

SOUTH FLORIDA NATURAL RESOURCES CENTER



NATIONAL PARK SERVICE
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**Vegetation of Shark Slough,
Everglades National Park**

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EVERGLADES NATIONAL PARK**

SFNRC Technical

Report 97-001

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INTRODUCTION

Shark Slough drainage, the largest in Everglades National Park (ENP), forms the southern portion of the greater Everglades system which, prior to agricultural development, began just below Lake Okeechobee and extended to the Gulf of Mexico. This low-lying, wide "river" comprises a mosaic of marsh communities, tree islands, ponds, and sloughs. In addition, Shark Slough supports important populations of freshwater fishes, reptiles, and birds, and influences the estuarine system of the Gulf of Mexico.

Before artificial drainage of the Everglades, which began in the late 19th century, water depths, and periods of inundation (hydroperiods) in southern Shark Slough averaged greater than at present. In addition, the timing and distribution of water flows was directly linked to the natural hydrological cycle and surface waters moved entirely as sheet flow down the Slough (Craighead 1971, Fennema *et al.* 1994). Although historically the Slough was fed by direct rainfall and by surface water flows from Lake Okeechobee, surface waters now originate entirely from diked impoundments immediately to the north of ENP. In addition, water flow within Shark Slough is diverted away from its channel by L-67 extension, a levee which extends about 16 km south from Tamiami Trail, nearly bisecting the Slough.

The imposition of artificial controls upon the natural system has led to important changes in the hydrological regime of Shark Slough. Comparison of water levels from gauging stations to computer simulations of surface water flows in the absence of the present system of roads and water control structures shows that the altered system has lost much of its dry season flows. Furthermore, the Slough has experienced larger peak wet season flows than would have occurred under natural conditions (Fennema *et al.* 1994). Water management practices over the past several decades also have diverted large water volumes to the west side of Shark Slough, significantly reducing the proportion of the flows passing through the main channel of the Slough.

Thus, depending on their distribution within the Slough, plant communities have been exposed to wetter or drier conditions over the past half-century than would be expected in a natural rainfall-driven system. Although as discussed below, several authors have attempted to determine the effects of hydrological alterations on the plant communities of Everglades National Park, relatively little is known of the extent that the current structure and distribution of vegetation within ENP has departed from pre-disturbance conditions.

As a first step in investigating vegetation patterns in Shark Slough within Everglades National Park, data were collected from field plots in 1980-81 under the direction of the senior author in order to establish a quantitative base-line suitable for evaluation in plant community composition and structure. The base-line was needed both to increase basic understanding of the dynamics of Everglades vegetation and to provide the information essential to evaluate the effects of managed freshwater inflows upon ENP ecosystems. Circumstances prevented the completion of the data analysis and report-writing phases of the project although a vegetation map (Fig. 1) was produced. Because of the continuing need for an accessible base-line of data on Shark Slough vegetation, particularly given the steps

currently underway to restore the Everglades, the junior author, cooperatively with the senior author, has completed and updated the unfinished report.

Specifically, the objectives of this report are to: 1) describe the patterns of plant communities within the Shark Slough portion of Everglades National Park as they existed in 1980; 2) describe quantitatively the composition of the marsh communities; 3) describe qualitatively the composition of selected Shark Slough tree communities; 4) provide supporting data on elevation, hydroperiods and soils for sampled areas, and 5) infer, within the limits of available data, the changes in vegetation that may have occurred in Shark Slough.

BACKGROUND

The area of Shark Slough considered in this report is restricted to the portion south of the Tamiami Trail, northeast of the estuarine areas, west of the Levee 67 extension, and east of the western Slough boundary as indicated in Figures 1 and 2. All of this area, estimated at 57,725 ha (Kushlan *et al.* 1975) lies within ENP. Northeast Shark Slough, located east of L-67 extension, although directly connected to the study area and authorized for addition to ENP, is not covered in this report.

Shark Slough is a shallow, natural basin oriented along a longitudinal northeast-southwest axis. Slough widths vary from 9-17 miles (northeast to southwest) and hydraulic gradients are 2-3 inches (5-7.5 cm) per mile, producing extremely small velocity vectors characteristic of sheet flow. Water quality, which had been monitored for about 25 years as of 1980 (Flora and Rosendahl 1981), had not been significantly degraded throughout most of the ENP portion of Shark Slough at the time that the vegetation inventories were conducted.

The Slough differs in several aspects throughout its extent within ENP. The northern portion of the Slough is higher in elevation and consequently supports somewhat different plant communities than elsewhere in the Slough, particularly in its main channel. In addition, although the tree islands in most of the Slough, as an apparent effect of the strongly directional flow, are distinctly elongate or teardrop-shaped, the higher hammocks in the northern portion lack the characteristic "tails" of the tree islands in the lower Slough. In contrast, the southernmost portion of the Slough intergrades into a broad transitional area that increasingly supports plants adapted to marine influences. In this zone, the water traversing the Slough gradually becomes distributed as a complex of small streams that coalesce within mangrove forest into the Harney, Shark and Broad Rivers. Thus in this region about 20 km inland from the Gulf of Mexico, the Slough as it is configured further north, comes to an end. The area of the current study stops short of the transition zone although even within the area we cover, coastal influences can be discerned in the vegetation, particularly within tree islands.

The soils of the Slough are of two major types: organic muck and calcareous marl. The thickest organic soils (up to 1.5 m deep) occur in the central Slough towards the southern end. The higher flanks of the Slough are rockier and overlain with marl. The marl is intermixed on with sand on the western side.

Both Everglades peat, derived principally from tall sawgrass marshes, and Loxahatchee peat, derived mostly from deep water communities characterized by white water lily (*Nymphaea odorata*) are found within the Slough, the latter predominating within ENP (Cohen and Spackman 1984). Deposition of organic sediments in the southern Everglades began about 5000 years ago (Gleason *et al.* 1984).

Marl deposits, formed through the precipitation of calcite crystals by periphyton, are usually found where mean annual hydroperiods allow for annual decline of the water table below the soil surface for protracted periods (Browder *et al.* 1994). In addition, in some Shark Slough areas, current hydrological conditions in the open marshes favor both marl formation and organic soil accumulation, resulting in a mixture of muck and marl in the surface layers. Fires, particularly during droughts, often have destroyed peat soils, leaving rock or marl surfaces (Craighead, 1971, Wade *et al.* 1980). While southern Shark Slough may be relatively free from the consequences of such interventions compared to areas to the north and east, the northeastern portions of the Slough probably have experienced alterations of peat deposits as a result of overdrainage and fire (Craighead 1971).

METHODS

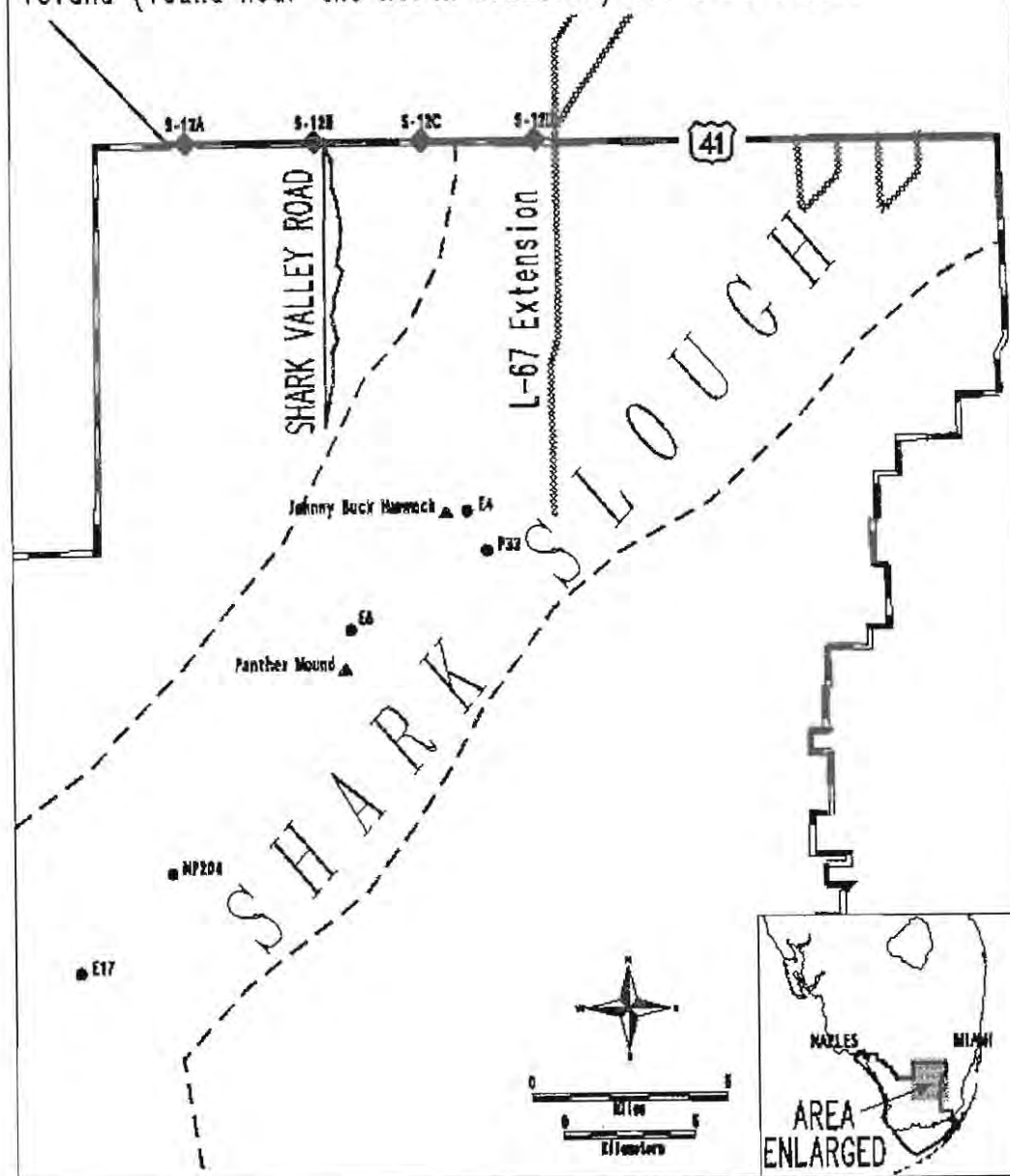
Vegetation Map

The vegetation map documented by this report (Fig. 1) was developed in association with a copy of a color infrared photograph taken in January 1973 by a NASA U2 flight. A copy of this photograph is available for inspection at the junior author's institution. The vegetation map presents communities encountered along three transects established across Shark Slough. An enlargement of the infrared photograph (1:16600) was used in the field. Plant communities were identified from the photograph and verified on the ground on the basis of dominant species. Plant community characterization was further accomplished by determining species composition and structure of the vegetation types. Field checking of infrared signatures and of final vegetation units on the transect maps was carried out extensively by helicopter and on foot.

Several sources of error can result from shortcomings in interpretation of infrared photographs although the errors are believed to have been kept acceptably small through intensive ground-truthing and the quantitative plot sampling. The greatest risk of errors in map interpretation were associated with differentiating the many color variations on the photograph. In particular, in the open spikerush (*Eleocharis cellulosa*) and sawgrass marshes, delineation was difficult because of the variable reflection of periphyton. This difficulty necessitated the establishment of a "spikerush/sawgrass" vegetation unit.

The presence or absence of small, scattered trees in the tall sawgrass stands could not always be verified because of their scant signature. Cattail (*Typha domingensis*) stands, typically small and diffuse, could not be seen from the infrared photograph and are only

Figure 2: Map of Shark Slough within Everglades National Park showing hydrological gauges mentioned in the text. Panther Mound (found along the middle transect) and Johnny Buck tree island (found near the north transect) are also shown.



indicated when they were identified on the ground. Willowheads were identified from the ground or when ponds were visible on the infrared photograph. On the photograph, only large willowheads without ponds could be identified. Many of the willowheads on the northern transect were verified from ground-truthing work conducted in an unrelated study (Kushlan, unpub. data).

Vegetation Sampling

The plant communities described represent the main types found in Shark Slough within ENP. Over the years, many terms have been reported in the literature to represent the same or very similar community types. Table 1 compares the terminology used in this report with the synonyms used by other researchers, dating back to Harshberger in 1914.

Three transects from six to 12 km long were established in 1980 across Shark Slough (Fig. 1). The graminoid (sedge, grass, rush) communities in Shark Slough were analyzed quantitatively, using sets of five 1 m² quadrats, arranged linearly. Five or six of these quadrat sets were sampled in each marsh community, yielding a sample of 25 or 30 m². Locations for the plots were selected to represent communities typical of Shark Slough as determined from field inspection and review of aerial photographs. Percent cover was visually determined for each species in each quadrat. Periphyton cover was indicated when encountered. Height of dominant graminoids was measured. Species composition and structure of bayheads, bayhead swamp forests, tropical hardwood hammocks, and willowheads also were qualitatively described.

