Chapter 4-- Everglades Landscapes Prior to Canal Drainage

"If the stranger visits the lower part of the State he will find in the interior a vast extent of wet, often inundated prairie with wooded islets scattered along its borders. At the north of this great swamp, the Everglades, is Lake Okeechobee, which during the rainy season overflows the entire prairie. A low rocky ridge lies between the Everglades and the Atlantic coastal shore. It projects westward far into the swamp in southern Dade County, and finally disappears in the great prairie. This ridge is cut into numerous islands, and water from the Everglades passes through the channels between out to the sea." (Simpson 1920).

"It is difficult for a person who has not seen the Everglades to form even an approximate idea of that far-extending expanse of sedge, with its stretches of shallow water, its narrow winding channels of deeper water, its scattered clumps of bushes, and its many islands. Photographs fail to convey the impressions of distance, of remoteness, and of virgin wildness which strike the visitor who for the first time looks out across that vast expanse." (Sanford, in Matson and Sanford (1913).

"It is also the general impression that there is a wide saw grass flat which extends from Okeechobee to the southern end of the peninsula, nearly all of this flat being under water during the rainy season, but in the southern part there are leads where boats can get through at the low water period, the deeper water being on either side of this flat. The islands or hammocks as they are called are along the east side and across the south end." (Stewart 1907).

"The appearance of the interior of the Everglades is unlike that of any region of which I have ever heard, and certainly it is in some respects the most remarkable on this continent. Imagine a vast lake of fresh water extending in every direction from shore to shore beyond the reach of human vision, ordinarily unruffled by a ripple on its surface, studded with thousands of islands of various sizes, from one-fourth of an acre to hundreds of acres in area, and which are generally covered with dense thickets of shrubbery and vines. Occasionally an island is found with lofty pines and palmettos upon it, but oftener they are without any, and not unusually a solitary majestic palmetto is seen, the only tree upon an island, as if to guide in approaching it, or as a place of signal or lookout for its former denizens. The surrounding waters, except in places that at first seem like channel ways (but which are not), are covered with the tall sawgrass, shooting up its straight and slender stem from the shallow bottom of the lake to the height often of 10 feet above the surface and covering all but a few rods around from your view. The water is pure and limpid and almost imperceptibly moves, not in partial currents, but, as it seems, in a mass, silently and slowly to the southward. The bottom of the lake at the distance of from 3 to 6 feet is covered with a deposit of decayed vegetable substance, the accumulated product of ages, generally 2 or 3 feet in depth on the white sand and rock that underlies it over the entire surface of the basin. The flexible grass bending gently to the breeze protects the waters from its influence. Lilies and other aquatic flowers of every variety and hue are to be seen on every side, in pleasant contrast with the pale green of the saw grass, and as you draw near an island the beauty of the scene is increased by the rich foliage and blooming flowers of the wild myrtle and the honeysuckle and other shrubs and vines that generally adorn its shores. The profound and wild solitude of the place, the solemn silence which pervades it, unless broken by the splashing of a paddle of the canoe or light batteau, with which only can you traverse the Pahayokee, or by the voices of your 'Campagnons du voyage,' add to awakened and excited curiousity feelings bordering on awe." (Buckingham Smith, 1848, in Sen. Doc. No. 89).

The above historical descriptions paint a vivid picture of the pre-drainage Everglades. The intent of the research described in this chapter was to gather as many such descriptions as possible, identify their locations, and then use them in combination with soil maps and aerial photography to: (1) explicitly map the pre-drainage boundaries of the Everglades, (2) map the boundaries of the landscapes that made up the Everglades and the surrounding areas (**Plate 13)**; and (3) describe the vegetation, soils and hydrology of each landscape in detail.

Endnotes are included after each landscape description providing a chronological list of historical observations and comments.

Literature Review

There have been several previous efforts at mapping the landscapes or vegetation communities of the Everglades. The earliest of these captured existing conditions at the time of mapping. Some later efforts have been reconstructive, attempting as we do to create a map of the pre-drainage system. A brief review follows.

John Harshberger, a landscape ecologist working at the Wager Free Institute of Science in Philadelphia, studied southern Florida during the 1910-1914 period, making a number of excursions inland from the eastern coast and one trip down the length of the North New River Canal. His investigations resulted in a monograph providing key observations of the early post-drainage system, as well as a phytogeographic map. His observations aided in the formulation of landscape descriptions for the Atlantic Coastal Ridge, the Eastern Flatwoods, the Everglades Keys, Marl Transverse Glades and Ridge and Slough landscape at the headwaters of the Miami River. Additionally, information on the distinction between the Sawgrass Plains and the Ridge and Slough landscapes was used to locate the transition between these two.

Roland Harper, botanist, worked in south Florida from approximately 1909 to at least 1927, writing a number of articles and a monograph published by the Florida Geological Survey.

His characterization of plant communities, some of which correspond to the landscapes of the present study, provided good background material but little detail within the Ridge and Slough system or the Sawgrass Plains.

John Davis, Jr., working in the first part of the 1940's, provides the first synoptic overview with detailed mapping of the interior of the Everglades. Davis' work should be used in a "big-picture" context. As he himself clearly indicates, his mapping style was not intended to be spatially precise for individual elements or boundaries. His primary goals were similar to those of Harshberger, and Harper before him, in that he set out to map what he observed in the field in 1940. However, Davis deviated from this approach for the Custard Apple Swamp landscape and in the urganized portions of the East Coast, in these areas mapping what he considered to represent the pre-drainage landscape. The well recognized Davis vegetation map is a valuable resource concerning the Everglades in the 1940's, but to interpret it as a map of the pre-drainage Everglades would be inconsistent with the author's intention

Based on extensive field work and aerial photography, Jones et al. (1948) produced a technical publication on the soils of the Everglades that included a detailed and relatively precise map of the soils in addition to a map of physiographic divisions of the Everglades These divisions are comparable in scale and type to the landscapes of the present study. Like the contemporaneous Davis (1943) map, the Jones et al. 1948, soil map is very accurate for the conditions present in 1940 and was not intended to represent pre-drainage conditions. The authors were mapping soils with the main goal of determining the usefulness of the soils for agricultural, and to a lesser extent, for urban use and as and natural habitats.

Robert Costanza deveoloped the first explicitly hindcast regional map of early Everglades landcover (Costanza, 1975). Using the Davis 1943 vegetation map as a baseline, with the recognition that changes had occurred in the Everglades by 1940, Costanza mapped what he determined to be generally representative of ca.1900 conditions.

A more recent study by Davis (unrelated) et al. (1994) produced a pre-drainage map of the Everglades by applying the hindcasting approach to existing maps, including the Davis (1943) vegetation map. This effort, involving the review of historical sources and comparisons of available historical maps, documented important changes in Everglades landscapes over time at multiple scales.

The present study builds on these previous mapping efforts. As discussed in Chapter 3, it became apparent that the first and necessary step for creating a pre-drainage map would be to develop a thorough, detailed understanding of the changes that had taken place between 1880 and 1940. This chapter will apply those changes to the maps from the 1940's then forecast in reverse in an effort to "hindcast" to pre-drainage conditions.

Comparison of Pre-Drainage Landscapes and 1940s Landscapes

The Indian name for the Everglades, Pa-hay-okee or "grassy water," suggests an expanse of moving water, shallow enough to support various species of aquatic plants. The results of this study, while partially consistent with such a description, also suggest important differences. Rather than being one uniform area, the Everglades was made up of five major landscapes with distinctive features. Two large landscapes formed the bulk of the Everglades, from Lake Okeechobee south almost to Whitewater Bay. These two, the Sawgrass Plains and the Ridge and Slough landscape, were both based on peat soils, 2 to 12 feet thick (**Figure 4.1** and **Figure 4.2**) Peat dating suggests that the Everglades are about 5,000 years old (Gleason and Stone, 1994).

