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CHANGES IN PLANT COMMUNITIES RELATIVE TO HYDROLOGIC CONDITIONS IN THE FLORIDA EVERGLADES

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Abstract: Distribution and percent cover of plant species in relation to hydroperiod (i.e., depth and duration of flooding) were examined along eight vegetation transects in Water Conservation Area 3A of the Everglades where water-level recorders were either present or subsequently installed. Transects were monitored between 1978 and 1984 to detect changes in plant communities resulting from the operation of water-control structures to improve distribution of water to WCA 3A. Hydroperiod increased significantly at four transects where long-term hydrologic data were available. Distribution of some obligate wetland species such as *Sagittaria lancifolia* increased significantly with longer flooding duration. Several taxa, including *Nymphaea odorata* and *Utricularia* spp., showed significant positive relationships with annual increases in water depth. *Typha domingensis* increased in frequency and cover at two transects close to the northernmost water-control structure despite showing no significant relationship with increased hydroperiod. Therefore, it seems that some other environmental factor, such as inputs of phosphorus enriched water through the structure, may be encouraging the encroachment of this species. Improved hydroperiod may be inadequate for Everglades restoration without water quality improvements since it will likely result in monotypic stands of *T. domingensis.*

Key Words: Everglades, Florida, hydrology, hydroperiod, plant communities, wetlands

INTRODUCTION

Several factors influence wetland plant community composition, including duration of flooding, depth of flooding, and soil water chemistry (Tabb 1963, Gerritsen and Greening 1989, Gunderson 1994). Hydroperiod (i.e., water depth and duration of flooding) is considered to be the major mechanism under which the unique vegetation patterns of the Everglades have evolved (Gunderson 1994). McPherson (1973) suggested that even slight changes in the depth and period of inundation influenced the presence of certain plant communities. Although the Everglades are characterized by slight topographic gradients, localized variation in elevation due to alligator holes, tree islands, or areas of burned peat can alter hydrology and influence the occurrence of plant species. Increased hydroperiod may result in the elimination of wet prairie vegetation and tree islands (Dineen 1974), whereas shortened duration of flooding can influence plant communities by increasing the incidence of severe fires that may penetrate the organic (muck) soils (Zaffke 1983). Other disturbances, such as frost, hurricanes, and nutrient input, may extensively alter vegetation community patterns (Gunderson 1994). Seasonal water-level fluctuations can control the occurrence of some plant species or communities by affecting seed germination, plant growth, and productivity (Gerritsen and Greening 1989). For example, a spring dry period seems to favor the existence of wet prairie in the northern Everglades (Goodrick 1984). Gunderson (1989) indicated that current species composition was not highly correlated with historic hydrology, suggesting that more recent hydrologic conditions may have greater influence on plant species presence. Annual drawdowns to expose the marsh soils in WCA 2A reduced plant composition, density, and biomass of more flood-tolerant species (Worth 1988).

Historically, the northern Everglades as described by Davis (1943) and Loveless (1959) were dominated by a mosaic of four plant communities: sawgrass marsh, wet prairie, aquatic slough, and tree islands. In addition to sloughs, Gunderson (1994) further classified communities associated with peat soils based on graminoid plant species. These communities consisted of tall (dense) and intermediate (sparse) sawgrass (*Cladium jamaicense*), and three types of wet prairie; spikerush (*Eleocharis* spp.) flats, beakrush (*Rhyncospora* spp.) flats, and maidencane (*Panicum hemitomon*) marshes. Although these plant communities still occur in parts of WCA 3A, more frequent peat fires due to alteration of the hydrology have resulted in a loss of tree islands, aquatic slough, and wet prairie (SFWMD 1992). These communities represent important wildlife habitat that are used extensively by foraging wading birds (Frederick 1994) and endangered snail kites (*Rostrhamus sociabilis plumbeus* Ridgeway) (Bennetts et al. 1988). In fact, long-term changes in the Everglades hydrology due to modifications in the water management system most likely have contributed to the disruption of feeding and nesting patterns of numerous avian fauna (Ogden 1994).

The purpose of this study was to evaluate potential changes in vegetative communities due to increased hydroperiod as a result of construction of water control structures S-339 and S-340. These structures were installed in the Miami Canal (C-123) and became operational in October 1980 (Figure 1). By maintaining higher canal water levels, these structures were expected to reduce discharge of water to southern WCA 3A by facilitating overland flow of water to northern WCA 3A through a series of gaps in the canal levee. Vegetation transects were installed across topographic gradients to examine distribution and coverage of plant species relative to elevation and temporal changes in hydroperiod.