Elevation Surveys and Soils Measurements

Relative elevation, soil type and soil depth across the Slough were determined in November 1980 at points along the south and middle transects, the latter just north of Panther Mound, a large tree island in central Shark Slough. Elevations, taken with a Dumpy Level, were related to water levels at staff gauges E-8 (Panther Mound) and E-17 (for the southern transect) on the days the survey was taken. See Figure 2 for gauge locations. The gauges had been surveyed to mean sea level in 1977. Elevation was determined at intervals ranging from 100 to 400 m. The first two km of the middle transect were walked to take readings at intervals of 100 m or less. An elevation survey was not made for the north transect, but the soil-substrate relationships of Rose and Rosendahl (1979) were used.

At each survey point along the two transects, water level and soil depth measurements were taken and the soil collected. Along all three transects, soil samples were taken in each plant community. Soils were identified to color and texture by the Soil Conservation Service (Lake Worth, Florida). Results are presented in Appendix I for sparse sawgrass, spikerush marsh, tall sawgrass and maiden-cane communities.

To better understand the relationship of changing elevation on community type, transects were established at 2-5 m intervals across plant community boundaries, especially tree islands. Elevations were taken on foot, using either water depth or a Dumpy Level; the

transects were between 20 and 100 m long. On these short transects water-levels were determined relative to the particular plant community rather than surveyed to absolute mean sea level.

Hydroperiod Calculations

In 1981, elevation and water-level measurements were taken in all communities. Water-level correlation equations (Probst and Rosendahl 1981) relating water depth measurements to gauge data were used for gauges P-33 and E-4 on the northern transect, P-33 and E-8 on the middle transect, and NP-204 and E-17 for the southern transect. Probst and Rosendahl (1981) found that water level data from the continuous stations in Shark Slough correlated very highly ($r=0.95$) with nearby staff gauges. Gauge locations are given in Fig. 2. Data were available for P-33 over the period 1953-1980, and for NP-204 from 1973 to 1980. Since E-17 and P-33 were far apart, the correlation coefficient was too low to be accepted for the calculation of hydroperiods in the southern transect. Thus the available data on the southern transect cover a shorter time period than those available for the middle and northern transects. Hydroperiods for the different plant communities were calculated from water levels at P-33 and NP-204 and elevations were measured for the plant communities. Water depths were calculated from water levels and ground elevation for years except for 1981, when water depths were measured directly.

RESULTS

Overview of Elevations, Hydroperiods and Soils

Within the marsh communities, elevation declined from about 1.5 m in the north transect to about 0.4 m along the south transect, a difference of 1.1 m (Table 2). The difference in elevation across the three transects was remarkably similar, about 0.26 m, (range= 0.19-0.33) from the highest point in the tall sawgrass marshes to the low point in spikerush marsh. Such a small difference underscores the significance of subtle topographic variations in influencing plant community development. As Table 2 indicates, the elevation differences, though small, have hydrological consequences as seen in associated hydroperiod and water depths. The relative hydrological differences are maintained across the range of annual precipitation experienced in the Everglades. In Figure 3, the elevation differences in three marsh community types are superimposed on water level data for years with dry, wet and average rainfall. The extent of inundation clearly depends on elevation.

As indicated in Fig. 3, elevation varies within each community by about 0.2-0.6 ft (5 to 20 cm) with the greatest range in bayheads and hammocks.

Fig. 3 (next page). Elevation of Shark Slough plant communities along three transects superimposed on water levels during a wet (1969-70), average (1977-78) and dry year (1964-65).

Table 1. Everglades vegetation classification categories reported in the literature.

Present Study	Harshberger 1914	Harper 1927	Davis 1943	Egler 1952	Loveless 1959	Kolipinski Higer 1978	Craighead 1971	McPherson 1973	Hofmeister Hilsenbeck Alexander 1979
Sparse-intermediate sawgrass	freshwater marsh formation	sawgrass marshes	sawgrass marsh	sawgrass swamp	sawgrass marsh: <i>Cladium</i> <i>Sagittaria</i> <i>P. hemionum</i>	sawgrass marsh	sawgrass marsh		sawgrass marsh
Tall sawgrass	sawgrass swamp river marsh	sawgrass marshes	sawgrass marsh		sawgrass marsh: <i>Cladium</i> <i>Myrica</i> <i>Ilex</i>		sawgrass marsh	dense sawgrass	sawgrass marsh
Spikerush		wet prairie	spikerush associates		wet prairie- <i>Eleocharis</i> flat	wet prairie	spikerush marsh	wet prairie	spikerush flat
Maidencane marsh		wet prairie	maidencane associates		wet prairie maidencane <i>Rhynchospora</i> flat	wet prairie	spikerush marsh	wet prairie	maidencane flat
Typha marsh			cattail associates						cattail marsh
Tropical Hardwood Hammock	high hammock	tropical hammock		hammock	tree islands		tropical hardwood hammock	tree island	tropical hardwood hammock
Bayhead	low hammock Everglades hammock	low hammocks	bay tree forest	Pecora-tailed flat hammock	tree islands	tree islands	bayheads	tree island	cocoplum thicket
Bayhead swamp forest			bay tree forest		tree islands	tree islands			
Willowheads					willow communities	tree islands	willowheads	tree island	S.S. bayhead willow thicket
Pontederia/Sagittaria*									
Slough*					slough communities			slough with <i>Nymphaea</i> <i>Sagittaria</i> <i>Pontederia</i>	Pickereelweed slough water lily

*These two communities do exist in Shark Slough in small areas, but are not delineated on the vegetation map.

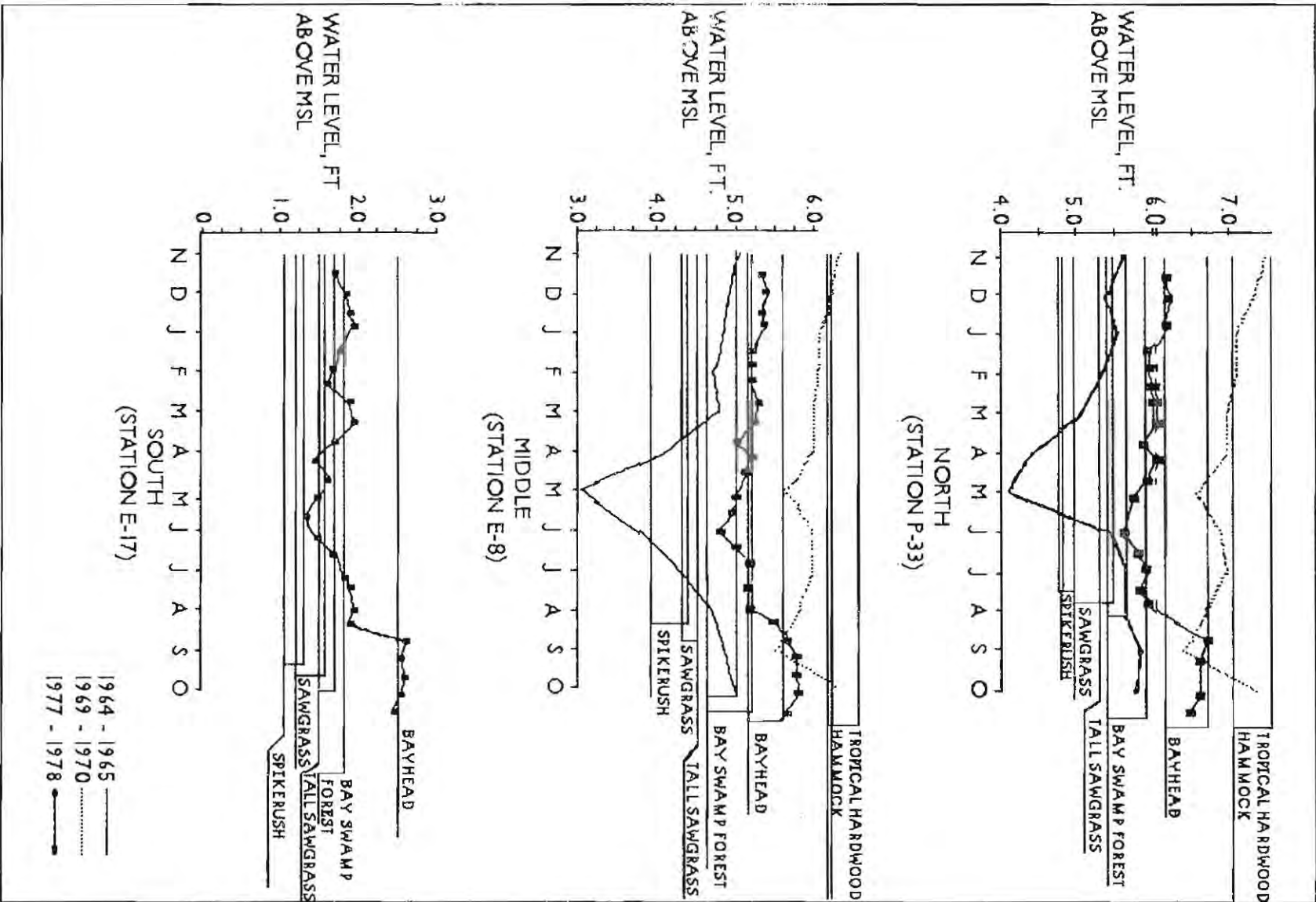


Table 2. Hydrological parameters in three community types found in the central portion of transects.

	North		Middle		South	
	Low Elevation	High Elevation	Low Elevation	High Elevation	Low Elevation	High Elevation
	5.0 ft	5.3 ft	4.3 ft	4.5 ft	1.2 ft	1.6 ft
	MSL	MSL	MSL	MSL	MSL	MSL
Sparse Sawgrass Marsh						
1977-78 Water levels (ft)	5.6-6.8	5.6-6.8	4.8-5.8	4.8-5.8	1.3-2.6	1.3-2.6
1977-78 Water depths (ft)	0.6-1.8	0.3-1.5	0.5-1.5	0.3-1.3	0.1-1.4	0-1.0
1977-78 Water depths (cm)	18-54	8.5-45	15-46	9-40	3-42	0-31
Highest record 1967-79 water depth (ft)	2.7	2.4	2.3	2.1	1.4	1.0
water depth (cm)	82	73	57	52	42	31
Hydroperiods (days/yr)						
1953-1980 mean	338	323	343	335	321	260
Range	242-366	183-366	262-366	228-365	261-365	188-365
	5.5 ft	5.6 ft	4.6 ft	5.0 ft	1.5 ft	1.7 ft
	MSL	MSL	MSL	MSL	MSL	MSL
Tall Sawgrass						
1977-78 Water levels (ft)	5.6-6.8	5.6-6.8	4.8-5.8	4.8-5.8	1.3-2.6	1.3-2.6
1977-78 Water depths (ft)	0.1-1.3	0-1.2	0.22-1.22	0-0.8	0-1.1	0-0.9
1977-78 Water depths (cm)	3-39	0-35	7-37	0-25	0-33	0-28
Highest record 1967-79 water depth (ft)	2.2	2.1	1.71	1.3	1.1	0.9
water depth (cm)	68	64	52	33	33	28
Hydroperiods (days/yr)						
1953-1980 mean	304	280	328	255	323	276
Range	136-366	106-365	208-366	0-365	194-365	160-365

The 1969-70 hydrological year was wet with protracted high water and hardwood hammocks along the north and middle transect, except in the highest portions, were inundated for over two months. In the the dry year of 1964-65, even the lowest elevation spikerush communities were free of surface water for about three months, and the sawgrass areas for about five months. Figure 3 also illustrates that hammocks in Shark Slough are found on outcrops extending above surrounding marshes by 0.45 m (1.5 ft) or more and that the two other forest types found in Shark Slough tree islands, bayhead and bay swamp forest, are clearly found at lower elevations than hammocks.

Interannual rainfall patterns, along with water management practices, have led to marked shifts in the annual durations of soil surface flooding. Sawgrass marshes in central Shark Slough were continuously inundated for periods of two or more years three times within the 1953 to 1980 period (Fig. 4). During dry years, however, there have been dry ground surfaces for three or more months.

Fig. 4. Number of days per year from 1953 to 1980 that the soil surface in sawgrass marshes of central Shark Slough were free of surface water.