By the 1800s, sufficient peat had accumulated within the Sawgrass Plains and most of the Ridge and Slough landscape to completely fill the Everglades basin, almost up to the surface of the surrounding rim (Wright 1911). In the more southerly part of the basin, the peat of the Ridge and Slough landscape did not fill the basin completely, leaving two slightly higher landscapes: the Ochopee and Rockland Marl Marshes (**Figure 4.3**). In these marshes, bedrock elevations rather than the peat surface largely determined ground surface elevations. Here the River of Grass flowed southwestward, concentrating flow through a shallow valley -- Shark [River] Slough. With the Custard Apple Swamp along the south shore of Lake Okeechobee, the River of Grass therefore included these five different major landscapes. Consideration of the Mangrove Fringe (beyond the scope of this study) would add an additional landscape.

Table 4.1 summarizes maps that can be compared with **Plate 13** of this study. The eastern uplands are well-mapped, as is the pre-drainage location of the Everglades border along these uplands. This reflects the concentration of most explorations inward from the Atlantic coast. Accurate and detailed mapping of the entire interior, that is, of the Everglades themselves, does not become available until the 1940s.

Table 4.1 Characteristics of principal landscape maps of the Everglades region.

Time Period Described	Map Reference	Comments
Pre-drainage (1850's)	Ives (1856) (**Figure 2.6** of this study)	Some spatial distortion of base map. Physiographically very accurate, especially much of eastern coastal uplands bordering Everglades. Little detail on interior (Everglades).
Early post-drainage (1910)	Harshberger (1913) (**Figure 2.7** of this study)	Some spatial distortion of base map. Physiographically very accurate, especially eastern coastal uplands bordering Everglades. Little detail on interior (Everglades). Text differentiates sawgrass plains from ridge and slough landscape.
Post-drainage (1940s)	Davis (1943) (**Plate 4** of this study)	Physiographically very accurate overview. Spatial details generalized. Maps interior in detail. Depicts 1940s conditions. Frmed and urban areas were hindcasted to estimate natural vegetation.
Post-drainage (1940s)	Jones et al. (1948) (**Plate 3** of this study)	Spatially very accurate. Maps interior, including tree island shapes and orientation. Depicts 1940s soil conditions; no attempt to hindcast to pre-drainage conditions. Text recognizes many changes had occurred.
Pre-drainage (estimated)	Costanza (1975)	Modified from Davis (1943) with only minor changes.
Pre-drainage (estimated)	Davis et al. (1994)	Modified from Davis (1943). More extensive hindcasting to pre-drainage conditions, based on historical narratives. A number of post-drainage (1940s) aspects persist in this map.

Unfortunately, by that time, the prime determinants of Everglades landscapes had already been greatly altered by drainage. Accurate representation of pre-drainage landscapes in the Everglades therefore necessarily involves a hindcasting effort to combine information on soils, vegetation, and hydrology with knowledge of the history of drainage. The map of the Everglades and adjacent landscapes produced in this study, **Plate 13**, resembles several aspects of previous maps, but also differs in important ways. The similarities are strongest within the bordering upland areas, where the sandy or rocky substrate has not been altered greatly by drainage. Differences are strongest within the original Everglades extent, where post-drainage changes in organic soils, topography, and vegetation had substantially affected previous maps.

The overall effect of post-drainage changes has been to create a more complex landscape pattern. The increased complexity is the combined result of two effects: (1) uneven application and influence of anthropogenic drainage on the organic soils of the Everglades; and (2) uneven properties--prior to drainage--of these organic soils, particularly in depth of the organic layer and variations in the underlying substrate. The combination of these two spatial non-uniformities transformed, after drainage began, an originally vast, extremely flat, and regionally very uniform surface of the accumulated peats of the Everglades basin into a patchwork of areas quite varied in substrate, topography, hydrology, and vegetation.

As a rough analogy, one can imagine a broad, shallow bowl, the bottom of which is covered in places with gravel, in other places with sand. A slurry of flocculent peat poured into the bowl will settle to form a flat surface, obscuring from view the irregularities of the sand and gravel bottom. Simulating the effects of drainage by allowing the peat to oxidize, results in objects closeset to surface being exposed. The decline of the peat surface was uneven due to differences in intensity of drainage. Impoundment of originally sloped portions of the Everglades created further "unevenness," as water depths became shallower at the upslope end of the impoundment; deeper at the downslope end.

The simplicity reflected in the pre-drainage Everglades landscapes (**Plate 13**) reflects the mechanisms which formed the Everglades reinforced by hydrology patterns: flow through network of sloughs in a pattern spread evenly across an extremely flat landscape with no central channel. The delineation of a distinct eastern border between the open, peat-based Everglades and the higher, mineral substrate eastern uplands drawn on **Plate 13** closely resembles the border shown on many pre-drainage maps, e.g. Ives (1856) (**Figure 2.6**); see also the early post-drainage map by Harshberger (1913) (**Figure 2.7**). Along the narrowest portion of the coast, between the New River (Ft. Lauderdale) and the Miami River, the extension of organic Everglades soils and sawgrass vegetation eastward between "ring-shaped islands" of higher pineland (White 1970) is clearly shown on pre-drainage township surveys (e.g., Williams 1870) and on early post-drainage maps as well (Love 1920; Squires 1923; White 1970). Military accounts from the third Seminole War report bridge building across the Peat Transverse Glades to create a continuous north-south road connecting the upland areas (Broward Legacy 199_). Although the differences in soil and vegetation between these Peat Transverse Glades and the islands of pine have been largely obscured by urban development, the original patterns are still used for flood management (Finkl 1994). Some remnants, such as a former tree island within a transverse glade, can still be recognized from aerial photographs (**Plate 39** and **Plate 40**).

The main difference between **Plate 13** and maps such as Ives (1856) and Harshberger (1913) in the eastern coastal area is the significant increase in spatial precision. This was achieved by using the highly detailed Jones *et al*. (1948) soil map as a base.

As previously discussed, the 1940s mapmakers did not intend to create hindcast maps of the pre-drainage system, so the 1940s maps are not strictly comparable with reconstructive pre-drainage maps. Nevertheless, absent other maps, the 1940s maps have continued to be used as estimates of natural or pre-drainage conditions (e.g, Gleason et al. 1974; Gleason and Stone 1994; Fennema et al. 1994; Galloway et al. 1999).

Comparison of the pre-drainage map of the present study with the 1940's characterization of physiographic divisions helps understand the process of hindcasting that was used to produce the pre-drainage map. Significant changes can be seen between the two maps (**Table 4.2**).

In the next section we will present an example of the process that was used to gather information and synthesize it to hindcast from the maps that were made in the 1940's.

A Sample Hindcasting of the Post-Drainage Peripheral Wet Prairies

The previous section listed ten areas that differed between the Jones *et al*. (1948) map of physiographic regions and the landscape maps of the present study (**Plate 13**). Comparison of Plate 13 with the Davis (1943) vegetation map, **Plate 4**) would reveal a very similar list of spatial differences. A third comparison with the landscape map of Davis et al. (1994) would result in fewer, but still find some of the same differences. Each of these spatial differences was analyzed in detail, and then hindcast on the basis of known changes and confirmed pre-drainage accounts.

We present here one such analysis for a specific area—the post-drainage peripheral wet prairies that appear on the Jones et al. (1948), Davis (1943), and Davis et al. (1994) maps along the east side of the Everglades between Ft. Lauderdale and Miami. **Plate 4** shows an extensive area of prairies between Ft. Lauderdale and Miami (North New River Canal to Tamiami Canal area; Townships 50 to 54, Ranges 40 and 41). By the 1940's these wet prairies we found on the western side of the Atlantic coastal ridge and extended eastward in narrow fingers between the pine forests of the coastal ridge. In contrast, the map of pre-drainage landscapes produced in this study (**Plate 13**) shows a quite different picture.