STUDY AREA

The Water Conservation Areas represent a portion of the Florida Everglades, a vast shallow marsh which historically extended from Lake Okeechobee to the estuaries of Florida Bay. Water Conservation Area (WCA) 3A is the largest of the impounded areas created by the U.S. Army Corps of Engineers (USCOE) as part of the Central and South Florida Flood Control Project (C&SF) authorized by the U.S. Congress through the Flood Control Act of 1948. Several modifications to the C&SF project resulted in the overdrainage of northern WCA 3A while construction of Levee 29 in 1962 created prolonged flooding in the southern portion (SFWMD 1992).

METHODS

Six vegetation transects ranging in length from 84 to 144 meters were established within WCA 3A in 1978, and two transects (3–4 and 3–28) were installed in 1979, either in close proximity to existing water-level recorders or in areas where recorders were subsequently installed (Figure 1). All transects were oriented in an east-west direction across elevation gradients, and sampling occurred annually between August 1978 and July 1984. Species presence, ground elevation, and soil depth within a 2 × 3m quadrat were recorded at 3m intervals along each transect. Ground elevation and soil depth were recorded only during the initial sample year. Frequency of occurrence (%) for 30 of the most common emergent plant species was calculated by dividing the number of quadrats in which a species was present by the total number of quadrats along each transect and calculated for data collected in all sampling years. In 1983 and 1984, plant species in each quadrat were assigned a cover class from 0 to 6 based on a modified Daubenmire (1959) scale, with the 0–5% category separated into two classes (i.e., 0 and 1–5%). Cover class midpoints for the seven categories (i.e., 0, 3%, 15%, 38%, 63%, 85%, and 98%) were used in data analyses.

Inundation frequency (duration of flooding) was calculated for each quadrat as the total number of days in which water levels exceeded ground elevation. Mean depth represents the average water level during inundation period. The SFWMD hydrologic data base provided all daily water-level data used to calculate inundation frequency and mean depth. For missing hydrologic data of less than two months, average daily readings were interpolated from existing readings. Water-regulation schedules and topographic data for the Water Conservation Areas are reported as feet above mean sea level (ft msl); however, elevations in this paper have been converted to metric.

Two vegetation data sets were used in the analyses. Data set #1 included percent occurrence of species along each transect for each year for a sample size of 43. Mean depth and inundation frequency were calculated using the mean transect elevation and hydrologic data. Temporal trend analyses conducted on data set #1 assumed independence among years. Comparisons were based on Mann's (1945) modification of Kendall's procedure (Hollander and Wolfe 1973), which provided exact probability levels for each sample size. These analyses indicated that the assumption of independence was violated for some species, but no attempt was made to correct this due to the small sample size. Although annual sampling dates varied from March to October, those species used in the analyses were relatively robust and were easily identified throughout the season. Temporal trend analysis was based on frequency data and therefore indicative of changes in plant distribution rather than dominance (i.e., cover or density) in the community. A drought in 1981 made these trends more difficult to detect; however, better results were obtained in analyses over longer time periods (i.e., > 4 years).

Data set #2 pooled the modified Daubenmire cover class data from 1983 and 1984 for a total of 564 quadrat observations. Cover class data were collected at approximately the same date each year to reduce possible seasonal variation. Stepwise regression identified