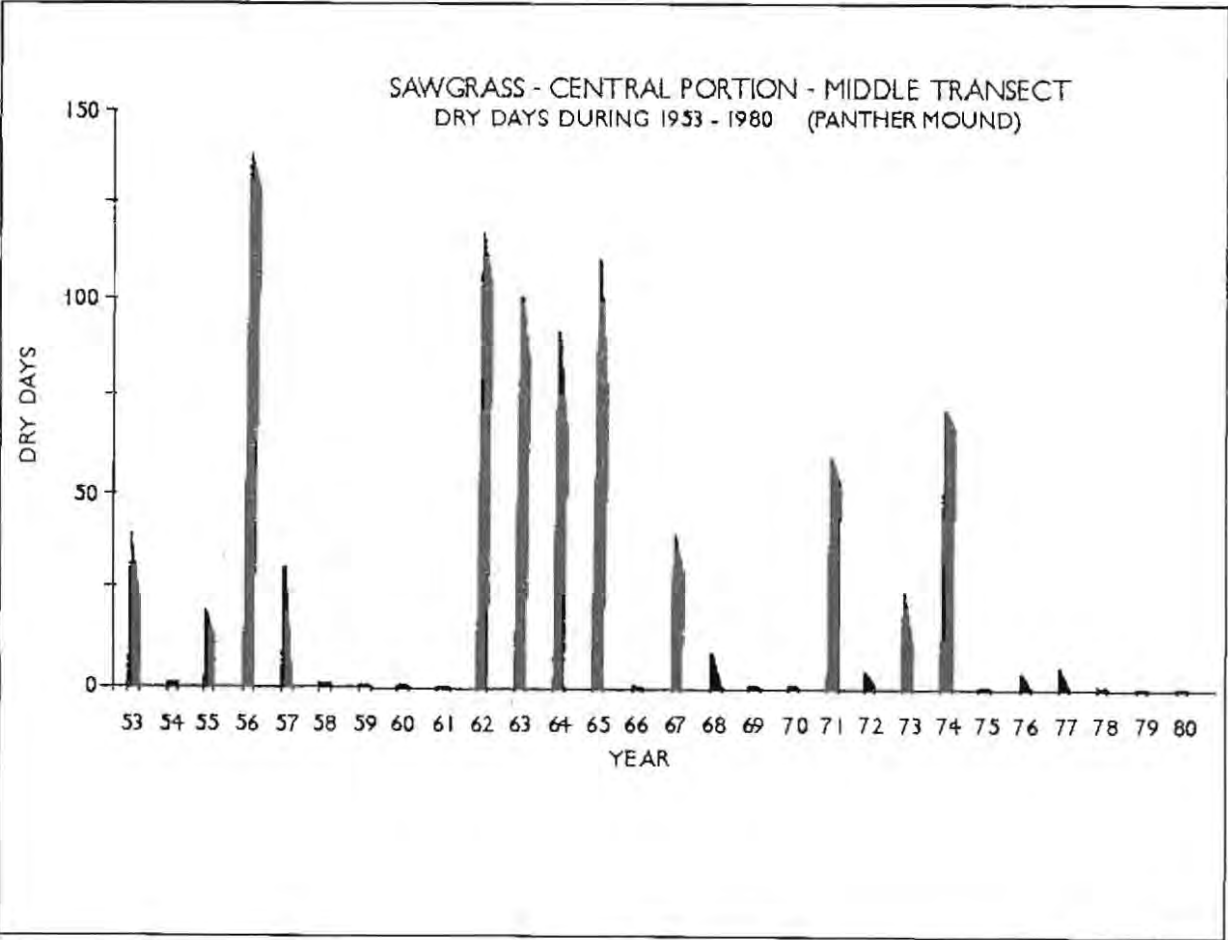


Table 2. Continued

	North		Middle		South	
	Low	High	Low	High	Low	High
	Elevation	Elevation	Elevation	Elevation	Elevation	Elevation
	4.8 ft	5.0 ft	3.9 ft	4.4 ft	1.1 ft	1.3 ft
	MSL	MSL	MSL	MSL	MSL	MSL
Spikerush Marsh						
1977-78 Water levels (ft)	5.6-6.8	5.6-6.8	4.8-5.8	4.8-5.8	1.3-2.6	1.3-2.6
1977-78 Water depths (ft)	0.8-2.0	0.6-1.8	0.93-1.93	0.4-1.4	0.3-1.5	0.04-1.3
1977-78 Water depths (cm)	24-61	18-54	29-59	13-43	8-47	1-40
Highest record 1967-79						
water depth (ft)	2.9	2.7	2.4	1.9	1.5	1.3
water depth (cm)	90	83	74	58	47	40
Hydroperiods (days/yr)						
1953-80 mean	344	338	352	335	331	315
Range	265-366	241-366	293-366	143-366	287-365	242-365

Northern transect. The 6 km wide northern transect was coincident with the area sampled by Rose and Rosendahl (1979). These workers found that soil surface elevations varied less than 0.3 m in the marshes, but that the bedrock was highly dissected, indicating that soil depths fluctuated widely. A slight elevation gradient from tall sawgrass to the open marsh was observed. The highly variable surface and sub-surface elevations are characteristic of the general Shark Slough area sampled in this study.

Middle transect. The lowest point along the 10 km long middle transect was only 25 cm below the highest point on the west end although surface elevation rises steeply with increasing distance from the Slough itself (Fig. 5). Overall, like along the northern transect, the relatively level soil surfaces contrasted with the dissected limestone substrate. The surface of the limestone substrate underlying the soils of the middle transect forms a trough differing by 1.2 m between the highest and the lowest point across the trough.

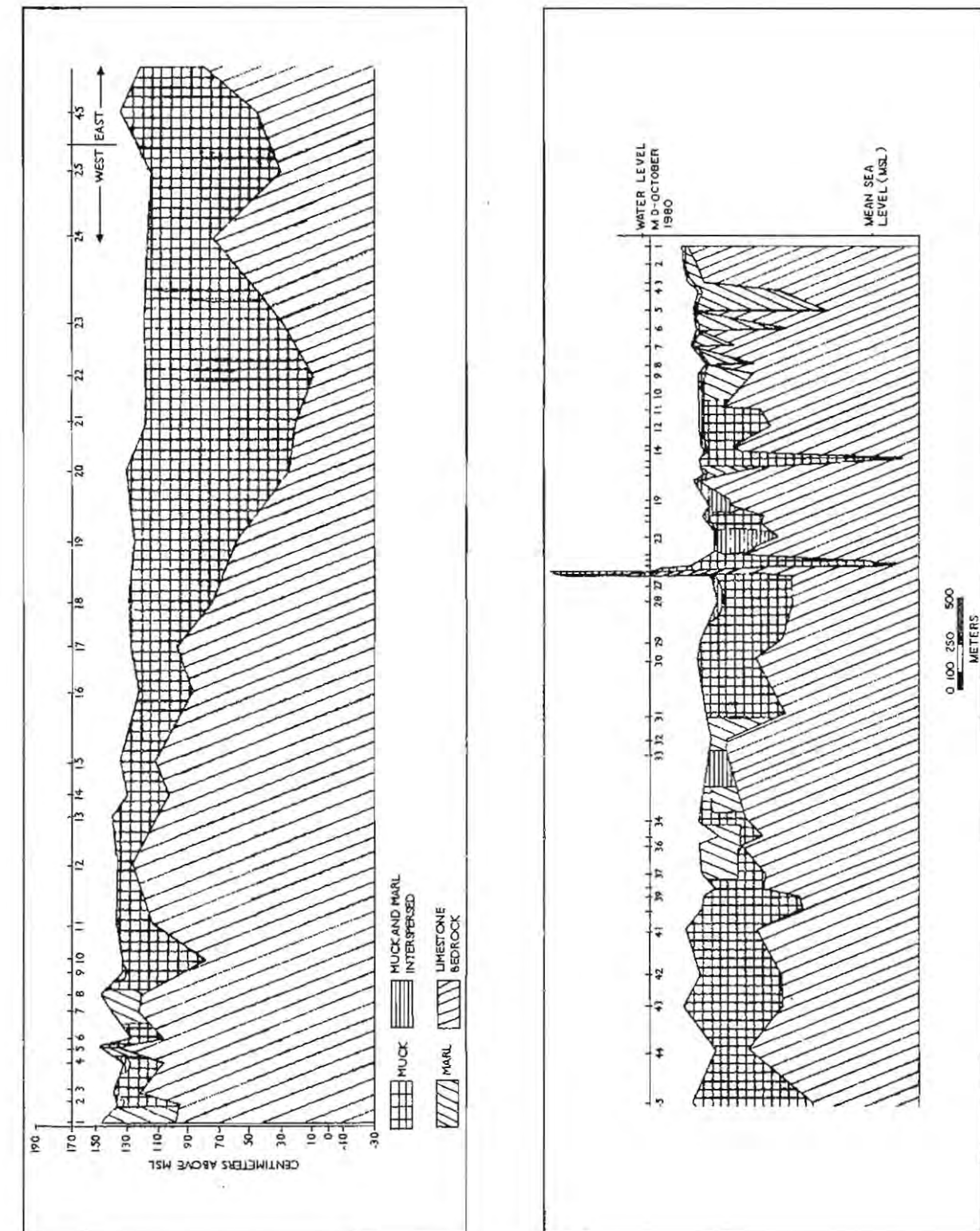
The major soil type in the slough is muck, but towards the sides of the trough, calcareous marl deposits increase in depth, replacing the muck (Fig. 5). Towards the east portion of the central slough, marl is sometimes found beneath large areas of open marsh despite hydroperiods apparently long enough to promote peat formation. In many surface samples of the middle transect, a mixture of muck and marl occurred.

Southern transect. The transect was located just north of the estuarine zone and extended 12 km reflecting the greater width of the Slough here than at the level of the middle transect. Again, the relatively level soil surface and dissected bedrock contrast (Fig. 6). The central portion of the southern transect was between 80 and 100 cm lower than the marsh near Panther Mound in the central portion of the middle transect. The lowest points of bedrock along the southern transect are below mean sea level. The soil patterns in the Slough are influenced by the location of the transects relative to the configuration of the Slough. Thus the soil depths in the eastern portion of the southern transect exceed those of the middle transect because the main channel of the Slough swings westward at the level of the southern transect. In addition, limestone outcrops characterize the easternmost 2 km of the middle transect, reducing soil accumulation. The easterly portion of the southern transect also passes across a shallow basin towards the Watson, Lane, and North River estuaries to the south. In contrast, the western side of the southern transect rises more towards the side of the trough and is covered more by marl.

General Vegetation Patterns

Shark Slough vegetation is distinctive and clearly different from any other plant community in North America and perhaps the world. Even though the total area of sawgrass marsh is large, the apparent uniformity is interrupted by hundreds of tree islands and over large areas masks a mosaic of marsh communities differing in dominant species and aspect. Although over large tracts periphyton dominates the ground (or water) surface, often mantling the stems and leaves of the macrophytes, its importance is not well represented in this report. The floating periphyton mats usually envelop and combine with well developed *Utricularia* (usually *U. foliosa* and *U. purpurea*) thalli and other hydrophytes to the extent

Fig. 5 (next page). Elevation, soils, and bedrock surface along the middle transect of Shark Slough, from west (top) to east (bottom). The numbers along the top indicate the locations of transect sampling poles.



that the floating complex dominates the visual aspect of extensive marsh areas.

As noted, the three mapped transects are 6, 10, and 12 km wide from east to west and about 2 km from north to south. Each transect delineates 11 community types: four tree communities, four graminoid communities, two mixed-dominance graminoid communities (spikerush/sawgrass and spikerush/maidencane), and one tree/graminoid mixture (tall sawgrass/bayhead species).

The total area mapped amounts to 5,873 ha, almost 10 percent of the Slough as defined by Kushlan et al. (1975). Appendix II includes all species encountered including those found outside of transects.

The three transects cross the same community types but the relative importance of each community differs with transect (Table 3). For example, tropical hardwood hammocks are abundant along the northern and middle transects but hardly present on the southern transect. Elongate, high-bedrock bayheads are abundant on the southern portion of the southern transect, but more typical circular peat-based bayheads occur in the rest of the slough.

Because the northern transect is relatively short, it excludes sparse sawgrass marsh found further east and west of the central slough. The longer middle and southern transects, however, do incorporate significant areas of sparse sawgrass.