Table 4.2 Landscape changes in the Everglades between pre-drainage conditions (pre 1880s) and the 1940s. Letters correspond to labels on **Figure 4.4.**

	Comments	Pre-drainage Vegetation	1940s Vegetation	Pre-drainage Soils	1940s Soils
A	***"An old slough."*** This arm of the Ridge and Slough landscape originally extended from the present Lox. Nat. Wildlife Refuge north to a cypress stand bordering Lake Okeechobee. Prebles (1884) documents an expedition in this area. Jones et al. (1948) included it in the Sawgrass Plains because due to drainage the soil was indistinguishable from Everglades Peat.	ridge & slough	sawgrass	peat	peat
B	***Loxahatchee Slough***. Another arm of the Everglades. At different times drained both into and out of Everglades.	ridge & slough	weedy shrub land	peat	sands
C	***"Freshwater Ponds."*** 20 mile long, 2 mile wide sawgrass marsh surrounded by pine flatwoods and scrub. Unnamed in historic literature. Corresponds approx. to location of Congress Ave. in northern Palm Beach Co.	sawgrass	wet prairie	peat	sands
D	***Central Ridge and Slough***. Drainage by the bordering North New River and Miami Canals eliminated sloughs in this large area, replacing them with sawgrass. See Chapter 3 for detailed analysis of the changes. This hindcasting reestablishes the original configuration of the Ridge and Slough landscape as a single, continuous unit, rather than two artificially isolated areas.	ridge & slough	sawgrass and tree islands	peat	peat
E	***"Sand Protrusion."*** Early maps and narratives establish this westward extension of sandy grasslands as a post-drainage phenomenon. Effective drainage in the wedge between North New River and South New River Canals oxidized the peat and exposed the underlying sand.	ridge & slough	weedy grassland	peat	sands
F	***Peat Transverse Glades***. The Everglades originally extended eastward in arms of peat soil and sawgrass along the borders of the Atlantic Coastal Rivers. Although the peat was already oxidized by the 1940s, the areas are still recognizable on maps of flood risk.	sawgrass	weedy/agric.	peat	sands
G	***"Peripheral Wet Prairies."*** Both Davis (1943) and Jones et al. (1948) note that drainage-induced oxidation of overlying peat converted the original Ridge and Slough landscape into sand prairies in this area.	ridge & slough	weedy grassland	peat	sands
H	***Everglades Keys, Marl Transverse Glades, and Rockland Marl Marsh area***. Originally a series of pine islands separated by the seasonal wet transverse glades, and bordered by Marl Marsh to the east and west. Drainage eliminated the transverse glades and blurred distinction with Marl Marsh to west.	marl marsh; pinelands; sawgrass in the marl transverse glades	Overdrained marl prairies; pinelands and agriculture (the "Miami Rock Ridge"	marl and/or pinnacle rock	marl and/or pinnacl e rock
I	***Marl Transverse Glades***. Prior to drainage were seasonally wet.	sawgrass	agriculture	marl	marl
J	***Taylor Slough***. Originally an arm of the Ridge and Slough landscape. Affected by regional drainage.	ridge & slough	sawgrass	peat + marl	peat + marl
K	***Ochopee Marl Marsh***. Jones *et al*. (1948) did not distinguish from Big Cypress, perhaps because area not of agricultural interest.	marl marsh	hammock & glades	marl	marl
L	***Pseudo-wet prairies (western)***. Drainage-induced wet prairies caused by oxidation of peat to underlying sand.	ridge & slough	weedy shrub land	peat	sands
M	***Northwest Sawgrass Plains***. Numerous accounts and maps establish that the SW corner of Lake Okeechobee was bordered by an extensive sawgrass marsh on deep peat. This extension of the Sawgrass Plains filled a valley surrounding Lake Hicpochee up to about 21 feet m.s.l. elevation. By the 1940s, effective drainage had oxidized extensive areas of peat to the underlying sand.	sawgrass	grassland	peat	sands

The Atlantic Coastal Ridge is narrow and actually more an archipelago of high ground islands than a continuous ridge. The Ridge and Slough landscape extends directly to the western edge of the coastal ridge or archipelago. The fingers of lower ground between the islands, labeled as the "Peat Transverse Glades", are indicated in this study as Everglades peat soils, that is, as soils formed from sawgrass remains. The differences between **Plate 13,** representing pre-drainage conditions, and the Davis map, representing 1940 conditions, are significant and important for understanding the pre-drainage water flows in the Everglades.

The hindcasting process can be explained through a series of illustrations included in this document. **Plate 35** shows an aerial view of the area between the New River (Ft. Lauderdale) and the Miami River. The view is a composite of aerial photographs taken in the spring of 1940, overlain with polygons (red) outlining the islands of high ground that formed the coastal ridge. Polygons are based on soil mapping. The Peat Transverse Glades are visible between the islands and connect through on the western side to the expanse of Everglades shown in the center and western portion of the image. In the western portion of the image a directional grain is visible (even more clearly visible on the original, larger photographs), however, as one approaches the coastal ridge, an area two to four miles wide just west of the ridge is visible on this image as a lighter colored, almost whitish area generally lacking the parallel grain visible on the western half of the image. This white area just west of the islands of the coastal ridge (red polygons) corresponds closely to the area identified by Davis (1943) as wet prairies.

If we now compare the 1940s aerial photographs with a mosaic of township surveys made mostly in 1870, and in all cases prior to drainage (compare **Plate 37** with **Plate 35**), we recognize the same islands of high ground (here in white) and note that each of the townships identifies the area directly west of the coastal ridge as "Everglades." This makes it clear that the Everglades directly bordered the ridge, but further detail is needed to establish whether this referred to wet prairies, expanses of pure sawgrass, or Ridge and Slough landscape.

The township surveys include plant community specific detail in the field notes. **Appendix C** gives a more detailed picture of this area prior to drainage (transects 4 through 10). Most of the descriptions mention sawgrass, to sloughs, and to some form of tree islands including either myrtle or cocoa plum; all typical elements of the Ridge and Slough landscape. Transects 8, 9 and 10 in Township 53, Range 41 do refer to "wet prairies" in addition to sawgrass and sloughs. Surveyors from the 1840s used the term "sawgrass prairies," so the species composition of the wet prairies mentioned in the Township 53, Range 41 notes is unclear, but may include other than Ridge and Slough species. Separate soils information indicates that prior to drainage the peat present throughout the area was several feet thick; a contrast from the sand-based wet prairies seen by Davis in the 1940s. A view of the Everglades coming up to the edge of the coastal ridge and to the headwaters of the Miami River is shown in **Figure 4.5.** Comparison with **Plate 35** helps locate the photograph shown in **Figure 4.5.** The location is in the center bottom of Township 53, Range 41, looking westnorthwest onto the area bounded by the newly constructed Miami Canal and the north fork of the Miami River. The vegetation visible in the background suggests tree islands in a field of sawgrass. **Figure 4.6** confirms this. This photograph was taken one year before **Figure 4.5** and probably at a location within the view or slightly to the left. The tall sawgrass and tree island suggest that the Ridge and Slough landscape extended east to the coastal ridge.

Figure, 4.7 shows the Miami Falls with the Everglades in the background. Water flowed from the Everglades over the falls into the Miami River; again an indication of a higher elevation landscape (Ridge and Slough) extending eastward directly up to the edge of the coastal ridge.

A whitish area in on **Plate 35** bounded by the Miami Canal to the north and Tamiami Canal to the south is the same whitish area visible in more detail on **Plate 34** in the upper right-hand corner **(**lower left corner of Township 53, Range 41). Mottled dark areas are visible within the white area. Comparison with a 1925 photomosaic (not included here) of the same area suggests that the dark mottles are peat-filled low spots in the sand subsoil, and that these peat low spots are the remnants of an uneven layer of peat that originally covered the whole area.

