asclepias lanceolata		0.23	0.55		0.02											0.01
16	ASCLON	Asclepias longifolia					0.02											
18	ASTBRA	Symphyotrichum bracei	0.34		1.53			0.51		0.46								
20	ASTDUM	Symphyotrichum dumosum	2.12	3.68	2.04		1.83	0.73	0.29	0.35		0.66						0.10
22	ASTTEN	Symphyotrichum tenuifolium		1.10		0.37	1.52		2.10			0.33						0.01
24	BACCAR	Bacopa caroliniana					0.19											6.52
32	CASFIL	Cassytha filiformis	0.94		3.23	3.02	0.87	2.61	0.05	2.74	0.84	1.19						1.05
33	CATBER	Catopsis berteroniana											0.13					0.06
34	CENASI	Centella asiatica	0.87		0.02	0.02	0.26											
39	CLAJAM	Cladium jamaicense	29.10	26.66	22.84	34.86	28.94	40.32	30.21	26.96	34.69	40.24	38.29	37.34	35.87	39.26	33.95	25.99
43	CRIAME	Crinum americanum	3.33	5.94	5.18	4.32	6.94	2.33	2.92	4.03	3.07	3.36						7.38
53	DYSANG	Dyschoriste angusta																0.01
56	ELECEL	Eleocharis cellulosa	2.47	4.22	5.11	5.84	6.52	34.05	42.52	47.24	46.42	32.04	6.86	6.37	3.68	8.07	5.81	18.59
60	ERAELL	Eragrostis elliottii		0.25			0.12		0.19									0.06
62	ERIQUE	Erigeron quercifolius		0.09														
66	EUPMIK	Eupatorium mikanioides			0.21		0.12											
71	FUIBRE	Fuirena breviseta							0.27									
72	FUISCI	Fuirena scirpoidea																0.15
73	FUIXX1	Fuirena sp.					0.07											
76	HELPIN	Helenium pinnatifidum	0.67	2.03	1.12	0.63	1.16	0.39	0.20	0.04	0.18	0.20						0.06
77	HELPOL	Heliotropium polyphyllum					0.10											
79	HYDCOR	Hydrolea corymbosa				0.16												0.09

SPP	CDCODE	G (TING)			M5_E					M5_W					M5_R			M6
SNO	SPCODE	Species name (ITIS)	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2019
81	HYMPAL	Hymenocallis palmeri	2.81	4.16	4.12	4.17	3.02	1.15	0.08		0.91	0.27						0.77
82	HYPALA	Hyptis alata	0.03		0.16	0.14	0.17											
86	IPOSAG	Ipomoea sagittata	2.53		3.01	1.01	2.21											0.05
87	IVAMIC	Iva microcephala	0.27		0.15	0.24												0.21
90	JUSANG	Justicia angusta	0.13	0.49	0.13	1.48	1.15	0.34	0.52		0.36	0.67						0.60
92	LEEHEX	Leersia hexandra	0.21		0.94	0.23	0.47											
94	LOBGLA	Lobelia glandulosa	0.17		0.21		0.13			0.20								
95	LUDALA	Ludwigia alata		0.55														
97	LUDMIC	Ludwigia microcarpa	0.11	0.20	0.29		0.21											
98	LUDREP	Ludwigia repens	0.41	0.37	0.79		0.08											
104	MIKSCA	Mikania scandens	0.03		0.24		0.03											
105	MITPET	Mitreola petiolata		0.33			0.20											
106	MORCER	Morella cerifera	0.02	0.12	0.18	0.02				0.43		0.06						
107	MUHCAP	Muhlenbergia capillaris var. filipes	14.97	13.57	11.96	7.59	7.72	0.57	2.56			0.16						0.32
109	NYMAQU	Nymphoides aquatica																1.16
111	OXYFIL	Oxypolis filiformis	0.02	0.02	0.02		0.30	0.03	0.20	0.23								0.21
113	PANHEM	Panicum hemitomon	0.46				0.45		0.14									9.21
115	PANTEN	Coleataenia tenera	1.25	0.53	0.94	0.65		0.82	0.47	0.23	0.39	0.99						0.99
116	PANVIR	Panicum virgatum	5.17	6.86	5.96	5.49	4.58	1.23	1.62	1.25	2.06	1.07						0.90
119	PASGEM	Paspalidium geminatum	0.09	0.13	0.21													1.00
120	PASMON	Paspalum monostachyum	0.41	3.97	2.04	2.14						0.29						
122	PELVIR	Peltandra virginica				0.11	0.02											0.07
123	PERBOR	Persea borbonia	0.02															
125	PHRAUS	Phragmites australis	0.12				0.65											
128	PHYNOD	Phyla nodiflora	1.82	0.02	1.56			0.50										
132	PIRCIS	Piriqueta cistoides ssp. caroliniana	0.14		0.02													
134	PLUROS	Pluchea baccharis	2.20	2.43	0.98	1.43	1.29		0.12									0.31
136	POLGRA	Polygala grandiflora	0.02															
137	POLHYD	Polygonum hydropiperoides			0.08													