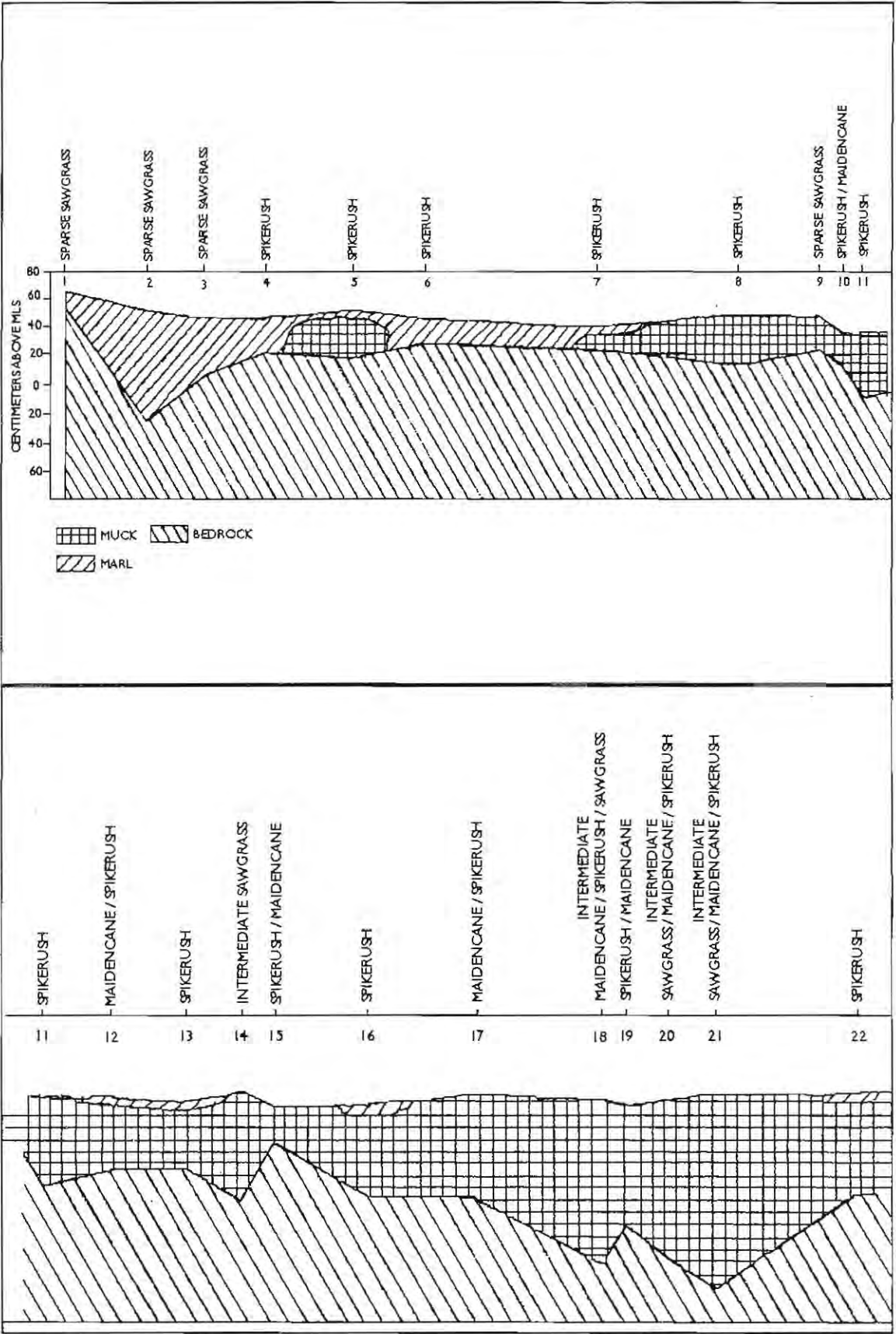
The ratio of sawgrass marsh to spikerush marsh varied from transect to transect. A large area on the west side of the southern transect was comprised of solid "sparse sawgrass marsh" as on the southeastern side. The distribution of sawgrass and spikerush marsh on the east and west side of the middle transect and along the entire northern transect was more patchy for the two communities. The largest percentage of spikerush/maidencane and the spikerush/sawgrass mosaic was encountered in the northern transect, probably because this

Table 3. Distribution of community types along mapped transects.*

	Percent of Transect Area		
	North %	Middle %	South %
Sawgrass	39	43	52
Spikerush	16	7	7
Spikerush/Maidencane	2	15	3
Spikerush/Sawgrass	19	11	13
Tall Sawgrass	13	15	11
Tall Sawgrass with Trees	4	5	9
Bayhead	2	2	3
Bayhead Swamp Forest	3	2	0.1
Willowheads	0.1	0.09	0.2
Tropical Hardwood Hammock	0.08	0.04	-

*Total Slough area equals 142,479 acres (57,725ha).

Fig. 6(next pages). A profile of soils, elevation and plant community type across the southern transect in Shark Slough from the west (top diagram), through the central and eastern segments (continuation page). The numbers across the upper horizontal line are transect pole locations, increasing in number from west to east. Segment lengths are 4.8km, 1.9km and 4.2km, west to east.



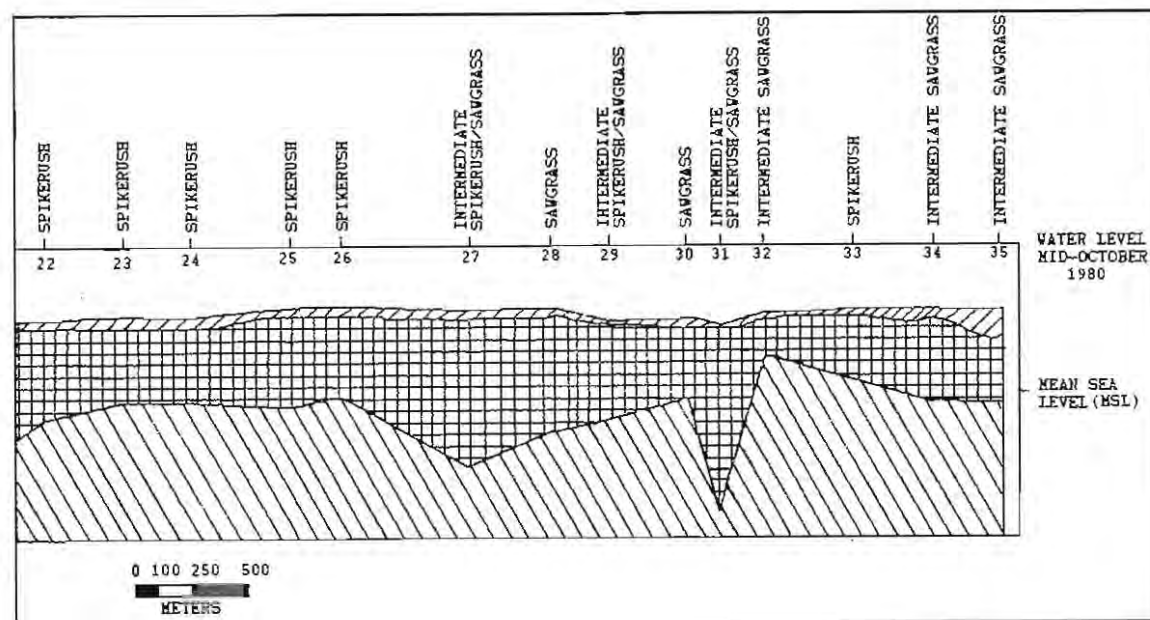


Fig. 6. (cont.). Eastern segment, southern transect.

area had the largest body of deep water (Table 3). The percentage cover of tall sawgrass and of tree islands was similar on all transects.

Marsh Communities

The sedge *Cladium jamaicense* was the dominant species in the sawgrass communities. Its biology has been described by Alexander (1971), Steward and Ornes (1975, 1983), Davis (1991), Herndon *et al.* (1991) and others. In this report, sawgrass communities were classified into sparse sawgrass community with sparse cover and heights up to 2 m, and tall sawgrass with dense cover and heights in excess of 2 m. In many areas, the distribution of

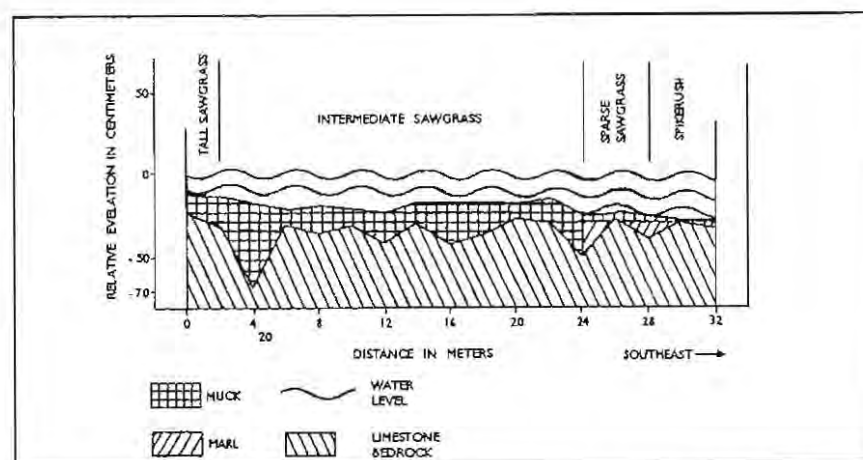


Fig. 7. Soils, relative elevation and prevalent vegetation across 32 m of Shark Slough near the middle transect from west (left) to east.

sawgrass density and heights suggests the possibility of defining an intermediate category as has been suggested by some authors but in this study, such a distinction could be made in only a few sites. The relative elevations associated with the three sawgrass types is generally consistent with Figs. 6 and 7.

Sparse sawgrass

The sparse sawgrass community was the most extensive in the Slough. In spite of its apparent uniformity in aspect, the sparse sawgrass community varied greatly in percent cover, height, soil type, periphyton, and associated macrophyte species. Most typically, the sparse sawgrass community included extensive, very sparse marshes over marl with low cover (usually well under 50%, sometimes as low as 10%) in which the sawgrass was shorter than 1 m. Denser stands also occur on muck in the center of the Slough with 50% cover and heights up to 2 m.

The extensive sparse sawgrass marshes found toward the sides of the Slough, usually over marl, were lowest in species diversity and plant cover. While sawgrass was associated with *Rhynchospora tracyi*, on the west and east borders of the transects, this species became less common towards the center, where aquatic species became more abundant. *Pontederia cordata* and *Peltandra virginica* are common associates here. The common spikerush, *Eleocharis cellulosa*, was the most constant associate in the sawgrass marshes. *Utricularia* species were present in all but the densest marshes. The forbs, *Justicia angusta*, *Crinum americanum*, and *Bacopa caroliniana*, as well as grasses of the genera *Panicum* (e.g. *P. hemitomon* and *P. tenerum*) and *Paspalidium geminatum* also occurred here.

The elevation of sparse sawgrass marshes was usually 10-15 cm higher than the adjacent spikerush/maidencane marsh and 10-15 cm lower than the sawgrass strand. In some instances, pure maidencane (*P. hemitomon*) occupied areas between spikerush and tall sawgrass. The sawgrass communities found on muck has conspicuously greater cover, density, and height than do those found on marl. Periphyton was characteristic of nearly all sawgrass marshes mantling the soil and water surface and many plant stems. Only in the densest marsh is the algal mat absent. In the sparse sawgrass community, the average macrophyte plant cover ranged from 11% on the southern transect to 16% on the middle transect.

In the sparse sawgrass community, the average macrophyte plant cover ranged from 11% on the southern transect to 16% on the middle transect. Sawgrass frequency was 100% throughout the community. Spikerush frequencies were high but frequencies of other species were low (Table 4). The sparse marshes were more extensive than intermediate sawgrass stands which most often skirted tall sawgrass strands and were narrow in extent. About 90% of the plant cover was sawgrass. Other species contributed little cover. Spikerush contributed more than a trace in only a few instances, as did *Rhynchospora tracyi*, *Pontederia cordata*, and *Bacopa caroliniana*.

The total number of species encountered in the sample plots in all transects was 17; the average number of species per m² was between four and six, and the number per transect varied from 10 to 15. Mean sawgrass height varied from 130 cm on the middle transect to 145 cm in the northern transect with small standard deviations in both cases.

The soil depths beneath sparse sawgrass ranged from an average of 34 cm on the middle transect to an average of 69 cm along the southern transect (Table 5).