The textured white area extends across the boundary of T53 R41 into T53 R40. A township survey that included measured depths of peat is available for T53 R40 and is shown in **Figure 4.8**. The whitish area would be in the middle to lower right corner of the township. The area is marked as having one or two, or in exceptional cases, zero feet of peat on top of several feet of sand. These soil depths, measured in 1912, indicate that the whitish area originally had a covering of peat, which is consistent with the tall, dense sawgrass shown in **Figure 4.6**. It is also consistent with the impression from the 1925, 1938, and 1940 aerial photographs of progressively oxidizing peat.

Comparing the peat depths shown in **Figure 4.8** with **Figure 3.10** further illustrates the changes that occurred in the areas just to the west of the coastal ridge (Township 53, Range 40 is indicated with a box labeled "J"). It can be seen that by 1940 the eastern half of this township showed essentially no peat remaining at all. The maximum remaining peat in 1940 was in the northwestern corner (**Figure 3.10**, Box J), mapped as "less than three feet." **Figure 4.8** indicates that the northwestern corner of the same township in 1912 had considerably deeper peat; four to six feet. The loss of peat visible on **Figure 3.10** as the white areas directly adjacent to the coastal ridge, explains the sand-based wet prairies seen by Davis in the 1940's. The same pattern can be confirmed in Township 51, Range 41, labeled "I" on **Figure 3.10**. By 1940, this half township also shows a considerable area with essentially no peat and a small portion showing "less than three feet." Comparison with **Figure 4.9** indicates that the area shown on **Figure 3.10** as having had less than three feet of peat in 1940 previously had more than six feet of peat in 1912. The areas shown as having essentially no peat typically had two to three, sometimes four feet of peat in 1912. The time course, by which oxidative loss of several feet of peat occurred down to the underlying sand, was measured at Davie, Florida (**Figure 3.7**).

Figure 3.16 shows, in schematic form, the changes from pre-drainage to the post-drainage conditions that were observed in the 1940s. Originally, the higher elevation of peat extended eastward to the edge of the coastal ridge. As the peat that had accumulated under wetter pre-drainage conditions oxidized, the surface lowered and the edge moved westward and exposed the sand at the surface. The underlying wedge of sand that extended out into the Everglades eventually became wet prairie. This is the origin of the whitish areas shown on the aerial photographs such as **Plate 35**.

Similar losses of organic soil and shifts to wet prairie species occurred within the Peat Transverse Glades. As the Everglades were drained and water levels lowered, less water passed eastward through the Peat Transverse Glades. The sawgrass peat was exposed to oxidation, and was replaced by wet prairie species. The loss of peat was not complete by the 1940s so a plan view would show the original width of the transverse glades, but with peat remaining only within the deepest portion in the center of the transverse glade. The transverse glades will be discussed in more detail later in this chapter.

Everglades Landscapes

The remainder of Chapter 4 consists of detailed descriptions of the landscapes of the pre-drainage Everglades and the surrounding uplands -- their vegetation, soils, topography, pre-drainage spatial extent, and hydrology. Each landscape description includes two parts: first, a general description of pre-drainage conditions including vegetation, topographic and hydrologic characteristics, and second, a hindcasting section. The general description represents a synthesis of all available historical descriptions. A limited number of representative narrative accounts of the landscape have been included to provide supporting eyewitness observations. The hindcasting section provides an analysis of differences in spatial extent of each landscape between pre-drainage and 1940s conditions. It includes information on how the original extents were estimated. The soil and vegetation changes discussed in Chapter 3 formed much of the basis for the hindcasting.

The source materials upon which the general descriptions are based are found in the chapter endnotes. Accounts from original observers of the Everglades are presented chronologically as direct quotations with annotations. Additional source material for landscape characterization can be found in the Appendices at the end of this document.

Custard Apple Swamp

Previous descriptions of the pre-drainage Custard Apple Swamp have often included a number of misperceptions. This is not surprising. Post-drainage sources are more numerous and have been more widely accessible than pre-drainage descriptions. The effects of early (1880's through 1890's) lowering of Lake Okeechobee by several feet were not widely recognized. As a result, the Custard Apple Swamp was seen as the sole gateway for Lake Okeechobee water to enter the Everglades. This gateway was thought to be in the form of a substantial rim, over which the lake would occasionally overflow. The Custard Apple Swamp was characterized as being up to four miles wide, 45 miles long, and extending as far west as the Three Mile Canal at Moorehaven.

Chronological reading of Custard Apple Swamp and Sawgrass Plains sources suggests that these impressions do not accurately describe pre-drainage conditions. Comparing sources with the chronology of drainage is particularly helpful in clarifying the extensive influence of post-drainage changes on this landscape, and helps form a more accurate pre-drainage picture.

General Description

As discussed in the Sawgrass Plains section of this chapter, sawgrass directly bordered Lake Okeechobee along 20 miles of the southwestern and southern shore line. No elevated rim was present; the waters of the lake simply extended as a level surface, flowing directly into the sawgrass. Rather than being an occasional, high water occurrence, this extension of lake water into the sawgrass persisted for most of the year during most years.

Although fewer historical sources of information are available for the Custard Apple Swamp, a similar direct connection to Lake Okeechobee appears to have been present prior to drainage. The description of the area as swamp forest and the presence of buttressing and tree bases enlarged by submergence all suggest that surface water from the Lake was present throughout much of most years. This is further supported by well-documented post-drainage soil subsidence and vegetation changes that occurred after Lake levels were lowered.

Prior to any anthropogenic, drainage-induced expansions in extent, the Custard Apple Swamp was a narrow (1 mile wide) band of nearly monotypic swamp forest, dominated by Custard Apple (*Annona glabra*), extending approximately 30 miles along the southern and eastern shores of Lake Okeechobee (**Figure 4.10**). The forest was dense, with intertwined branches and additional vines that together formed a closed canopy and almost impenetrable thicket. The trees were variously reported as 15, 20 or 30 feet tall. At times the trees were covered by a high-climbing vine, the moon-flower (*Calonyction aculcatum*). Individual cypress trees were occasionally found among the custard apples.

On the downstream, southern side of the Custard Apple Swamp, in 1883 a transitional marsh, described as “yma grass, wampu or warmpea, mixed with scrub willow”, was reported to extend for a short distance before surrendering to the Sawgrass Plains. Thirty years later, surveyors’ descriptions from the same area suggest that the transitional marsh was wetter (deeper) than the sawgrass area: “from willow into open glade, wild millet and lillies” and “from open glade of wild millet and flags into willow.” Many post-drainage descriptions refer to thickets of willow and elderberry (*Sambucus intermedia*), either interspersed between patches of custard apple or in a band paralleling the southern boundary of the Custard Apple Swamp.

However, at the same time a number of post-drainage observers clearly state that willow and elders could, and did, invade areas of sawgrass, after water levels were lowered by drainage. It is therefore not clear to what extent a bordering band of willow and elderberry was originally present. The willow and elderberry marsh may be a post-drainage expansion into and south of the transitional marsh. The width of the Custard Apple Swamp alone, when surveyed in 1915-1916, was 1.0 to 1.5 miles. At that time, the elderberry-willow band was 0.5 to 0.75 miles wide.

Pre-drainage descriptions of the custard apple shoreline were not found, but post-drainage accounts, written after Lake Okeechobee levels were lowered, indicate “no banks” and “low muddy and irregular shore with its dense growth of pond-apple.” The reference to no banks is probably an explicit differentiation from the peat banks that occurred along the sawgrass areas found further west on the shoreline. “Muddy” is likely a reference to the high (50%) inorganic fraction in the custard apple soils or to inorganic silts that apparently washed in from the Lake.

At least eight short rivers exited from Lake Okeechobee into the Custard Apple Swamp. These rivers flowed southerly, out of the lake, rather than into it, reflecting the southward slope of the Everglades. The rivers were short enough that at least some, and maybe all, merged and disappeared into the swamp before reaching the southern border of the Custard Apple Swamp. State surveyors working in 1915 and 1916 found dry river beds and referred to some as “dead rivers”. It seems likely that these rivers went dry when lake water levels were first lowered, i.e., well before 1915-1916.