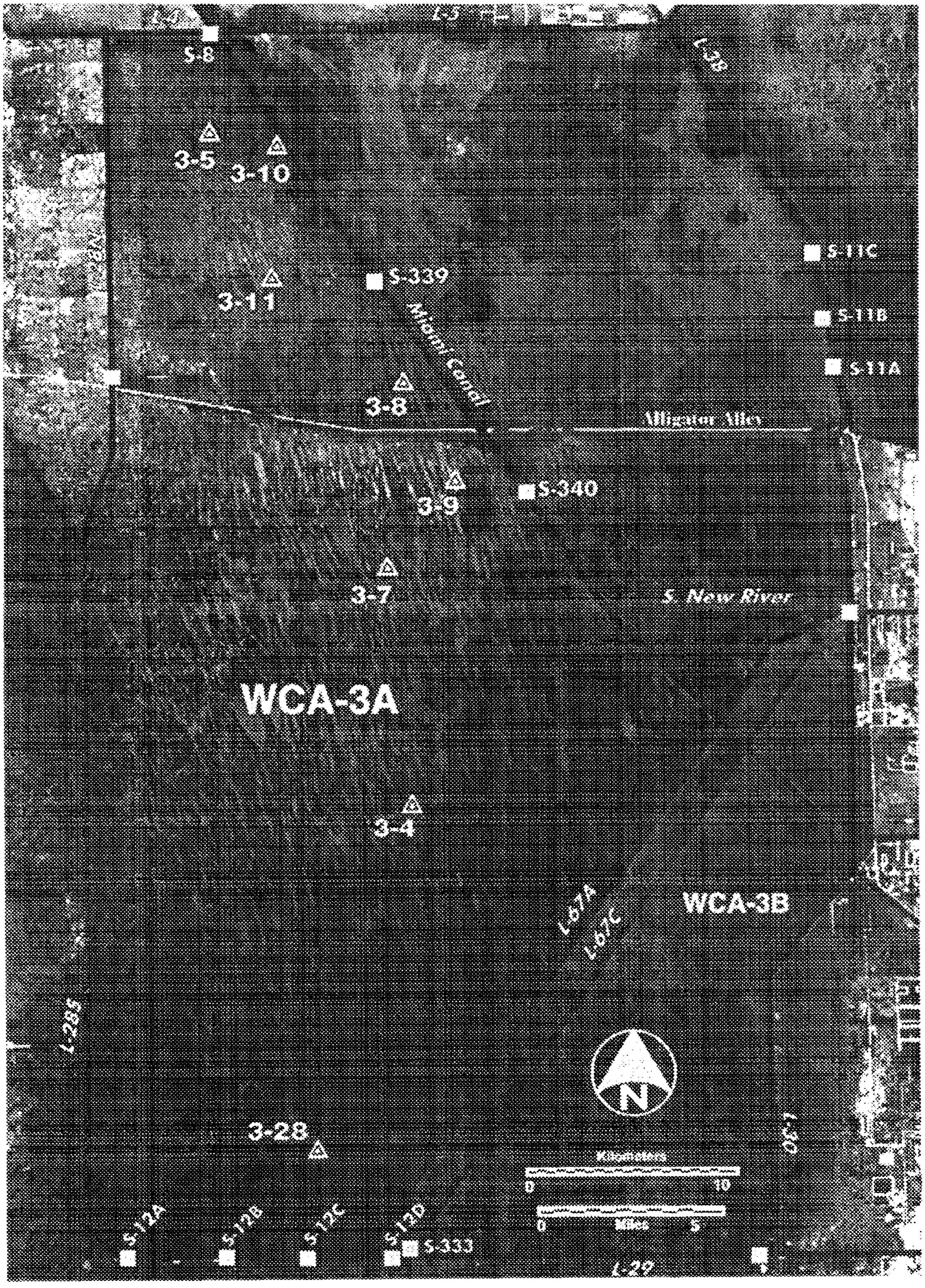

Figure 1. Location of vegetation transects and water level recorders in WCA 3A.

Table 1. Time trend analyses (1978–1984) comparing five transects in WCA 3A. Probability levels (P) are presented.

	3–4	3–5	3–7	3–10	3–28
Site Variables					
2-year inundation frequency	ns	ns	ns	++	ns
4-year inundation frequency	+	ns	ns	+	--
6-year inundation frequency	+	+	++	ns	ns
2-year mean depth	ns	++	++	+	ns
4-year mean depth	+++	++	++	ns	ns
6-year mean depth	+++	ns	+++	ns	ns
Species					
Panicum hemitomon	ns	--	ns	+	ns
Erigeron quercifolius	*	--	*	ns	*
Cyperus haspan	*	--	+	ns	*
Baccharis spp.	*	--	ns	---	*
Polygonum spp.	ns	---	+	ns	*
Sagittaria lancifolia	ns	+++	+++	+	ns
Andropogon spp.	*	ns	*	--	*
Paspalidium paludivagum	ns	ns	+	ns	ns
Eupatorium capillifolium	*	ns	+	ns	*
E. coelestinum	*	ns	--	ns	ns
Ludwigia alata	*	ns	++	ns	*
Eleocharis cellulosa	ns	*	++	*	ns
Typha domingensis	*	ns	ns	++	*
Crinum americana	*	ns	ns	*	ns
Pontederia lanceolata	ns	ns	ns	ns	--
Bacopa caroliniana	ns	*	ns	*	--

ns = no significance, * = not present during study. + = positive trend ($P < 0.05$) ++ = ($P < 0.01$) +++ = ($P < 0.001$).
-- = negative trend ($P < 0.05$) --- = ($P < 0.01$).