Table 4. Cover and frequency of occurrence by species in sparse sawgrass community. Data summarized by transect.*

Species	Mean % cover			Frequency (%)		
	N	M	S	N	M	S
<i>Cladium jamaicense</i>	10.75±13.5	15.44±9.9	9.26±10	100	100	10
<i>Eleocharis cellulosa</i>	2.15±.98	0.44	0.93	100	68	97
<i>Panicum hemitomon</i>	0.04	-	0.27	55	4	33
<i>P. tenerum</i>	T	-	T	4	-	3
<i>Paspalidium geminatum</i>	T	-	T	20	-	3
<i>Rhynchospora microcarpa</i>	-	T	T	-	12	3
<i>R. tracyi</i>	-	0.16	T	-	-	40
<i>Aeschenomene pratensis</i>	T	-	-	10	-	-
<i>Aster tenuifolius</i>	-	-	T	-	-	3
<i>Bacopa caroliniana</i>	T	-	0.93	30	-	43
<i>Crinum americanum</i>	0.12	-	T	35	-	7
<i>Justicia angusta</i>	T	T	T	10	24	7
<i>Agalinis harperi</i>	-	T	T	-	-	3
<i>Pluchea rosea</i>	-	-	T	-	-	10
<i>Pontederia cordata</i>	T	0.16	-	5	16	-
<i>Sagittaria lancifolia</i>	-	-	T	-	-	7
<i>Utricularia biflora</i>	-	T	T	-	4	7
Community						
Mean Plant Cover (%)	13.1	16.2	11.4			
Total # Species	10	8	15			
Mean # Species/m ²	5.6	4.2	5.7			
Mean height (cm)	145	130	135			
sawgrass						

Table Footnotes: T = Trace; -=absence* N = North, M = Middle, S = South

Water depths for sawgrass communities varied over the year from north to south. Measurements made between December 1980 and February 1981 varied from 31 to 38 cm. Water depths calculated for the period 1967 to 1979, varied from 82 cm above the soil surface during wet months to unspecified levels below surface during the dry months. Water levels exceeded 1 m only for short and infrequent periods. More often, the water depths in this community fell to within 20 and 50 cm during the wet season. The emergent portion of sawgrass generally rose 70-100 cm above the water surface. Between 1953 and 1980, the mean hydroperiod was 330 days (range 183-366) along the northern transect and 339 days on average (range 295-365) along the middle transect. On the southern transect, the mean was 290 days (range 188-365) over the period 1973 to 1980 (Table 2). Hydroperiods varied more towards the sides of the Slough. On the middle and southern transects, drier conditions occurred on the west side of the slough sooner than on the eastern portion because of the steeper ground-surface slope.

Where soil was especially shallow, rock outcrops and deep solution holes on the middle transect produced patches of sawgrass between unvegetated areas and rock outcrops. On

the southeast portion of the southern transect, the soil was deeper, and sawgrass more evenly distributed.

Tall sawgrass

In addition to the distinctively shaped tree islands, elongate strands of tall sawgrass form characteristic landscape features of Shark Slough. Sawgrass strands occur where there is very little other plant cover and in the tails of tree islands. Tall sawgrass often surrounds bayhead swamp forest and other tree islands. Tall sawgrass strands are conspicuous by virtue of their great height and density. Heights reach at least 2 m above the soil surface and may reach 3 m. Stands are very dense; consequently they often burn in the summer even in water depths reaching 50 cm. Falling between bayheads and intermediate sawgrass in elevation and hydroperiod, tall sawgrass communities contain species of both adjacent communities. Thus its species richness exceeds that of other marsh communities.

Sawgrass frequency reached 100% within the community, far greater than any other species (Table 6). In contrast to the sparse sawgrass community, sawgrass cover approached almost 100% on all transects. Secondary species occurring in at least 10% of the quadrats along the three transects were spikerush, *Blechnum serrulatum*, *Bacopa caroliniana* and *Justicia angusta*. More than in any other community, tall sawgrass was most constant in cover, with a low standard deviation. Even in this community, spikerush was a frequent

Table 5. Site analysis by community. Summary for three transects. Water and soil depths recorded in plots at time of vegetation sampling.

	Tall Sawgrass	Sparse Sawgrass	Maidencane	Spikerush
NORTH				
Average Soil Depth (cm)	48 ± 12	53 ± 21	41 ± 18	30 ± 9
Average Water Depth (cm)	24 ± 8	31 ± 4.6	40 ± 3.6	43 ± 2.8
Average Plant Cover (%)	96 ± 8.6	13 ± 13	6 ± 2.5	6 ± 3.6
Average Open (%)	4	87	94	95
Total # Species	14	10	8	11
Average # Species/m ²	6	5.6	4.5	4
MIDDLE				
Average Soil Depth (cm)	79 +50	34 ± 26	60 ± 26.4	34.2 ± 19
Average Water Depth (cm)	23.6 ± 6	33 ± 7.5	43.9 ± 6.9	42.4 ± 11.4
Average Plant Cover (%)	96 ± 10	16 ± 10	3.5 ± 1.8	2.3 ± .85
Average Open (%)	4	84	96.3	97.6
Total # Species	14	11	11	12
Average # Species/m ²	5	4.2	5.5	4.6
SOUTH				
Average Soil Depth (cm)	82.7 ± 44	69 ± 13	64.4 ± 40.3	48.6 ± 23
Average Water Depth (cm)	26 ± 8	38 ± 8.3	51.5 ± 6	38.3 ± 4.7
Average Plant Cover (%)	96 ± 4.5	11 ± 10	7 ± 2.4	2 ± .9
Average Open (%)	4	89	93	98
Total # Species	13	15	6	6
Average # Species/m ²	4	5.7	5.4	2.8

associate, but much less so than in the sparse sawgrass community. A species not found in any quadrats but often encountered in ecotones between tall sawgrass and edges of small bayheads was *Polygonum hydropiperoides*.

Table 6. Plant cover and frequency of occurrence by species in the tall sawgrass community. Data summarized by transect.

Species	Mean % Cover/m ²			Frequency (%)		
	N	M	S	N	M	S
<i>Cladium jamaicense</i>	95.16 + 8.59	94.90 + 10	96.00	100	100	100
<i>Eleocharis cellulosa</i>	0.36	0.90	T	23	47	10
<i>Panicum hemitomon</i>	T	-	-	13	-	-
<i>Typha domingensis</i>	-	T	-	-	7	-
<i>Annona glabra</i>	T	-	T	3	-	3
<i>Cephalanthus occidentalis</i>	-	-	T	-	-	3
<i>Myrica cerifera</i>	-	T	-	-	3	-
<i>Persea borbonia</i>	T	T	-	3	3	-
<i>Blechnum serrulatum</i>	T	T	0.16	13	17	17
<i>Bacopa caroliniana</i>	0.20	T	T	30	17	13
<i>Eriocaulon compressum</i>	-	-	T	-	-	3
<i>Hymenocallis palmeri</i>	T	-	-	7	-	-
<i>Justicia angusta</i>	T	T	T	43	13	17
<i>Ipomoea sagittata</i>	T	-	T	10	0	3
<i>Ludwigia alata</i>	-	T	-	-	7	-
<i>L. microcarpa</i>	T	-	-	7	-	-
<i>Peltandra virginica</i>	T	0.20	T	10.0	13	6.7
<i>Pluchea rosea</i>	T	T	T	13	10.0	3
<i>Pontederia cordata</i>	T	R	R	7	17	23
<i>Sagittaria lancifolia</i>	-	T	T	-	3	3
<i>Utricularia biflora</i>	-	T	-	-	13	-
Community						
Mean Plant Cover (%)	95.7	96.0	96.2			
Total # Species	14	14	13			
Mean # Species/m ²	6	5	4			
Mean height (cm) sawgrass	212	225	242			

T = Trace

- = absence

* N = North, M = Middle, S = South

Soil depths varied between transects (Table 5), particularly going from the central portion along each transect of the Slough to the flanks. Since soil depths were averaged for all plots along one transect, regardless of position, they varied significantly. Even though in the

sample plots muck depth varied from 48 to 83 cm, the muck layer often exceeded 1 m deep elsewhere near Panther Mound.

Alligators often seek tall sawgrass strands to build nests; the decreased hydroperiod associated with relatively high elevation and availability of nest material may contribute to that choice. While soil surface elevations of the tall sawgrass stands exceed those of other marsh communities in most of the Slough, on the west and east sides of the Slough where water depths are shallower, tall sawgrass grows at lower elevations than the surrounding spikerush or sparse sawgrass. On the west side of the middle transect, tall sawgrass islands are located in bedrock troughs filled with muck and surrounded by marl soils supporting sparse sawgrass or spikerush. The marl sites often experience hydroperiods of 6 months, while the lower elevation tall sawgrass stands often are inundated for 8 months. This situation is common also in Taylor Slough (Olmsted *et al.* 1980) where extensive marl communities surround a narrow channel overlain with muck or peat that supports tall sawgrass.

Hydroperiods and water depths in the three main marsh community types over the period of record in the central portions of the three transects were shorter than for the other marsh community types, reflecting the relatively high elevation of the tall sawgrass (Table 2). The southern transect, especially the western side, shows the reverse. The highest water depths over the period of record (1967-1979) vary substantially among the three transects, with the greatest maximum depths along the northern transect and lowest along the southern transect.

The apparent successional relationship between tall sawgrass strands and bayhead swamp forest sometimes results in their interspersion. Also, tall sawgrass is often succeeded by willow or by *Typha* when fires burn the organic soil and destroy the sawgrass rhizomes. Then sawgrass may gradually replace these species by rhizomatous ingrowth from surrounding areas.

Tall sawgrass with trees

The southern tails of tree islands, downstream of the bayhead swamp forest, often comprise a mixture of sawgrass and woody species, with tall sawgrass dominant. When a fire burns through such a stand, the established species generally persist, the sawgrass from rhizomes and regrowth of burned culms, and the trees and shrubs as sprouts from stem bases. Specific dynamics of the tall sawgrass-swamp forest relationship, however, have not been adequately studied. The tree species in this community type are the same as those found in the tall sawgrass community (Table 6), although they are more abundant here. Pond apple (*Annona glabra*) and buttonbush (*Cephalanthus occidentalis*) sometimes are the commonest woody species.

The elevations, soil depths and hydroperiods of tall sawgrass strands, similar to that of bayhead swamp forest, seems to be conducive to tree establishment. The two community types often intermingle, usually over small areas. The trees have open crowns and often are interspersed among thick stands of swamp fern (*Blechnum serrulatum*), occasional *Typha*, and varying concentrations of the aquatic plants *Peltandra virginica*, *Pontederia cordata*, and *Sagittaria lancifolia*. These associations may represent incipient bayheads or degraded willowheads.

Typha islands

This is one of the least understood unit mapped. The species present in ENP is regarded as *T. domingensis*. It appears to be successional to sawgrass after fire in some places. In some areas of the southern Big Cypress National Preserve, *Typha* became established in areas where sawgrass was burned out (Hofstetter and Alexander, 1979). Recruitment from surrounding sawgrass rhizomes occurred after several years. The status of *Typha* in Shark Slough in 1980 was not well understood. Some dying *Typha* had been observed along the northern transect. Tilmant (1975) recognized *Typha* marsh as a small component of his study site mosaic in Shark Slough. *Typha* was found mostly on deeper soils than was tall sawgrass. Invasion of sawgrass marshes by scattered *Typha* near Rookery Branch in lower Shark Slough also has been observed.

Spikerush marsh

In Shark Slough, the spikerush marsh was the second most extensive community after sparse sawgrass. Generally, this community occurs at lower elevations than other marsh communities. The dominant species is the sedge *Eleocharis cellulosa* (spikerush), with a scattering of other grasses and sedges, particularly species of the genera *Panicum* and *Rhynchospora*. Aquatic plants like *Peltandra virginica*, *Sagittaria lancifolia*, *Bacopa caroliniana* and species of *Utricularia* are also found here. The substrate can be either muck or marl.

With an average macrophyte cover of 2.8% (range 1.6-4.6%), this community had the lowest plant cover of any association analyzed (Table 7). The low cover favors the abundant growth of periphyton. The average number of species was low, between 2.8 and 4.6/m², with a total of 12 per transect. species. *Eleocharis* was the dominant species with a 100% frequency and a cover of 1.5-3.9%, while *Panicum hemitomom* and *Sagittaria lancifolia* follow with less than 1% cover and variable frequencies on the transects (Table 7). In the open marsh of sawgrass and spikerush, the most common vascular plants are various submerged species of *Utricularia*. The importance of these species was underestimated by our data, however, because cover or frequency was considered only if the emergent flower stalks were present. The white water lily, *Nymphaea odorata*, an indicator species of deep water sloughs (McPherson, 1973) is a scattered member of this community. In contrast, this water lily dominates large areas of the slough community of Conservation Area 3A north of Shark Slough and appears to have supplanted spikerush marshes in the southern portion of that water storage basin.

Average marl and muck soil depths of the spikerush community varied from 30 cm to 49 cm with rather large standard deviations. Water depths in the spikerush marsh at the time of sampling (38-43 cm) and for previous years were the greatest of all communities as expected from the elevation surveys (Tables 2 and 5). The shallowest water depths in the spikerush marsh were found in the southern transect. The spikerush marsh community was found in areas with the longest hydroperiods in Shark Slough (Table 2). Mean annual hydroperiods for the period of record varied from 315 to 352 days. However, the ranges varied from 241 to 366 days in the northern transect and 143 to 365 days in the middle transect.