Ecological factors that determined the pre-drainage extent of the Custard Apple Swamp are of particular interest. Information from early accounts indicates that (1) an extensive portion of the shore line of Lake Okeechobee and all the shore line of Lake Hicpochee was sawgrass (i.e., without intervening custard apple), prior to drainage, and (2) after drainage, at least scattered custard apple apparently invaded some of this sawgrass. Harshberger (1914) suggested that the custard apple extent might be related to frost and temperature effects due to the moderating influence of the lake. It is not clear how temperature buffering would explain the presence of custard apple east of Sand Point, but not west of it. Several authors noted that the much higher mineral content of the custard apple soils in comparison with the sawgrass soils (50% instead of 10%) likely reflected the washing in of inorganic silts from the southeastern corner of Lake Okeechobee (**Figure 4.11**). Comparison of the Custard Apple Swamp extent, as mapped in this study (**Plate 13**) using State township surveys, with the extent of custard apple soils (Okeechobee mucks) mapped by Jones et al. (1948) (**Plate 11**) shows a close match. The match is significant because the two mapping approaches are likely to have been independent. Jones et al. (1948), in places, used vegetation patterns as a proxy to map certain soils, but the high agricultural value of the custard apple soils makes it likely that they were directly mapped from soil borings. The close match between the locations of soils and the pre-drainage vegetation suggests that the distribution of dense custard apple swamp was linked to the lake-derived minerals in the soil.

Many descriptions of the pre-drainage Everglades mention a "custard apple rim." This rim is potentially an important aspect of the pre-drainage relationship between Lake Okeechobee and the Everglades. The "rim" may have been a visual effect of the height of the trees that accentuated the change in elevation that occurred between the lake bottom and the shoreline and may not necessarily have been a feature that extended above the water surface. The term "rim" may also imply that the soils of the narrow strip of Custard Apple Swamp were elevated above either the lake level to the north or the sawgrass marsh to the south, or both. The rim does not appear to have been higher than the water level in the lake. Prior to drainage, the lake level was above the land surface during a large portion of the year, keeping surface water present in the Custard Apple Swamp. This relationship—land surface approximately even with the lake level—appears to have persisted even after drainage. As the lake was progessively lowered, subsidence of the custard apple soil appears to have roughly kept pace (**Figure 32**):

> "The elevation of the land is now from 16 to 17 feet above sea level which is about level with the normal lake level." (Herr 1943).

It therefore appears unlikely that the concept of a custard apple rim arose by comparison with lake levels on the north side, whether under pre- or post-drainage conditions.

Although it can only be hypothesized, it seems likely that the appearance of a rim arose from differing soil properties to the south, and that it in fact is a man-made artifact of uneven, drainage-induced soil subsidence. As previously noted, the custard apple soils differed from the adjacent sawgrass soils by having much lower organic matter contents (50% organic material in the custard apple soil *vs*. 90% in the sawgrass soil). Only the organic fraction subsided, so for the same lowering of water tables, the subsidence in the sawgrass soil would be almost twice that in the custard apple soil, leaving the latter higher; a “rim.” A drainage engineer in fact noticed this prior to 1936:

> “In the heavier muck soils, such as the 'custard apple' belt adjacent to Lake Okeechobee, the subsidence appears to be less than that in the sawgrass peat farther out from the lake. This is due to the higher mineral content and greater density of the custard apple soil.” (Clayton 1936, p. 14).

The Custard Apple Swamp extended up the eastern shore of Lake Okeechobee as far as the border between townships 41 and 42 (Reyes 1855-T41 37; Hardin 1916-T42 R7; Livingstone and Heister 1919-T41 R37)., which is aproximately the point where the West Palm Beach Canal enters Lake Okeecobee. North of this, the narrow strip of swamp forest separating Lake Okeechobee from the Sawgrass Plains changed completely. Cypress swamps replaced the custard apple; the shoreline changed from low and swampy to distinct beaches of white sand; and a sand ridge several feet high paralleled the shore. The cypress forest extended north along the shore approximately to the present location of Port Mayaca

Hydrology

Estimation of pre-drainage water depths for the Custard Apple Swamp is complicated by the almost complete absence of pre-drainage point observations of water depths and by the severity of early drainage (see also Chapter 5, Lake Okeechobee outflows). Lowering of Lake Okeechobee levels during the early 1880s caused water tables to drop several feet below ground in the sawgrass areas bordering the lake and presumably lowered water tables in the Custard Apple Swamp to similar extremes. The fact that water tables were below ground surface would explain the scarcity of observed surface water depths in post-drainage accounts.

We based estimates of the pre-drainage depths and hydroperiods in this landscape on the characteristics of the vegetation (buttressed, enlarged bases of the custard apple trees), and the repeated identification of the area as a “swamp” suggesting that surface water was present much of the time. The misconception that this swamp was higher than adjacent sawgrass derives primarily from the term “custard apple rim” applied to this area. As noted above, the rim appears to have been a post-drainage artifact of subsidence. Additionally, the descriptions of a lower relative elevation of the transitional marsh to the Sawgrass Plain and the preference of deeper water depths for custard apple compared to sawgrass, suggest that pre-drainage water depths were deeper in the Custard Apple Swamp than in Sawgrass Plains and hydroperiods were longer.

We estimate that average long-term water depths ranged from 0.0 feet above land surface at the end of the dry season to 2.0 feet above at the end of the wet season, with a hydroperiod of 11 to 12 months.

Hindcasting

Four mapped (or mapable) sources, all post-drainage, are available for estimating the pre-drainage extent of the Custard Apple Swamp: Kreamer's (1892) map (**Plate 6**), Harshberger's (1914) vetegation map, field notes from the State township surveys conducted in 1915-1916, and the Davis (1943) vegetation map (**Plate 4**). Kreamer's map has been found to be both detailed and accurate in areas where it could be compared with earlier U.S. Township surveys. Unfortunately, it extends only as far east as Range 35. Much of the Custard Apple Swamp is therefore not included. As discussed above, Harshberger's sketch is known to have errors and is too general to be useful for quantifying pre-drainage extents. The Davis (1943) map of the vegetation of southern Florida has been frequently used as an estimate of the pre-drainage extent of the Custard Apple Swamp. The landscape was almost completely obliterated by that time, but Davis considered it sufficiently important that he explicitly deviated from his practice of mapping the landscapes he actually saw and instead estimated a pre-drainage extent. Unfortunately, though his estimates of the westward and eastward extents match well with other sources, he seems to have substantially overestimated the width of the landscape.

The most detailed information on the width of the landscape is available from the field notes of State township surveys carried out in 1915 and 1916, mostly by Otis Hardin. These surveys mapped not only the township lines, but more importantly, the subdivision lines, providing a network of transects, one mile apart, with vegetation described and transitions mapped to the nearest hundredth of a chain (ca. 0.5 foot). The notes mention custard apple, willow, elderberry ("alder"), and sawgrass. Mapping out these notes results in a band of custard apple generally 1.0 to 1.5 miles wide and a willow and elderberry band 0.5 to 0.75 mile wide. As noted previously, the willow and elderberry band may well be largely or completely a post-drainage artifact, and the custard apple band itself may have expanded after drainage.

The mapping derived from the State surveys can be compared with the Kreamer (1892) map where they overlap in Townships 34 and 35. In Township 35, where the landscape is at about typical width, the combined width of the custard apple and willow/elder bands is very similar to the single band labeled “Willow & Custard Apple” by Kreamer. However, further west in Township 34, where the landscape narrowed down to zero, the State survey notes showed a much wider extent than Kreamer’s (1892) map, presumably indicating substantial post-drainage expansion between 1892 and 1916.