the site factors that indicated a relationship with species presence. Regression was performed by using cover class as the dependent variable and site conditions as independent variables. These variables included soil depth, water depth, and inundation frequency, and the squared values for each of these variables (e.g., soil depth^2). This procedure analyzed the eight taxa that occurred at greater than 5% coverage on the transects: *Cladium jamaicense, Ludwigia repens, Nymphaea odorata, Panicum hemitomon, Sagittaria lancifolia, Typha domingensis, Eleocharis cellulosa,* and *Utricularia* spp. Two-way Chi-square contingency tables estimated the degree of agreement between observed and predicted values of a species presence and absence. Quadratic transformations of independent variable means and graphical inspection were used to examine possible nonlinear relationships among species occurrence and hydrologic variables.

RESULTS

Temporal trend analyses for five transects indicated that inundation frequency and mean inundation depth increased significantly ($P < 0.05$) from 1978 to 1984 for transects 3–4, 3–5,3–7, and 3–10 (Table 1). Definitive trends were not evident at transect 3–28.

Plants responded differently to increased hydroperiod among the transects. For example, five species declined on transect 3–5, whereas seven species increased on transect 3–7. The frequency of five species changed significantly at more than one transect, and *S. lancifolia* increased significantly ($P < 0.05$) in response to greater hydroperiod at three transects. Results were complicated by the drought and fire that occurred in 1981. For example, the frequency of *T. domingensis* increased at transect 3–5 from 17% in 1978 to 50% in 1981 but was severely reduced to 13% following the drought. Although this species again increased in frequency to 40% by 1984, a positive trend over the entire 1978–1984 period was not detected.

Table 2 summarizes the hydrologic conditions at the eight transects over the various data-collection intervals. The short period of hydrologic data available for transects 3–8, 3–9, and 3–11 precluded meaningful trend analysis. However, 1982–1984 data indicated that the three transects were influenced differently by hydrologic conditions. For example, inundation frequency and mean depth decreased at transect 3–8, while at transect 3–11, inundation frequency increased but mean depth declined. Inundation frequency did not change at transect 3–9; however, depth increased over the two-year period.

Table 2. A summary of hydrologic conditions and dominant species at eight transects in WCA 3A.

Transect	Inundation Frequency (%)	Mean Water Depth (cm)	Dominant Species
3-10*	31.6	10.0	*Cladium jamaicense, Sagittaria lancifolia, Ludwigia repens, Typha domingensis*
3-11**	53.1	14.0	*Cladium jamaicense, Eleocharis cellulosa, Rhyncospora inundata*
3-5***	56.9	13.9	*Cladium jamaicense, Ludwigia repens, Typha domingensis*
3-8**	61.4	18.3	*Panicum hemitomon, Eleocharis cellulosa, Utricularia* sp.
3-7***	74.6	18.2	*Cladium jamaicense, Utricularia* spp.
3-9**	84.6	37.2	*Cladium jamaicense, Utricularia* spp., *Eleocharis cellulosa*
3-4*	94.7	47.3	*Utricularia* sp., *Eleocharis cellulosa, Sagittaria lancifolia*
3-28***	96.4	61.5	*Nymphaea odorata, Utricularia* spp., *Eleocharis cellulosa*

* Hydrologic data from March 1978–July 1984.
** Hydrologic data from January 1981–July 1984.
*** Hydrologic data from March 1972–July 1984.

Stepwise regression indicated that the environmental variables explained from 2 to 46% of the variation in the occurrence of eight plant species (Table 3). The mean water depth over the previous year seemed to be a more reliable predictor than inundation frequency.

Nymphaea odorata declined in frequency from 37% to 6% on transect 3–7 during the 1981 drought. Similar reductions in distribution of this species occurred on transects 3–4 and 3–9. Although no significant trends were detected, *Rhyncospora tracyi* also responded quickly to changing hydrologic conditions. This species was not present on transect 3–28 prior to the drought but was recorded in 40–50% of the quadrats sampled in 1981 and 1982. Subsequently, *R. tracyi* declined to 10% frequency as hydroperiod increased in 1983 and 1984. Small sample sizes precluded meaningful analysis of plant species over longer time periods (i.e., > 6 years).