Maidencane-spikerush marsh

This community type, distinctive because of the importance of maidencane, always occurs adjacent to spikerush marsh. Though it differs in aspect from spikerush marsh, this community had only lightly higher species richness (4.5-5.5/ m²; Table 8).

Table 7. Plant cover and frequency of occurrence by species in spikerush marsh. Data summarized by transect.*

Species	Mean % cover / 1m ²			Frequency (m ²)		
	N	M	S	N	M	S
<i>Eleocharis cellulosa</i>	3.90 ± 1.55	1.88 ± .86	1.5 ± .97	100	100	100
<i>Rhynchospora microcarpa</i>	T	-	-	4	-	-
<i>R. tracyi</i>	T	T	T	16	44	57
<i>Panicum hemitomom</i>	0.20	0.12	T	48	24	7
<i>P. tenerum</i>	T	T	-	-	4	-
<i>Paspalidium geminatum</i>	T	T	T	28	20	20
<i>Justicia angusta</i>	-	T	-	-	4	-
<i>Bacopa caroliniana</i>	T	-	T	28	-	10
<i>Nymphaea odorata</i>	0.40	-	-	8	-	-
<i>Oxypolis filiformis</i>	T	-	-	8	-	-
<i>Peltandra virginica</i>	T	-	-	12	-	-
<i>Sagittaria lancifolia</i>	0.12	0.28	0.13	12	48	43
<i>Utricularia biflora</i>	-	T	-	-	4	-
<i>U. purpurea</i>	T	T	-	4	8	-
<i>U. resupinata</i>	-	T	-	-	4	-
<i>U. cornuta</i>	-	T	-	-	4	-
Community						
Mean total plant cover	4.6 ± 3.6	2.3 ± .85	1.6 ± .9			
Mean # species/m ²	4.0	4.6	2.8			
Total # species	12	11	6			
Mean plant height cm (spikerush)	76	75	70			

T = Trace

- = absence

* N = North, M = Middle, S = South

On infrared photographs, maidencane-spikerush stands were not as easily recognized as the spikerush community and therefore, the area of maidencane community could be somewhat underestimated.

The cover of this unit (3.5-6.5%) was slightly higher than for spikerush. Maidencane and spikerush occurred in all plots. *Paspalidium geminatum* is more frequent in this community than in the spikerush marsh. Maidencane cover was highest along the middle and southern transect, and spikerush is dominant on the northern transect.

Table. 8 Plant cover and frequency of occurrence by species in maidencane-spikerush community.

Species	Mean % cover/1m ²			Frequency %		
	N	M	S	N	M	S
<i>Cladium jamaicense</i>	-	0.50	-	-	25	-
<i>Eleocharis cellulosa</i>	3.50 + 2.3	.80 + .5	2.00 + .7	100	100	100
<i>Panicum hemitomon</i>	2.56 + 1.8	1.47 + 1.17	3.40 + 1.8	100	100	100
<i>Paspalidium geminatum</i>	0.23	T	0.28	50	15	58
<i>Rhynchospora microcarpa</i>	-	T-3--	-	-	-	-
<i>R. tracyi</i>	-	T	0.16	-	10	28
<i>Bacopa caroliniana</i>	T	0.15	0.28	30	35	32
<i>Crinum americanum</i>	T	-	-	3	-	-
<i>Justicia angusta</i>	-	T	-	-	5	-
<i>Nymphaea odorata</i>	-	0.60	-	-	5	-
<i>Peltandra virginica</i>	T	-	-	3	-	-
<i>Sagittaria lancifolia</i>	T	T	0.28	30	45	40
<i>Utricularia biflora</i>	-	T	-	-	10	-
<i>U. purpurea</i>	-	T	-	-	10	-
<i>U. radiata</i>	-	-	.2	-	-	28
Community						
Mean plant cover (%)	6.3	3.5	6.5			
Mean # species/m ²	4.5	5.5	5.4			
Total # species	8	11	6			
Mean plant height cm (maidencane)	97	94	92			

T = Trace

- = absence

* N = North, M = Middle, S = South

Soil depth varied more between transects than within them. In Shark Slough, maidencane communities occur on peat or muck but not on marl. The soils under maidencane in the sampling sites averaged 16 cm deeper than under spikerush (Table 5). The latter seems to be the most obvious difference observed between the two mapped units. In areas bordering tall sawgrass, maidencane grows densely, to the exclusion of other species. This pattern is not reflected in the sampling data because plots fell in areas of sparse maidencane growth adjacent to spikerush growth.

Spikerush-sawgrass mosaic

Delineation of this type is appropriate where sawgrass islands occurring within spikerush marsh or spikerush marshes within sparse sawgrass are frequent at a scale too small to distinguish separate communities. The ecotones between these two communities are often indistinct. On the ground sawgrass appears to be invading the spikerush marsh in many areas that cannot be recognized from the infrared photographs. These two communities are successional related through fire and other disturbance. Spikerush becomes established in areas where the root system of sawgrass has been burned (Craighead

1971) or in areas where sawgrass has been damaged by airboats. The transition from sawgrass to spikerush is very abrupt in areas where fires have burned. How long it takes without disturbance for sawgrass to reinvade these marshes by rhizomes from the adjoining sawgrass marsh is unknown but certainly is much slower than the establishment of spikerush in burned sawgrass marsh.

Northwest Shark Slough Marshes

The northwestern flank of Shark Slough, on either side of Shark Valley Road, is higher in elevation than the rest of the Slough. The soil here is shallower than elsewhere in the Slough and is not a true marl, but rather a transitional deposit between marl and a poorly drained Rockdale fine sandy loam. The marsh communities here are distinct, partially because they have been slightly disturbed by the construction of the road. However, the shallower soils and higher elevations also create differing ecological conditions. Many of the tree islands here, for example, are principally hammocks, rather than bayheads as they are in most of Shark Slough tree islands. The bayheads that are present sometimes are surrounded by cypress. Cypress forms a few solid stands and is also scattered in the marsh, the only place in Shark Slough where cypress communities occur.

The marsh or prairie communities of northwest Shark Slough differ from those further south in hydroperiod and soil type as well as in species composition. The sparse sawgrass marshes are interspersed with prairie and include *Rhynchospora tracyi*, *Oxypolis filiformis*, and *Pluchea rosea* (Table 9). Unlike elsewhere in the Slough, there was no surface water during sampling. Thus both in terms of forested and marsh communities, these northern sites bear considerable similarity to the communities of the higher elevation Northeast Shark Slough and Rocky Glades to the east and southeast (Olmsted et al. 1980).

Total vascular cover for this community averaged 6%, more like a spikerush marsh than a sawgrass marsh. The frequency of grasses, sedges, and forbs was high in this community (Table 9). In sawgrass and spikerush marshes further south, usually just two species are frequent, and the forbs seldom reach 30% frequency. *Justicia angusta* was as often encountered here as was sawgrass. Aquatic plants such as *Sagittaria* and *Pontederia* were absent; two terrestrial *Utricularia* species were present, but none of the floating ones. Another distinctive feature of these communities is the presence of *Myrica cerifera* in one-third of the plots. The species was absent from the three southern transects.

Tree Island Vegetation

Tree islands develop on slightly elevated limestone outcrops or in bedrock depressions within the marshes and are characteristic of Shark Slough. Four different tree-dominated community types are described, of which three (tropical hardwood hammock, willowhead, bayhead) were discussed by Davis (1943), Craighead (1971), and others. In the present treatment, bayheads are sub-divided into bayheads and bayhead swamp forest. The latter type has not been previously described before for Everglades National Park, but can be delineated based on species composition. The swamp forest type resembles the swamp forests of the Big Cypress National Preserve (Gunderson and Loope 1982). The community types are described below and the species encountered are given in Appendix II.

Table 9. Mixed marsh, Tram Road.

Species	Mean % Cover/m ²	Frequency %
<i>Cladium jamaicense</i>	5.23	87
<i>Panicum tenerum</i>	0.33	63
<i>Panicum hemitomon</i>	0.03	7
<i>P. virgatum</i>	T	3
<i>Eleocharis cellulosa</i>	0.64	87
<i>Rhynchospora tracyi</i>	0.30	67
<i>Myrica cerifera</i>	T	33
<i>Agalinis harperi</i>	T	16.7
<i>Justicia angusta</i>	0.04	80
<i>Oxypolis filiformis</i>	T	10
<i>Pluchea rosea</i>	0.07	20
<i>Utricularia resupinata</i>	T	37
<i>U. subulata</i>	T	37
Open	93.4	

Soil depth (cm) = 12 ± 7
Average water depth = 0
Average plant cover/m² = 5.7%
Total # species = 13
Average # species/m² = 9
Soil type = marl

Tropical hardwood hammock

The upstream portions of the largest tree islands in Shark Slough often have small areas of tropical hardwood hammock. The hammocks are found on bedrock highs rising as much as one meter above the surrounding sawgrass marsh (Fig. 3). Consequently, during most years, the hammocks are free of inundation but many if not all are flooded during wet years such as 1969. In most portions of Shark Slough, the vegetation immediately adjoining tropical hardwood hammocks on tree islands is usually bayhead swamp forest.

Since hammocks in the Slough are seldom more than 500 m² in area, the number of species in this tropical hardwood forest is rather low compared to other hammocks in the pinelands or the prairies of Everglades National Park (Olmsted et al. 1981). Because hammocks are the only dry places in the Slough during the rainy season, the Indians, and later, whites settlers, used them as camping places and cultivated crops there as well. In many hammocks, native trees have been cut and exotic species planted, however, all known use of the tree islands by man ceased by, or soon after, 1947 when ENP was established. Only by the presence of exotics is there any basis for concluding that the current tree composition differs from pre-disturbance conditions. Some planted species such as Key Lime (*Citrus aurantifolia*), sweet orange (*C. sinensis*) and guava (*Psidium guajava*) persist in some hammocks. Large trees of the exotic Brazilian pepper (*Schinus terebinthifolius*) are present on some tree islands as is the short-lived papaya (*Carica papaya*). Although the latter species may have been cultivated at one time it has now become naturalized and appears throughout upland areas of south Florida following disturbances of forest canopies.

The presence in a few Shark Slough hammocks of the native coastal species *Sapindus saponaria* and *Ximenia americana* suggests the influence of man but this has not been confirmed. The soil depth in the hammocks that were cultivated is comparatively deep (up to 40 cm), while soils are thinner in the northern hammocks (15 cm).

The major tree species of Shark Slough hammocks are *Bursera simaruba* (gumbo limbo), *Celtis laevigata* (hackberry), *Eugenia axillaris* (white stopper), *Sabal palmetto* (sabal palm), *Ficus aurea* (strangler fig) and *Mastichodendron foetidissimum* (mastic). As noted earlier, in the southernmost reaches of Shark Slough, hammocks are poorly developed in tree islands. On the southwest flanks of the Slough, however, within or near Big Cypress National Preserve, small elevated outcrops of limestone support local patches of hammock species within the bayhead-dominated portions of the tree islands. Here, large trees of *Lysiloma latisiliqua* and *Quercus laurifolia*, species absent elsewhere in the Slough, extend well above the surrounding bayheads, but other species more typical of the Slough are also often present.

Each of these species, except the *Eugenia* is capable of attaining large size and girth. The tallest trees in many hammocks reach heights of 10-14 m. However most if not all hammocks were badly damaged by Hurricane Andrew, the first hurricane capable of damaging Shark Slough hammocks in over thirty years. The eye of this Category 4 storm passed directly over Shark Slough in August 1992 (Armentano et al. 1995). But although damage to the crowns of canopy trees was sometimes severe in the hammocks, mortality was low (Jones et al. 1997). Typically, the understory of Shark Slough hammocks is sparse and reproduction of overstory trees is low, at least partially due to herbivory by deer. In wet years, deer and feral hog destruction of the understory may be severe if high waters limit animal movements for long periods (Jones et al. 1997).

In the northern portion of Shark Slough, on either side of the Tram Road, where the highest ground in the Slough is found, the tropical hardwood hammocks are distinctive. Topographic bedrock highs form plateaus that rise above the surrounding marsh prairie vegetation by about 2 ft (0.61 m). Hydroperiods are shorter than further south in the Slough and bayhead swamp forest is absent. These hammocks are more diverse in species than the hammock portions of more southerly tree islands and do not seem to have been farmed.