We mapped the pre-drainage extents of Custard Apple Swamp and Willow/Elderberry thicket shown on **Plate 13** directly from the State survey notes, with modification at the west end to reflect Kreamer (1892). The specific township surveys used are shown on **Figure 2.4.**

Custard Apple Endnotes

Note: Field measurements are in chains (CHS). 1 Chain = 66ft.

1. A map of Lake Okeechobee sketched in 1838 (Backus 1838) indicates a forested border along the southeastern and eastern shoreline. Although not labeled as to species, this presumably referred to the Custard Apple Swamp, and further north, to cypress.
2. Similarly, a “Map of the seat of war in Florida” (Mackay and Blake 1839) also clearly indicates trees along the southern and eastern shores.
3. A canoe expedition in 1842 led by Lieutenant John Prebles traveled up the eastern edge of the Everglades from Ft. Lauderdale to Lake Okeechobee (Feb. 14-22) and back to Ft. Lauderdale (April 2-10). The expedition apparently came up the long narrow arm of Ridge and Slough landscape (**Plate 8**), making it likely that they reached the lake shore in Township 41 Range 37. The description of crossing a narrow cypress swamp, followed by a sandy ridge would be consistent with other descriptions of the cypress swamp in this township:

   > “At 4:30 P.M. left the Everglades, passed through a narrow belt of cypress swamp, hauled over a sandy ridge, and launched our canoes in the waters of Lake Okeechobee . . .” Prebles (1945 [1883]).
4. The south Florida portion of a map of the State of Florida (Bureau of Topographical Engineers 1846) indicates a 1 to 2 mile wide band of trees around the southern and eastern shores of Lake Okeechobee. The wet area to the south and east of this band is labeled as the “Pah-hay-o-kee or Grass Water known as the Everglades.”
5. In December of 1855, U.S. Surveyor W. J. Reyes surveyed the subdivisions of Township 41 South, Range 37 East. This is the only township of the Custard Apple and Cypress Swamps to have been surveyed by U.S. Surveyors. All others were surveyed much later as State surveys, between 1912 and 1919, after the initial lowering of Lake Okeechobee.

   “Run bet. secs. 2 and 11 West
   40.00 chs set 1/4 sec post, no mound, water too deep.
   48.00 chs across sawgrass to swamp.
   75.97 to east bank of Lake Okeechobee ...
   M.C. referenced by a cypress 9 ins. ... 12 ins.
   3rd rate sawgrass and swamp / ...

   Run bet. secs 10 and 15 West
   3.66 chs to east bank of Lake Okeechobee
   M.C. referenced by a cypress 14 ins. ... cypress 16 ins.
   2nd rate low hammock / ...

   Run bet. secs 14 and 23 West
   30.00 chs across sawgrass to low hammock
   40.00 chs set 1/4 sec post referenced by a Bay 4 ins ... Bay 5 ins
   73.21 chs to east bank of Lake Okeechobee

M.C. referenced by a Bay 4 ins ... cypress 10 ins
2nd rate low hammock and 3rd rate sawgrass / ...

Run bet secs 22 and 27 West
14.00 chs across sawgrass to low hammock
40.00 chs set 1/4 sec post referenced by an Ash 15 ins ... Bay 9 ins
70.51 chs to east bank of Lake Okeechobee
M.C. referenced by a cypress 10 ins ... cypress 14 ins
2nd rate low hammock and sawgrass / ...

Run bet. secs. 33 and 4 West
40.00 chs set 1/4 sec post referenced by a papau 9 ins ... bay 6 ins
45.75 chs to east bank of L. O.
M.C. referenced by a cypress 20 ins ... cypress 24 ins
2nd rate low hammock" (Reyes 1855-T41 R37, p. 1-5).

6. Canova in 1857 East (?) shoreline . When surveyed in 1855, Township 41, Range 37 was all cypress, and no custard apple, so Canova's landing on the east coast was likely further south, in either township 42 or 43, both of which had shorelines of custard apple throughout:

   "Finally his keen eye fell upon tracks, in the sand of the beach." (p. 25)

   "Underneath a group of custard-apple trees, which were growing in the water near the beach, I saw a blue rag fluttering in the breeze,... Immediately afterward I saw a canoe tied up close to the shore." (p. 26)

   "The myriads of custard-apple trees around us were loaded with fruit,... A grove of custard-apple trees, full of fruit, will perfume the air for half a mile around." (p. 29)

7. During an expedition sponsored by the Forest and Stream magazine, the naturalist and writer Fred A. Ober (pseudonym Fred Beverly) reached Lake Okeechobee in the spring of 1874. A map included in Ober's accounts is labeled "Custard Apples" along the south shore, and "Cypress Belt with Sandy Shore" along the east shore (Ober [Beverly] 1874). The land behind and inland of the Cypress Belt is labeled "Saw Grass." The combination of cypress, sandy shore, with sawgrass behind is consistent with other observers. Note that Ober was apparently unaware of the short rivers flowing out of Lake Okeechobee through and into the Custard Apple Swamp:

   "… Three deep bays, each some five miles across, terminate Lake Okechobee at its southern shore. They are lined with the same desolate shores of reeds, canes, and scrubby willows, and the successive points terminate in scraggy 'custard-apple' trees, filled with the nests of cormorants and snake-birds.

   A lone cypress terminates a long point of marsh, and back of this is a deep bay, the last and southernmost.

   Here are the Everglades, where the water of the great lake filters through an immense swamp, through the spongy shores of grass, canes, and lily-roots, through gloomy forests of cypress, to the ocean and the gulf.

   No creek, no river, forms the outlet of the waters of this vast lake; the accumulated drainage of thousands of square miles of territory slowly percolates through the Everglades by thousands of channels with countless ramifications." (Ober 1874b, p. 593).

8. The Times-Democrat expedition started their travels southward in November 1883 from the southern shores of Lake Okeechobee, first exploring a number of short rivers flowing out of the lake:

   "Examining streams, or lagoons, flowing southerly from lake [Okeechobee], we found 8 streams from 1 to 2 miles apart, along south shore. These water courses extend only about one or two miles southerly from lake shore and are from 1 to 200 yards in width; depth of water 8 to 10 feet. Bottom soft mud, no rock. No perceptible current until we get 2 miles from lake, through custard apple swamp. The third stream west of the most easterly one we have selected from which to enter saw grass." (Hopkins 1907).

9. Col. C. A. Hopkins, the expedition's engineer, noted dimensions of the selected stream, and also the presence of camp sites. It is not clear whether "land … two feet above water" refers only to the camp sites, or applied more generally. The presence of so few camp sites suggests that most of the area was at least boggy, if not covered with standing water. According to Capt. Hendry, who participated in the early portion of the trip, the Times-Democrat expedition of 1883 started at South Bay, so this stream was located in Township 44 R36:

   "The stream above named is about 250 yards wide at its mouth and continues from 1-1/4 miles; varying in width from 250 to 20 yards in width; it then narrows to a small creek from five to ten feet deep, through swamp and finally loses itself at a distance of 2-1/2 miles. After leaving the lake 1-1/2 miles, we found a perceptible current flowing southerly. There are three good "camp grounds" on this river; the land in many places two feet above water and exceedingly rich in quality; in fact I have never seen better soil in or out of Florida." (Hopkins 1907).

10. Major A. P. Williams' account parallels that of Hopkins, confirming that the stream eventually merged into the waters of the custard apple swamp. The description of a subsequent marsh of "yma grass, wampu (wampee; *Pontedaria cordata*), and scrub willow" south of the custard apple swamp and prior to the sawgrass is intriguing:

    "The river has narrowed down to a stream ... The boughs of the trees lap over the water, the vines form a perfect net-work to bar our progress... We have gone but a couple of miles when we discover that the river no longer exists, but has lost itself in a dense swamp of custard apples. ... to all appearances, impenetrable thicket" …

    "[About 3 o'clock leave thicket to reach] borders of a marsh of yma grass, wampu or warmpea, and mixed with scrub willow." (Williams 1883 in Wintringham 1964).