In the present study, stepwise regression indicated that (soil depth)^2 explained 20% of the variation in the distribution of *C. jamaicense*. However, this relationship must be considered inconclusive because soil measurements were only taken during 1979 and the analysis assumed no change in soil depth over the remainder of the study.

Changes in elevation of 0.1m along several transects seemed to influence the presence of *C. jamaicense, Utricularia* spp., and *N. odorata*, especially on transect 3–28 where all three species were common (Figures 2a, 2b, and 2c). However, the latter two species responded quite differently to water depth compared with *C. jamaicense*. Transect 3–5 had a slight topographic gradient and relatively shallow water depth and a short flooding duration that seemed to favor the development of dense stands of *C. jamaicense*, although coverage of this species varied considerably along the transect (Figure 3). An increase in elevation of slightly over 0.1 m resulted in a 45% decline in

Table 3. Stepwise regression results for comparisons between site variables and eight plant species found in WCA 3A. Total and partial R^2 values and probability levels (P) are given.

Plant Species	Total R^2	Soil Depth	Soil Depth^2	Year Water Depth	Year Water Depth^2	Year Inundation Frequency^2
Utricularia spp.	0.19	0.01*	0.02**	0.16**	ns	ns
Typha domingensis	0.02	ns	ns	0.01*	ns	ns
Sagittaria lancifolia	0.07	0.03**	ns	ns	0.04**	ns
Panicum hemitomon	0.22	0.11**	ns	ns	ns	0.05**
Nymphaea odorata	0.46	ns	ns	ns	0.45**	ns
Ludwigia repens	0.05	ns	ns	ns	0.04**	ns
Eleocharis cellulosa	0.13	0.02**	0.07**	ns	ns	ns
Cladium jamaicense	0.28	ns	0.20**	ns	0.05**	ns

ns = no significance.
* = significant ($p < 0.01$).
** = significant ($p < 0.001$).

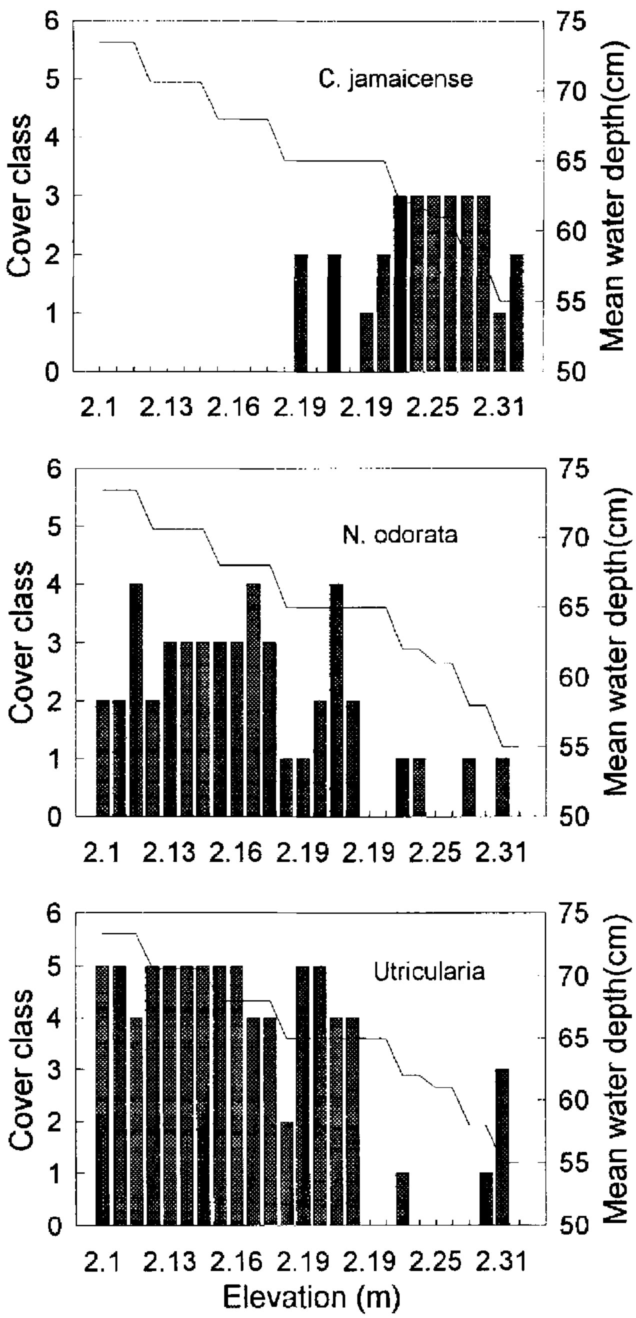

Figure 2. Cover classes (bars) for *C.* jamaicense (a) *N. odorata* (b) and *Utricularia* spp. (c) in relation to mean water depth (line) and surface elevation at transect 3–28 in WCA 3A.