Bayheads

Most of the hundreds of tree islands that dot Shark Slough are bayheads. Compositionally Slough bayheads resemble those found elsewhere in ENP and in the water conservation areas to the north. A mature bayhead is a closed canopy forest consisting mainly of seven species. Five of these are temperate in distribution: red bay (*Persea borbonia*), sweet bay (*Magnolia virginiana*), dahoon holly (*Ilex cassine*), willow (*Salix caroliniana*), and wax myrtle (*Myrica cerifera*); cocoplum (*Chrysobalanus icaco*) and pondapple (*Annona glabra*) are tropical.

In Shark Slough, bayheads are often surrounded by tall sawgrass. Because of the very dense canopy cover, the ground layer is very sparse and consists mostly of swamp fern (*Blechnum serrulatum*) and leather fern (*Acrostichum danaeifolium*). Canopy height reaches an average 8-10 m.

Bayhead soils typically are mucks. Depths vary but in four bayheads probed in the southern and middle areas, depths fell between 15 and 100 cm deep. In addition, several

bayheads were reconnoitered on the west and east ends of the middle transect. Since the bedrock is slightly higher here than in the center of the Slough, the soil depths are shallower as well. Soil depths varied between 5 and 25 cm on the west side and 40 cm on the east side, near the E-26 gauge. The latter was on bedrock elevated above the general surroundings. Typically bayheads are found in a predictable position within the elevational sequence of Shark Slough ecosystems. Particularly in the northern and middle transect areas, the usual pattern consists of a gradual increase in elevation from spikerush marsh, to intermediate sawgrass, sometimes to tall sawgrass, and then to the bayheads. Additional community relationships based on data from some of the same Shark Slough areas are discussed in Olmsted and Loope (1984). The pattern is somewhat different on the east side of the southern transect. Here elongated bayheads are found on slightly higher bedrock and unlike bayheads in other areas in the Slough, are not surrounded by tall sawgrass. Here also bayheads often are dominated by *Chrysobalanus icaco*, the only tree species. These are probably the driest bayheads in the Slough with typical hydroperiods of only 2-3 months. In contrast, most bayheads in the middle and northern areas of the Slough, depending on where they are located relative to the topography of the Slough and whether they are on bedrock highs or on accumulated muck, are inundated from 2 to 6 months.

Bayhead swamp forest

This community is very similar in species composition and physiognomy to bayheads, but is not confined to relatively small circular stands as are most bayheads. Instead, the bayhead swamp forest usually comprises the elongate downstream portion of a tree island that has a tropical hardwood hammock at its northern end. The areal extent of bayhead swamp forest on a tree island usually far exceeds that of the bayheads and hammocks.

While the bayhead "proper" has a closed canopy and is, therefore, shaded in the understory, the bayhead swamp forest has a very open canopy. The understory has small islands of sawgrass or cattails (*Typha*) and a number of aquatic plants like *Utricularia* spp., *Sagittaria lancifolia*, *Pontederia cordata*, *Vallisneria americana* and *Bacopa caroliniana*. The soil is an organic muck sometimes exceeding 1 m in depth. The swamp forest is always found in bedrock depressions and has a hydroperiod of up to 10 month/year. If there have been no recent disturbances, tree heights decrease from upstream to downstream. Since frequency of lightning fires and prescribed fires in these areas is fairly high, however, one often finds a banding of differently aged swamp forest communities. These also vary in dominance and mixture of graminoids. Pondapple (*Annona glabra*) and buttonbush (*Cephalanthus occidentalis*) are frequent associates of the other typical bayhead tree species with *Annona* sometimes codominant with willow and cocoplum.

The elevation of the swamp forest varies and is sometimes the same as that of tall sawgrass, but is always lower than that of the hardwood hammock. Even in the absence of recent disturbance, the soil surface of the bay swamp forest is very uneven because of fallen logs, stumps, and soil accumulation around tree bases. The difference in height between the hammock trees and the shorter trees of the surrounding swamp forest is quite obvious and can be as much as 3-5 m.

Willowheads

Willows (*Salix caroliniana*), besides being common tree island species, also often form

monotypic stands in willowheads. Many willowheads are actually ponds that are surrounded by willows in bands of different widths. The ponds probably had their beginning in slight soil depressions which were deepened by the work of alligators. Willowheads are mostly surrounded by tall sawgrass strands which are on equal or even slightly higher elevation. Tall sawgrass and willows, both typically found on muck soils, are successional related communities. When fire consumes surface muck and thereby lowers the elevation in a tall sawgrass strand, willows often invade. The position of the ecotone between tall sawgrass and willowheads is relatively fluid. Willows are intolerant of shade and, therefore, mostly successional or maintained by fire (Robertson 1955, Craighead 1971). Aquatic species like *Sagittaria* and *Pontederia* are often associated with willowheads as is *Leersia hexandra*, the southern cut grass. *Pontederia cordata*, *Sagittaria lancifolia*, and *Peltandra virginica* stands are often found near willowheads on thick mucks.

DISCUSSION

A question of both scientific and resource management interest concerns whether the present vegetation of Shark Slough represents a significant departure from the natural pattern of the pre-drainage period. Unfortunately, pertinent information is quite limited, dating back no further than the 1940s. Earlier observations, although made by knowledgeable scientists, were at best semi-quantitative and limited by accessibility. With a few limited exceptions, noted below, previous observers left no field data or sampling locations that could be re-analyzed. In addition, although it can be assumed that hydrology exerts an important influence on wetlands vegetation, detecting plant community responses at specific locations can be obscured by hydropattern variability (Gunderson 1989). Another complicating factor operating at specific sites can be intercession of fires that destroy existing vegetation and even soils, altering local hydrological regimes. Particularly where the prevalent vegetation is herbaceous, detailed sampling at fixed sites over one or more time intervals is essential unless changes are so great as to be unambiguously detectable by aerial photography or more casual assessments.

It was not until the late 1950's, when major drainage canals in the Lake Okeechobee and northern Everglades region had been in place for some 30 years, that more detailed work appeared on the vegetation of Shark Slough, mainly north of ENP. These impounded water conservation areas, separated from the Park by the Tamiami Trail and associated canals and levees, once comprised major components of the greater pre-disturbance Shark Slough system. The systematic observations of Loveless (1959) and others make it clear that radical alteration of natural hydrology caused profound changes in the natural vegetation of the water conservation areas. McPherson (1973), Goodrick (1974), and Volk et al. (1974) reported further on the vegetation response to the protracted flooding in the water conservation areas already manifested prior to the time of the present study.

The landscape-scale changes in the water conservation areas have been profound and readily detectable at even a relatively coarse level of resolution (Alexander and Crook 1975, Davis et al. 1994, Rutchey and Vilchek 1994). Tree islands have changed character or disappeared, and sawgrass and spikerush marshes have declined over large areas. A vast

deep-water slough community of mostly aquatic plants exists today in the impounded areas, with *Nymphaea odorata* as a widespread dominant.

Comparison with Davis's Map

One of the few sources of earlier information on Everglades vegetation is the monograph and map produced by Davis (1943). The current vegetation of the water conservation areas represents a strong departure from the vegetation described by Davis (1943) who based his work on field work and on aerial photography of 1940. In contrast, departures from the patterns observed by Davis in Shark Slough south of Tamiami Trail are less obvious primarily because the changes have been less profound. Direct comparisons with Davis (1943) are problematic, however, because Davis's analyses were not quantified or documentable as to location. He assigned most or all of southern Shark Slough to the category "slough and tree islands areas". His map (Davis 1943) refers to the same area as "sloughs, ponds and lakes (with aquatic plants)", but included tree islands and sawgrass either as elongate extensions of the tree islands or separately as strands. The slightly higher east and west flanks of Shark Slough were described as southern marshes and wet prairies. The western and eastern ends of the middle and southern transects of the present study approach areas designated by Davis as southern marshes and wet prairie without actually extending into them. Note that Davis intended "wet prairie" to refer to marl areas dominated by mixtures of forb and graminoid species but with dominance by sparse sawgrass and spikerush and increasing admixtures of many other species associated with slightly higher elevations and sometimes on rock outcrops.

Inspection of 1940 aerial photography suggests that, at the coarse scale level of resolution, Shark Slough within ENP has remained essentially stable in its distribution of major plant communities. But the "slough" community, an indicator of long-term inundation by relatively deep water, may not have covered as large an area in 1940 as indicated by Davis's map for Shark Slough. Aerial photography of 1940, 1954, 1965, 1971, and 1973 reinforce the impression that deep-water slough areas covered smaller areas than suggested by Davis's map. Similarly, in 1980, unlike in adjacent water conservation areas, the slough community occupied only small areas in Shark Slough within ENP. Instead, at least some of the areas designated as slough on Davis's map appear to have been occupied by sawgrass in 1980 while spikerush and maidencane marshes occurred in the deepest areas instead of a slough community dominated by aquatic species.

That water lily sloughs may have prevailed over more extensive areas in earlier times is suggested by the predominance of Loxahatchee peat in Shark Slough (Cohen and Spackman 1974). A plausible explanation for the apparent discrepancy between the prevalence of Loxahatchee peat, known to be formed under essentially continuous deep inundation, and the relative scarcity in 1980 of the *Nymphaea* - dominated aquatic communities that produce Loxahatchee peat, is that by the 1940's, uncontrolled drainage may have already eliminated most *Nymphaea* communities in Shark Slough. Further investigation of hydrology-peat-vegetation relationships would help test the validity of this tentative conclusion.

Davis's (1943) description of other graminoid plant communities also is somewhat incompatible with 1980 patterns. The same species are present, but in different

combinations. Spikerush and maidencane marshes appear to resemble Davis's slough communities except that he does not mention the two species in discussion of the slough community. These discrepancies are not fully understandable and thus cannot be clearly attributed to real changes in vegetation. But the fact that Davis does not mention the currently abundant sawgrass marshes in Shark Slough, is further suggestive of a significant shift in vegetation that may be explainable by artificial drainage.

Evidence for Disturbance Effects on Vegetation

More detailed observations also demonstrate that further vegetation change has occurred. Kolipinski and Higer (1969) show that community changes occurred from 1940 to 1967 in several areas of Shark Slough within ENP that appear consistent with the effects of hydroperiod reduction. They concluded that marsh once characterized by periphyton, spikerush, *Utricularia* spp., *Sagittaria lancifolia*, and *Rhynchospora* spp. had declined since 1940. In sites near our northern transect, Kolopinski and Higer (1969) found that these species were replaced by sawgrass communities. In lower Shark Slough, just south of the southern transect, *Rhizophora mangle* (red mangrove), willow, cocoplum and pond apple, all woody species, had expanded in place of aquatic species. The woody expansion originated along the margins of tree islands and the banks of headwater streams which become common in lower Shark Slough.

Further evidence of the expansion of woody species into herbaceous marsh during the era of water management can be found in several papers (e.g., Johnson, 1958, Wade *et al.* 1980, and Alexander and Crook, 1975, 1984). It should be noted, however, that the spread of "bushy vegetation" reported by Johnson (1958) could not be confirmed by the senior author through inspection of aerial photographs.

Alexander and Crook (1975, 1984) described vegetation changes from the 1940s to the 1970s of several kinds throughout south Florida based on field studies supplemented by literature review and interpretation of aerial photographs. They concluded that the major factors influencing overall south Florida vegetation (including, but extending far beyond Shark Slough) were water management, increased fires, sea level rise and displacement by exotic species.

Davis *et al.* (1994) provide some confirming evidence of drainage-induced vegetation change in Shark Slough. They examined aerial photographs from the mid-1980s that covered the square-mile field plots inventoried by Alexander and Crook (1975). Two of these plots were located in the study area being reported on here. In both cases, decrease in wet prairie (equivalent to *Eleocharis* and *P. hemitomum* stands in the present study) and increase in sawgrass marsh was noted. In plot #61, located near the middle transect of the present study, shrub cover also increased. Two other plots, located near Tamiami Trail also exhibited declines in wet prairie and increases in sawgrass cover. In this area, various kinds of disturbance have led to altered vegetation, including elevated soil phosphorous levels (Doren *et al.* 1997). Overall, our information on the relative elevations and hydroperiods of these community types indicate that reduced hydroperiod is a major contributory factor to the observed effects as Alexander and Crook (1975) and Davis *et al.* (1994) have suggested.

Effects of Fire on Sawgrass

Fire has influenced the extent and composition of plant communities in the Slough for

a long time and continues to affect the successional relationships between sparse sawgrass communities and *Eleocharis* marshes, as well as between tall sawgrass strands and woody vegetation. The natural fires that have occurred in south Florida have varied from light to catastrophic, depending on water levels and fuel loads. Fire frequency has probably increased during the last 50-60 years or more because of increasingly drier conditions during the spring (Davis 1943, Robertson 1955, Craighead 1971). Taylor and Herndon (1981) reported on the fire history of Everglades National Park, including lightning fires, prescription fires, and man-set wildfires.