SPP	CDCODE	G (TELG)			M5_E					M5_W	7				M5_R			M6
SNO	SPCODE	Species name (ITIS)	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2019
138	PONCOR	Pontederia cordata			0.02		0.19											
140	PROPAL	Proserpinaca palustris	0.37	0.79	0.30	0.02	0.02											
145	RHIMAN	Rhizophora mangle	0.09					0.68	1.16	2.37	4.23	9.86	48.42	46.72	52.08	48.95	49.98	2.35
147	RHYCOL	Rhynchospora colorata		0.19														
148	RHYDIV	Rhynchospora divergens					0.37			0.20								
150	RHYINU	Rhynchospora inundata	0.62	0.58	0.95	0.72	0.21					0.10						
151	RHYMIC	Rhynchospora microcarpa	1.24	2.74	2.99	3.33	3.02	0.39		2.72	2.60	0.66						0.05
153	RHYTRA	Rhynchospora tracyi	7.96	3.73	6.31	10.84	7.46	2.60	2.60	1.39	3.12	6.66						6.30
157	SACGIG	Saccharum giganteum					0.09											
158	SAGLAN	Sagittaria lancifolia	0.11	0.23	0.12	0.52	0.58	3.56	3.24	0.62	0.55	1.15						3.56
162	SCHALB	Schoenolirion albiflorum		0.02														0.02
163	SCHNIG	Schoenus nigricans	0.12	0.30		0.31	0.13											
164	SCHRHI	Schizachyrium rhizomatum	13.19	12.39	10.48	8.45	10.10	6.86	6.10	5.66	0.40	ı						0.92
168	SETPAR	Setaria parviflora		0.02			0.45											
173	SOLSTR	Solidago stricta	0.35		0.49		0.21	0.31	0.14	0.38								0.07
174	SPABAK	Spartina bakeri	1.93	1.03	2.29	1.13												
176	TAXDIS	Taxodium distichum var. imbricrium		0.02		0.18												0.02
177	TEUCAN	Teucrium canadense			0.09													
181	TILBAL	Tillandsia balbisiana											0.13			2.88		0.22
182	TILFLE	Tillandsia flexuosa											1.42					0.06
183	TILPAU	Tillandsia paucifolia											0.24	1.66	0.62			0.06
184	TILREC	Tillandsia recurvata																0.06
185	TILUTR	Tillandsia utriculata											0.70					
186	TILXX1	Tillandsia sp.													0.62		5.91	
189	TYPDOM	Typha domingensis																0.45
195	UNKX12	Unknown sp12							0.39									
196	UNKX13	Unknown sp13							0.02	,								
197	UNKX14	Unknown sp14			0.13													

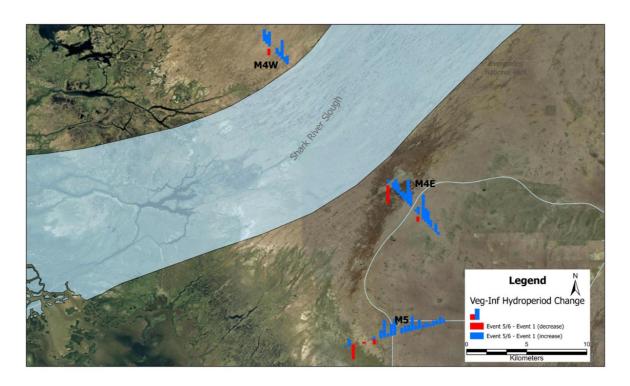
SPP	CDCODE	Charles manne (ITIC)			M5_E					M5_W	,				M5_R			M6
SNO	SPCODE	Species name (ITIS)	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2008	2011	2014	2018	2022	2019
204	UNKX21	Unknown sp21																0.01
205	UNKX22	Unknown sp22																0.05
218	UNKX35	Unknown sp35					0.12											
227	UNKXX3	Unknown sp03				0.11												
233	UNKXX9	Unknown sp09	0.15															
234	UTRCOR	Utricularia cornuta	0.48		0.05													
235	UTRFOL	Utricularia foliosa							1.03					5.06	6.98	0.84	0.95	0.35
236	UTRGIB	Utricularia gibba		0.02					0.72									0.08
237	UTRPUR	Utricularia purpurea				0.03	0.29			2.09			3.82	2.85	0.16		3.41	5.65
238	UTRRES	Utricularia resupinata							0.13	0.43	0.15							
240	UTRXX1	Utricularia sp.					0.14											
241	VERBLO	Vernonia blodgettii																0.01



Appendix 5: Change in vegetation-inferred hydroperiod between E6 (or E5) and E1 on marl prairie portions of M1 and M3. Sites in the western marl prairie poriton of M3 were last sampled in 2022 (E5).



Appendix 6: Change in vegetation-inferred hydroperiod between E6 (2023/2024) and E4 (2015/2016) on marl prairie portions of M1 and M2 (M2E) and eastern poriton of M3 (M3E).



Appendix 7: Change in vegetation-inferred hydroperiod between E5 (2021/2022) and E1 (2008) on marl prairie portions of M4 and M5.



Appendix 8: Photos showing the hydrologic condition and vegetation at the site M2E-3600 during the time of survey in 2015 and 2023. (Photos: 2015 – Jesus Blanco; 2023 – Santiago Castaneda).