mean water depth and a 20% reduction in inundation frequency at 3–7 (Figures 4a and 4b).

General site conditions for 30 of the most common emergent plant taxa are summarized in Table 4. Except for *Baccharis* spp., *Cynoctonum mitreola, Erigeron quercifolius,* and *Eupatorium coelestinum,* all plant species tolerated 100% inundation frequencies for at least a one-year duration.

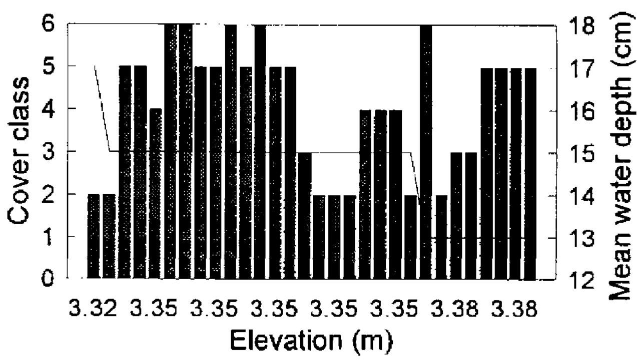

Figure 3. Cover classes (bars) for *Cladium jamaicense* in relation to mean water depth (line) and surface elevation at transect 3–5 in WCA 3A.

DISCUSSION

Hydrologic data indicated that water levels increased in WCA 3A with the operation of the S-339 and S-340 structures. Four transects (3–4, 3–5, 3–7, and 3–10) showed significant increases in inundation frequency and depth from 1978 to 1984. However, 3–28, which already had an extended inundation frequency and was located at some distance from either structure, appeared to be little affected. The significant increase in hydroperiod at 3–4 and lack of change at 3–28 suggests that although the structures were not successful in relieving flooded conditions in southern WCA 3A, they did increase sheet flow to northern 3A.

There was little change in plant communities over the study period at transects 3–4 and 3–28 that had the greatest depth and longest flooding duration, except for the extensive growth of *R. tracyi* during the drought. This rapid response may indicate the presence of a viable soil seed source and indicate that even a brief period of soil drying may encourage germination. Pesnell and Brown (1977) observed extensive germination of this species in dry soils or shallow water depths (7–15 cm). Similar responses by *R. tracyi* in other wetland systems where severe drought is less frequent indicates that seeds may retain viability for long durations and may be readily abundant in the soil (Gerritsen and Greening 1989).

Typha domingensis showed a weak relationship with depth and no significant relationship with increased inundation frequency (Table 3). Since hydroperiod trends increased significantly in northern WCA 3A, it seems that another factor may be responsible for the progressive spread of *T. domingensis* at transects 3–5 and 3–10. Koch and Reddy (1992) and Davis (1994) reported that high nutrient levels provided *T. domingensis* with a competitive advantage over *C. jamaicense,* a species that has evolved under highly oligotrophic conditions. Considerable discharge and loading of phosphorus has occurred during the study period