Sawgrass, a rhizomatous plant, is well adapted to fire and easily burns in dense stands, even over water in the summer. Under continuously high water conditions, sawgrass forms tussocks, a condition not often seen within the study area. But the rate at which marshes are subject to rising water levels is important. Fire and deep flooding appear to be critical co-factors explaining cases of sawgrass mortality. When fire burns back culms immediately prior to rapid flooding which often follows storms, water levels can rise at rates sufficient to inhibit sawgrass regrowth which normally follows burning (Herndon et al. 1991). A sawgrass kill of about 40 ha occurred because of flooding following a fire in Taylor Slough after Tropical Storm Dennis in 1981 (Herndon et al. 1991). Therefore, proper timing of burns is very important.

A different type of decline of sawgrass populations in patches has often been reported within Shark Slough. This condition, designated as sawgrass decadence, and reported by Wade et al. (1980), Alexander and Crook (1984) and others, represents local areas of die-back of sawgrass culms that sometimes are open to colonization by woody species. Causes are seldom obvious. Lack of fire, nutritional problems, fungal infection in meristem, and a boring larva (*Scirpophaga perstialis*) have all been cited as possible causes (Hofstetter and Parsons 1975). Of interest though is the observation that extensive areas of sawgrass decadence that caused concern in the early 1970s could not be distinguished from healthy (burned or unburned) sawgrass in 1980 (Wade et al. 1980). Thus the extent to which episodic die-back of sawgrass related to fire and flooding interactions or to biotic factors contributes to shifting vegetation patterns is unclear except for specific areas and times. However, because the area of sawgrass probably has expanded in Shark Slough in the past half-century, episodic sawgrass die-back is unlikely to have been a primary factor in the changing vegetation patterns.

CONCLUSIONS

Shark Slough is the southern portion of the greater Everglades marshes extending from Lake Okeechobee to Everglades National Park. This report provides baseline information on the composition of the major vegetation types found in Shark River Slough within Everglades National Park in relationship to environmental factors. In 1980-81, eleven vegetation community types were identified, including five herbaceous marsh communities. Each of these, sparse and tall sawgrass, spikerush, and maidencane marsh, was analyzed for plant cover, composition, and species frequency along three cross-Slough transects. Four types of

woody communities, tropical hammock, bayhead, bayhead swamp forest and willow head, were delineated and qualitatively described.

Sparse sawgrass is the predominant marsh community type in Shark Slough, covering 45% of the mapped area. Tall sawgrass covers another 13%, and spikerush-sawgrass mixture 14%, totalling nearly three-quarters of the Slough occupied by sawgrass-dominated communities. The Shark Slough marsh communities are distinguished by their low species diversity (3 to 6 species/ m²), single species dominance and low vascular plant cover (2-16%) except for tall sawgrass stands where cover reaches 96%.

On the broadest scale, the structure and extent of plant communities in Shark Slough are largely similar to the way they were in 1940, influenced mainly by hydrology and fire. On a finer scale shifts in several community types appear related to alterations of the natural hydrological regime.

One plant community, the aquatic "slough type", is uncommon at the present time, less so than reported for 1940. At least some of the apparent reduction in slough area, however, seems attributable to the limited characterization of Shark Slough vegetation presented in the earlier work rather than to actual conversion to non-slough vegetation. But it is highly probable that slough vegetation was more ubiquitous 100 years ago, before artificial drainage (Johnson 1958, Kolipinski and Higer 1969, Craighead 1971, Alexander and Crook 1975, Hofstetter and Parsons 1975).

Many reports in the late 1960's and early 1970's and again in the 1990s mentioned the deterioration or decline of sawgrass in the overall Everglades and the increase of woody vegetation. As far as Shark Slough in Everglades National Park is concerned, reduction of areas dominated by sawgrass communities over the past 50 years (as of 1980) has occurred only locally, and it would be very difficult to say that sawgrass had diminished in extent. Although the invasion of woody species into sawgrass communities has occurred, there is a dynamic relationship between sawgrass and woody species that would allow for increase or decrease of either community, depending on fire and water level. Johnson's interpretation (1958) of increase of "brushy" vegetation was incorrect. However, the detailed, measured change in woody vegetation by Kolipinski and Higer (1969) along creekbeds was probably accurate. The available evidence, however, supports the conclusion that sawgrass communities have expanded in Shark Slough as a response to reduction in hydroperiods.

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Appendix I. Soil type and texture from sampling sites along the middle transect.

MIDDLE TRANSECT				
Community	Pole	Soil Type	Sample Depth (cm)	Texture and Color
SG	W-1	marl	top 10	small organic matter component, gray-brown, numerous fine shell fragments
SG	W-1	marl	20	light brownish gray, light loamy marl
EL	W-7	marl	top 10	dark gray marl, mixed with organic matter, numerous fine shell fragments
EL	W-7	marl	20	light, brownish gray, light loamy marl
EL	W-11	muck	top 10	root fragments mixed in dark brown
SG	W-25	muck	top 10	<10% fiber (brown)
SG	W-25	muck	20	brown, bit more friable than TS-W-25
TS	W-25	muck	top 10	very dark brown, <10% fiber
TS	W-25	muck	20	very dark brown, <10% fiber
SG	E-43	muck with marl intermixed	top 10	very dark brown, very granular
SG	E-43	muck	20	brown, very little fiber
MC	E-40	muck	top 10	black muck, <10% fiber
EL	E-40	muck	top 10	black, very granular, some marl mixed in
EL	E-40	Lauderhill muck	20	pH = 7, black
MC	E-40	muck	20	very granular, low fiber, friable, black
EL	E-35	marl	top 10	silt loamy, gray marl with organics, numerous fine shell fragments
EL	E-35	muck with marl intermixed	25	brown, very little fiber
TS	E-24	Lauderhill muck	25	black, slightly more fibrous than E-40. soil has <10% fiber
SG	E-6	marl with some muck	top 10	gray, silty marl with muck below, numerous fine shell fragments
SG	E-6	marl and muck	15-20	shelly gray marl and muck
SOUTHERN TRANSECT AND OTHER AREAS				
SG	S-2	intermixed muck and marl	top 10	dark brown
SG	SG-2	shell perrine marl	20	grayish brown silt, loamy marl, numerous fine shell fragments
SG	S-19	muck	15	brown muck with 10% fiber content
TS	S-9	muck	top 10	dark brown, fine roots mixed in
SG	S-35	Perrine marl, shallow	20	light, brownish gray, heavy texture, borderline silty, clay loam
SG	S-35	peat	10	shelly silt, loamy marl
SG	Tram Road	marl	top 10	sandy loam, poorly drained, (gritty) transition marl to Rockdale soil

SG=sparse sawgrass; TS=tall sawgrass; EL=*Eleocharis cellulosa* dominated marsh; MC= *Panicum hemitomon* dominated marsh

"Pole" (column 2) refers to the nearest transect pole; a map of pole locations is archived at the South Florida Natural Resources Center

Appendix II, cont.

in Table 9.

<i>Trees/Shrubs</i>	<i>Tropical Hardwood Hammock</i>	<i>Bayhead Swamp Forest</i>	<i>Bayhead</i>	<i>Willowhead</i>	<i>Tall Sawgrass</i>	<i>Sparse Sawgrass</i>	<i>Spikerush Maldenian Marsh</i>	<i>Typha</i>
<i>Annona glabra</i>		X	(x)	x				
<i>Ardisia esculentoides</i>	x							
<i>Bumelia salicifolia</i>	x							
<i>Bursera simaruba</i>	x							
<i>Carica papaya*</i>	x							
<i>Cassia ligustrina</i>	x							
<i>Celtis laevigata</i>	x							
<i>Cephalanthus occidentalis</i>		x	(x)	x	x			
<i>Chrysobalanus icaco</i>	(x)	x						
<i>Chrysophyllum olivaceiforme</i>	x			x				
<i>Citrus aurantifolia*</i>	x							
<i>C. aurantium*</i>	x							
<i>C. sinensis*</i>	x							
<i>Coccoloba diversifolia</i>	x							
<i>Eugenia axillaris</i>	x							
<i>Eugenia foetida</i>	x							
<i>Exothea paniculata</i>	x							
<i>Ficus aurea</i>	x			x				
<i>Ficus citrifolia</i>	x			x				
<i>Guapira discolor</i>	x							
<i>Hamelia patens</i>	x							
<i>Ilex cassine</i>	x	x	(x)					
<i>Lysiloma latissilqua</i>	x							
<i>Magnolia virginiana</i>	(x)	x	x(x)					
<i>Mastichodendron foetidissimum</i>	x*							
<i>Myrica cerifera</i>	(x)	x	x(x)	x	x			
<i>Myrsine floridana</i>	x			x				
<i>Nectandra coriacea</i>	x							
<i>Persea borbonia</i>	x	x	x(x)	x	x			
<i>Piscidia piscipula</i>	x							
<i>Psychotria nervosa</i>	x							
<i>P. sulzeri</i>	x							

	Tropical Hardwood Hammock	Bayhead Swamp Forest	Bayhead	Willowhead	Tall Sawgrass	Sparse Sawgrass	Spikerush Maldenian Marsh	Typha
<i>Blechnum serrulatum</i>	x	x	x(x)	x	x			
Appendix II, con't.								
<i>Boehmeria cylindrica</i>		x	x	x	x			
<i>Capriaria bicolor</i>	x							
<i>Citrum americanum</i>					x			
<i>Cynanchum scoparium</i>								
<i>Eriocaulon compressum</i>			(x)	x	x			
<i>Gerardia linifolia</i>								
<i>Hydrocotyle verticillata</i>			x		x			
<i>Hydrolea corymbosum</i>					x			
<i>Hymenocallis palmeri</i>				x	x			
<i>Justicia angusta</i>				x	x			
<i>Ludwigia peruviana</i>			x		x			
<i>L. alata</i>				x	x			
<i>L. curtisii</i>				x	x			
<i>L. repens</i>				x	x			
<i>Nepenthes exaltata</i>	x	x	x	x	x			
<i>Nuphar lutea</i>				x				
<i>Nymphaea odorata</i>								
<i>Nymphaeoides aquatica</i>								
<i>Oxypolis filiformis</i>								
<i>Parietaria floridana</i>								
<i>Peltandra virginica</i>								
<i>Pluchea rosea</i>								
<i>Polygonum hydropiperoides</i>								
<i>P. punctatum</i>								
<i>Polypodium aureum</i>	x		x					
<i>P. phyllitidis</i>	x		x					
<i>Pontederia cordata</i>		x						
<i>Proserpinaca palustris</i>			(x)	x	x			
<i>Psilotum nudum</i>			x	x				
<i>Rivina humilis</i>	x							
<i>Sagittaria lancifolia</i>		x	(x)	x	x			

Appendix II, con't

	Tropical Hardwood Hammock	Bayhead Swamp Forest	Bayhead	Willowhead	Tall Sawgrass	Sparse Sawgrass	Spikerush Maldenian Marsh	Typha
<i>S. stagnorum</i>		x	x					
<i>Samolus parviflorus</i>	x							
<i>Saururus cernuus</i>		x	(x)					
<i>Sida elliptica</i>	x		(x)	x				
<i>Thalia geniculata</i>	x		x					
<i>Thelypteris kunthii</i>			x					
<i>Thelypteris sp.</i>			x					
<i>Tillandsia fasciculata</i>	x		x					
<i>T. valenzuelana</i>	x							
<i>Utricularia biflora</i>		x						
<i>U. cornuta</i>		x						
<i>U. foliosa</i>								
<i>U. purpurea</i>								
<i>U. radiata</i>								
<i>U. resupinata</i>								
<i>Vallisneria americana</i>								
<i>Verbena sp.</i>		x	(x)					
Graminoids								
<i>Cladium jamaicense</i>		x	(x)					
<i>Cyperus sp.</i>								
<i>Dichromena colorata</i>								
<i>Eleocharis cellulosa</i>		x	x					
<i>Fimbristylis sp.</i>								
<i>Leersia hexandra</i>		x						
<i>Panicum hemitomon</i>		x	(x)					
<i>P. tenerum</i>								
<i>Paspalum geminatum</i>		x						
<i>Rhynchospora microcarpa</i>								
<i>R. tracyi</i>								
<i>Typha domingensis</i>		x		x				
TOTAL NUMBER OF SPECIES	59(6)	39	36(22)	42	35	31	28	7

() Species in ecotones

* Not native to Florida

Note: 28 species were added to the original Olmsted list from unpublished data of D. Jones and T. Armentano



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