11. An 1892 survey and map of potential "sugar lands" along the southeast shore of Lake Okeechobee (Kreamer 1892) indicates a band of "Willow & Custard Apple Swamp" bordering the lake in Ranges 34 and 35. The band is about one mile wide, tapering to "Thickets" less than 1/8 mile wide further west. Given the rapidity of shrub encroachment after initial lowering of Lake Okeechobee levels in the early 1880s (see Chapter 5, Lake Okeechobee outflows), it is likely that the narrow strip of "Thickets" is a post-drainage artifact.

12. In Township 44 Range 35, the Kreamer (1892) map shows a multi-forked Ritta River, about 1 mile long, in sections 1 and 2. Twenty three years later, Hardin (1915-T44 R35) shows an approximately 1/2 mile long, unforked river within Section 1, probably a remnant of Ritta R.

13. W.A. Roberts, "timber estimator and land locator, Ft. Myers, Florida" (Stewart 1907) described the south shore of Lake Okeechobee as including both custard apple and continuous reaches of sawgrass. The sawgrass referred to by Roberts was likely west of Sand Point in Township 43, Range 34:

    "Along the south shore of Lake Okeechobee no banks. A border of custard apple 1/8 to 1/2 mile in width and continuous reaches of saw grass, some of which appear to be 15 feet high. The custard apple was from 4 to 8 inches in diameter and 15 to 20 feet high." (Stewart 1907).

14. An observation by drainage engineer J. O. Wright, most likely made in March 1908, found very low water levels (two feet below ground surface) within an area of organic soil and within the Custard Apple Swamp (Hardin 1916-T42 R37). As Wright was reporting on the progress of drainage, and had just mentioned a similar lowering of 3-4 feet at a different location on the lake shore, this water level is assumed to reflect anthropogenic lowering of the lake:

    "On the south shore of Pelican Lake two trappers were found who had a small garden. They were growing onions, cabbage, peas, turnips, and tomatoes. The muck was 14 feet deep and the water, at the time of the visit [likely March 1908; see p.173], 24 inches below the surface." (Wright 1911, p. 174).

15. A personal letter by Major Frank Coburn Dickey, on a U.S. Army Corps of Engineers survey of Lake Okeechobee shoreline, Feb 7-15, 1910, suggests that the Custard Apple Swamp was wet enough that three feet of drainage would be needed to make it usable. Major Dickey also mentions "swampy" conditions as well as what were apparently intermittent ridges:

    "It certainly was beautiful and a little farther on we came to a clump of trees or brush of custard apples they call them loaded down with morning glory and gourd vines and these strange plants called airplants in blossom. ... It's beautiful here but swampy off of the ridges which run through the place and all green with abundant vegetation."

"The land [along the shore of Lake Okeechobee, South Bay area] is now selling at $50.00 per acre and most of it is under water but the state of Florida is draining it by canals to the Atlantic and the Gulf. ... They are figuring on a 3 ft. drain. That would put the whole section in fine condition." (Dickey 1910).

16. In a State survey of the north boundary of Township 43 Range 34 in 1912, drainage engineer and surveyor F. C. Elliot came to what appears to have been an isolated patch of Custard Apple Swamp. Elliot noted a water depth of two feet, but unfortunately the time of year is not known. 800 feet from the lake shore, Elliot came to an elevated area devoid of custard apple. This might be an example of the intermittent ridges suggested by Major Dickey's letter:

"1st mile East between Sects. 31 & 7 [orig. 6]
40.00 saw grass marsh begins to change to willows and flag. very boggy
56.40 Intersected North bank of the Nine Mile Canal.
80.00 Set stand. Cor. in heavy willow swamp, very boggy.
Soil Muck. Rock 8 ft [below ground surface].

2nd Mile E. bet. Sects 32 & 8 [orig. 5]
4.00 Custard apple swamp, water about 2 ft deep.
34.00 Through Custard Apple to higher ground bordering Lake Okeechobee, covered with dense growth of weeds. Land very fine and elevated.
46.00 Set Meander Corner 50 links in Lake Okeechobee." (Elliot 1912-T43 R34, p. 73-74)

17. Samuel Sanford, formerly a field geologist in South Florida for the Florida East Coast railroad (Chapter 2), does not discuss custard apple along the southern shore of Lake Okeechobee, but does give a detailed description of the relationship between the lake and the Everglades, and mentions the cypress swamp bordering the lake's eastern side. Sanford's work was published in a U.S. Geological Survey Water Supply paper in 1913, and reflects observations made approximately from 1905 to 1913:

"...water...escapes from Lake Okechobee through a canal connecting with the Caloosahatchee and through the saw grass. The short streams around the southern edge of the lake, shown on most maps of Florida, do not flow into the lake but from it. They close up within a few miles and the thick growth of saw grass makes the movement of water in any given direction very slow. Some of the water entering the lake reaches the Gulf and some the Atlantic, the water moving as a mass slowly southward. When the lake rises to about 22 feet above mean sea level it is said to overflow into the Everglades along its whole southern border."

"Arms [of the Everglades] extend farther north, but much of the eastern and most of the northern shore of the lake is bordered by cypress swamps, some of these containing the tallest and cleanest cypress to be found in Florida." (Sanford, in Matson and Sanford 1913, p.54).

18. The botanist and landscape ecologist John Harshberger collected in the Custard Apple Swamp, on June 22, 1912:

"[The Custard-Apple Formation] is one of the most remarkable formations in South Florida (Plate X, Fig. 1). It consists of an almost pure growth of the custard-apple, *Annona glabra* L., with an occasional cypress tree sticking its top above the general level of the crowns of the custard-apple trees. As seen from the cupola of the hotel on the south shore of Lake Okeechobee at the entrance to the South New River Canal [now known as the Miami Canal; Township 44, Range 35], the custard-apple forest extends east and west, as far as the eye could reach, and in a southward direction from the border of the lake, a distance of about 4.8 kilometers (3 miles). (Harshberger 1914, p. 153).

Systematic mapping by others indicates that Harshberger's visual estimate of the Custard Apple Swamp being 3 miles wide was approximately twice the actual width. The township survey for the area of encompassing Harshberger's hotel, Hardin (1915)-T44 R35, indicates only 1 to 1.25 miles of custard apple, followed by 0.5 mile of willow. The earlier agricultural map by Kreamer (1892) shows very similar total width of 1.5 miles of "Willow & Custard Apple."

19. In addition to the width, Harshberger estimated the length of the Custard Apple Swamp along the shoreline. His estimate of the eastern limit is consistent with other sources, but his estimate of the western extent is not:

    The width of the [Custard Apple] formation is in a few places only half a mile and along the south shore of the lake it is separated from the water by a narrow strip of shore line. The location of the extended custard-apple forest, or hammock, is shown on the large map extending on the west from the Three Mile Canal around the southern end of the lake to Pelican Bay and around the shores of Pelican Bay, where the remarkable pond-apple hammock serves as a rookery for various kinds of birds... (Harshberger 1914, p. 153).

    In the Sawgrass Plains section of this chapter it was shown that sawgrass, without intervening custard apple, bordered Lake Okeechobee as far east as Sand Point (T43 R34). Harshberger's depiction of custard apple as far west as the Three Mile Canal (T42 R32; Fig. 2.7) overestimates the landscape extent by ten miles. This either reflects a post-drainage westward expansion of custard apple, or it is simply an overestimate. The "narrow strip of shore line" that Harshberger notes is most likely a post-drainage artifact of lowered lake levels.