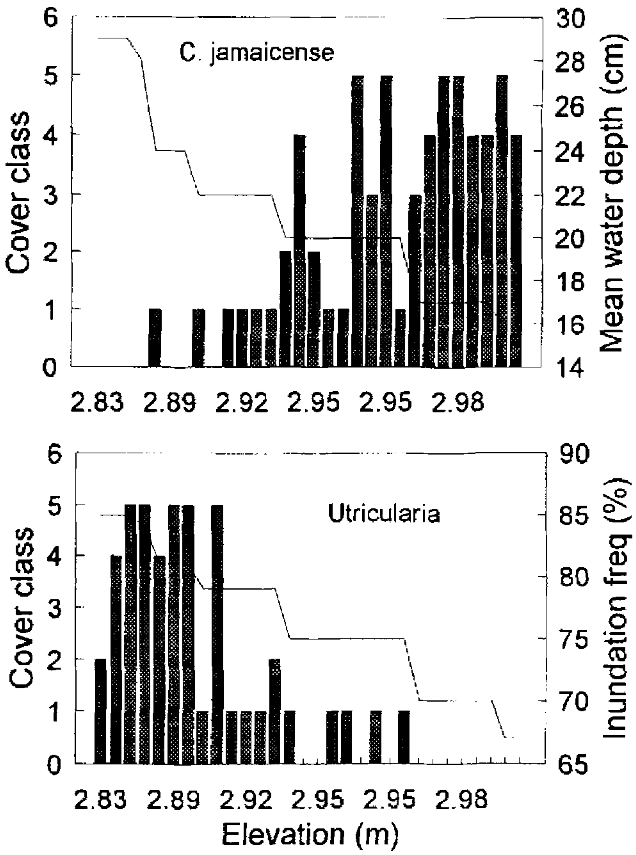

Figure 4. a) Cover classes (bars) for *Cladium jamaicense* in relation to mean water depth (line) and surface elevation at transect 3–7 in WCA 3A. b) Cover classes (bars) for *Utricularia* spp. in relation to inundation frequency (line) and surface elevation at transect 3–7 in WCA 3A.

through pump station S-8, located approximately 15 km upstream from S-339 (SFWMD 1992). *Typha domingensis* was encountered along three transects in close proximity to S-339, suggesting that the discharge of nutrient enriched water has contributed to the rapid encroachment of *T. domingensis* into northern WCA 3A. Similar displacement of *C. jamaicense* and other plant communities with monotypic stands of *Typha* sp. has been reported for WCA 2A (Rutchey and Vilchek 1994). Davis (1994) indicated that the drought that occurred between 1988 and 1990 in the Everglades caused a temporary dieback of *Typha*. However, the drought in 1981 did not reduce the frequency of *T. domingensis* at transect 3–10, where a significant increase in coverage was observed.

Sagittaria lancifolia increased significantly over time at three transects, suggesting that this species was responding favorably to increased hydroperiods. *Baccharis* spp. seemed to be the most flood intolerant of the 30 species, since it showed a significant negative trend on the two northernmost transects and was absent from transects with longer inundation frequencies. *Nymphaea odorata* was extremely flood tolerant and was reduced considerably at several transects following the 1981 drought. McPherson (1973) reported a similar decline of this species and *Bacopa caroliniana* in sloughs located in southern WCA 3A following a 30-day drying of the marsh surface in 1971. These results suggest that *N. odorata*, being sensitive even to short dry periods, may be a good predictor of slough conditions in the northern Everglades. The narrow range of inundation frequency for *N. odorata, E. elongata, R. tracyi*, and *Baccharis* spp. suggests that these taxa require near optimal conditions on an annual basis to persist. In contrast, those taxa with a wide range of inundation frequencies or considerable variation in mean depth have greater tolerance for short periods of wet or dry extremes (Table 4). *Rhyncospora tracyi* and *P. hemitomon* have been used as indicator species to document changes in a northern Everglades wet prairie (Goodrick 1974). However, *R. tracyi* seems to be a more suitable predictor of wet prairie since *P. hemitomon* occurred in close association with sawgrass over a wide range of hydrologic conditions in WCA 3A. In fact, Wood and Tanner (1990) questioned the classification of wet prairie in southern WCA 3A due to the complete absence of *Rhyncospora* spp.

Topography and variable rainfall patterns must be considered critical factors in preserving the heterogeneity of the northern Everglades plant communities, primarily because they influence water depth and flooding duration. Transects that crossed distinct changes in elevation had the greatest diversity in plant communities, and even small changes in topography influenced presence or absence of some species. For example, transect 3–28 had the longest period of inundation, but a 0.1 m change in elevation resulted in a transformation from aquatic slough to a *C. jamaicense* dominated community (Figures 2a, 2b, and 2c). *Utricularia* spp. and *N. odorata* responded favorably at the lowest elevations along transect 3–7 but disappeared from the higher elevations (Figures 4a and 4b). Both taxa were influenced to some degree by mean depth over one year, indicating that they responded quickly to favorable conditions in a wet year while disappearing during drought. Coverage of *C. jamaicense* varied considerably along transect 3–5 despite little change in elevation, indicating that distribution of this species was influenced by other factors, such as soil depth or past disturbance.

CONCLUSIONS

Operation of S-339 and S-340 seemed to be successful in increasing frequency of inundation and mean depth for several areas in WCA 3A. The in-

Table 4. Summary of site conditions for thirty plant species found in WCA 3A. Number of occurrences (N) out of 564 quadrats, mean soil depth (standard deviation), inundation frequency range, and mean inundation depth (standard deviation) are given.

	N	Mean Soil Depth (cm)	Range of Inundation Frequency (%)	Mean Water Depth (cm)
Andropogon spp.	12	33 (26)	0–100	13 (9)
Baccharis spp.	14	15 (5)	0–22	<1
Bacopa caroliniana (Walter) B. Rob	211	46 (20)	33–100	36 (24)
Cladium jamaicense Crantz	338	53 (34)	0–100	25 (18)
Crinum americanum L.	121	48 (23)	0–100	27 (20)
Cynoctonum mitreola (L.) Britton	56	29 (27)	0–92	9 (5)
Cyperus haspan L.	69	38 (32)	0–100	13 (9)
Eleocharis cellulosa Torr.	330	45 (16)	45–100	34 (22)
E. elongata Chapm.	59	57 (11)	100	71 (11)
Erigeron quercifolius Lam.	59	21 (16)	0–88	8 (6)
Eupatorium capillifolium (Lam.) Small	85	35 (24)	0–100	16 (11)
E. coelestinum (L.) DC.	46	33 (24)	0–96	7 (7)
Hymenocallis spp.	77	45 (19)	48–100	46 (29)
Ludwigia alata Elliott	115	48 (30)	33–100	16 (8)
L. repens J. Forst.	134	56 (38)	0–100	19 (10)
Nymphaea odorata Soland.	129	53 (12)	63–100	54 (21)
Nymphoides aquatica (Walter) Kuntze	64	49 (19)	48–100	48 (24)
Panicum hemitomon Schultes	400	43 (20)	0–100	28 (21)
Paspalidium geminatum (Forsk.) Stapf	267	45 (17)	0–100	33 (21)
Peltandra virginica (L.) Kunth	24	50 (22)	48–100	30 (21)
Pluchea rosea Godfr.	154	42 (26)	0–100	16 (10)
Polygonum spp.	84	59 (39)	33–100	24 (12)
Pontederia lanceolata L.	131	46 (28)	33–100	29 (20)
Rhyncospora inundata (Oakes) Fernald	120	41 (23)	33–100	25 (18)
R. tracyi Britton	201	43 (17)	49–100	33 (20)
Sagittaria lancifolia L.	291	44 (27)	0–100	24 (18)
Salix caroliniana Michx.	30	57 (45)	36–100	38 (21)
Sarcostema clausa (Jacq.) Schultes	13	34 (17)	0–100	17 (14)
Typha domingensis Pers.	47	57 (33)	63–100	24 (12)
Utricularia spp.	310	48 (14)	48–100	37 (22)

creased hydroperiod was beneficial for several aquatic plant species including *S. lancifolia* and *N. odorata*, and resulted in the reduction of facultative wetland taxa such as *Baccharis* spp.

Despite considerable overlap of plant species among different vegetative communities in the Everglades, *R. tracyi* and *N. odorata* seem to be the best indicators of wet prairie and aquatic slough, respectively. *Rhyncospora tracyi* responded favorably to short dry periods in the deeper water marshes of southern WCA 3A. This rapid re-colonization suggests that a viable seed source was available and that wet prairie may have been present under previous hydrologic conditions. It also demonstrates that re-establishing natural hydrologic regimes in the Everglades could result in restoration of this valuable wildlife habitat.

It is well accepted that the Everglades is a dynamic ecosystem sustained by gradually fluctuating water levels, with heterogeneity of plant communities maintained on a small spatial scale by local variations in topography. In general, wetland plant species have adapted to seasonal water-level fluctuations, which result in stable or climax communities that experience shifts in species dominance. However, long-term anthropogenic changes in hydrology, such as prolonged flooding or overdrainage have had a detrimental impact on portions of WCA 3A by reducing diversity of flora and disrupting the breediing cycles of a number of Everglades fauna. Instability in the natural hydrologic regime combined with other artificial disturbances (e.g., nutrient input) may increase the potential for detrimental alteration of native plant communities. Therefore, it seems that proper management for sustained natural heterogeneity in WCA 3A will require both hydrologic modification and water quality improvement.

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