20. Prior to the drainage initiated in 1881 by Disston, Lake Hicpochee was surrounded only by dense sawgrass (Sawgrass Plains section, this chapter). Harshberger's observations of shrubs and vines along its shore in June of 1912 confirm that an incipient custard apple swamp forest, replete with associated shrubs and vines, could invade sawgrass shorelines, provided that water levels had been lowered:

    > "Lake Hicpochee is a large lake with a basin like a soup plate, surrounded by saw-grass marsh. … Scattered along the shores of the lake were noted low custard-apple trees, *Annona glabra* L., willows, *Salix* sp., waxberry, *Myrica (Cerothamnus) ceriferus* (L.) Small, elder, *Sambucus canadensis* L. Over these shrubs climbed a vine, *Ampelopsis arborea* (L.) Rusby, and a monn-flower, *Calonyction aculeatum* (L.) House." (Harshberger 1914, p. 149).

21. The following description by Harshberger seems anomalous when compared with other observers' descriptions of custard apple trees growing in water. Harshberger's description appears to suggest that the area was dry when he collected; where one would expect mentions of water, Harshberger instead refers to "ground" and "forest floor." Pre-drainage wet season water levels would be expected to be well above ground surface by the end of June, so Harshberger's observations either suggest an unusually dry year or, more likely, the effects of pre-1912 drainage:

    > "The main forest of custard-apple trees south of the lake consists of a close stand of trees 9 meters (30 feet) tall, forming a dense shade, so that a twilight pervades these solitudes. The branches are twisted and interlocked and the crown is therefore very dense. The undergrowth is close, so that it is with difficulty that one can penetrate the forest (Plate X, Fig. 1). Three ferns are conspicuous on the ground. A rare fern, new to Florida, *Meniscium serratum* Cav., was collected by me, as also the large tropic fern, *Acrostichum aureum* L. and *Dryopteris patens* (Sw.) Kuntze. All of these ferns, in sporulation on June 22, were growing out of the rich, black humus covering the deep muck of the Everglades. This fact suggests the natural succession of vegetation, the custard-apple trees invading a saw-grass strip, so that the custard-apple forest is subsequent to a saw-grass marsh in the region under discussion. The southern elder, *Sambucus intermedia* Carr., in full flower on June 22 occupied the more open and therefore lighter parts of the forest. Two herbs, however, are noteworthy as growing in almost pure associations on the forest floor. In one place, we find *Persicaria (Polygonum) punctata* (Ell.) Small covering the ground, in other places *Commeline erecta* L. is exclusive. Two other herbs are important elements of the herbaceous contingent, viz., the false nettle, *Boehmeria cylindrica* (L.) Willd., and *Jussiaea peruviana* L., while the monn-flower, *Calonyction (Ipomeae) aculeatum* (L.) House, climbed up the trees. Especially on the lake, or open side of the forest where it covers every available support in dense hanging masses. …" (Harshberger 1914, p. 154).

22. Harshberger was apparently curious why custard apple was present along some part of the Lake Okeechobee shoreline and not along others. He conveys a temperature-related hypothesis. Other hypotheses relate it to a difference in soil type:

    > "It seems that the custard-apple, or pond-apple tree, is extremely sensitive to frosts, and its growth in a narrow strip along the south shore of Lake Okeechobee is to be explained by the ameliorating effect of the large, shallow body of water, which warms up rapidly in the sun, lying to the north and west of the southern shore line of the lake." (Harshberger 1914, p. 154).

23. On a boat trip up the North New River canal in November 1913, the botanist and frequent south Florida observer John K. Small described the Custard Apple Swamp:

    > "As we approached the lake [coming north along the North New River Canal] a gradual elevation of the land was noticeable. This higher land supported dense hammocks, consisting chiefly of pond-apple or custard-apple (*Anonna glabra*), while the most conspicuous and everblooming shrub there is the southern elder (*Sambucus intermedia*). However, by far the commonest plant of all is the high-climbing vine, known in cultivation as the moon-flower (*Calonyction aculcatum*). (Small 1914, p. 72-73).

    It is not clear whether the "higher land" and "gradual elevation" noted by Small accurately reflect a pre-drainage distinction between the Custard Apple and the Sawgrass Plains elevation, or whether these already reflect differential soil subsidence due to differing mineral contents.

24. During the 1913 exploration, Small describes what he calls "mud flats" between the Custard Apple shore and Torry Island:

    > "Access to the hammocks of this island [Torry Island] is often difficult chiefly on account of mud-flats which extend far from the shore [of Lake Okeechobee]. These expanses consist of the most non-resistant liquid mud I have ever experienced. They support a growth of maiden-cane (*Panicum hemitomon*), bulrushes (*Scirpus validus*), water-hyacinth (*Piaropus crassipes*), water-lettuce (*Pistia stratiotes*) and pennywort (*Hydrocotyl umbellata*), but any one who sets foot thereon sinks in the mud to an indefinite depth about as readily as in pure water." (Small 1914, p. 72-73).

    The persistence of a thick layer of this "most non-resistant liquid mud" with specific gravity very nearly equal to that of water suggests an organic floc rather than a mineral sediment. Particularly when contrasted with other descriptions, e.g. the lake "standing high and clear" (Will 1964), the presence of these sediments may be a reflection of lake levels already lowered by drainage.

25. Small's description of the Custard Apple Swamp itself is very similar to the previous one. The buttressed trunks likely reflect growth in water, at least under pre-drainage conditions. (See also Dachnowski-Stokes 1930):

    > Behind these mud flats [i.e., those between Torry Island and the shore of Lake Okeechobee] one meets with a very dense line of pond-apple or custard-apple trees with curiously buttressed or branched trunks. These trees often form hammocks acres in extent to the exclusion of all other kinds. In these groves, other vegetation is scant. Various vines struggle to the tops of the trees for sunlight, those more conspicuous are a kind of gourd, and still more surprising, a high-climbing dew-flower (*Commelina*). This plant with its stout fleshy stems and branches climbs all over the limbs of the pond-apple trees, often reaching to the highest branches. Air-plants were represented by both orchids and bromeliads." (Small 1914, p. 72-73).

26. The following observation by Small indicates that the custard apple swamp extended eastward from the southern shore of the lake up to Pelican Harbour (T42 R37), and describes the cypress swamp that continued further up the eastern side. Small also distinguishes the muddy and irregular shore characteristic of the Custard Apple Swamp from the white sand shore and ridge of the cypress swamp:

    > "After devoting as much time to Pelican Lake [drained and no longer exists; c.f. Fig. 2.7 and Hardin (1916)-T42 R37, Sections 17, 16, and 9] as our schedule allowed, we returned to Pelican harbour [Pelican Bay] and passed outside, where we began our course northward along the eastern shore of Lake Okeechobee. [The point rounded by Small's party as they passed out of the inlet to Pelican Lake was "Bacom Point, often labeled "Cypress Point" on pre-1900 maps; e.g. Fig. 2.6. Just above Pelican harbor and northward from it both the land and the vegetation undergoes an abrupt and a conspicuous change. A ridge of fine white siliceous sand runs parallel with the shore of the lake. This ridge is several feet high and varies, as far as we observed, from about twenty-five feet to two hundred feet in width. Behind this ridge lies a dense cypress swamp. Along the lakeside the shore is open and of clean sand, and not of mud as it is a little further south. ... Thus a complete change of scenery takes place. The low muddy and irregular shore with its dense growth of pond-apple gives place to a ridge clothed for the most part with a remarkable growth of bald-cypress (*Taxodium distichum*) and palmetto (*Sabal Palmetto*). In appearance this ridge seems to be a series

> of ancient sand-dunes... These sand-dunes support a very dense growth of the two above-mentioned trees. The growth is almost impenetrable in many places." (Small 1914).

Small's description of cypress and a sandy ridge supports the hypothesis that the Rodgers expedition in 1842 came up the former narrow arm of Ridge and Slough landscape paralleling the present L-8 canal, and that the expedition reached the lake in Township 41 Range 37.

27. The soil surveyors Baldwin and Hawker made detailed measurements of soil characteristics and water levels in 1915 along 6-mile long east-west transects, one at each milepost along the North New River canal. (In the Custard Apple area these transects were centered within T44 R36, extending about 1/2 mile into R37). Data collected by Baldwin and Hawker (1915) indicate that water levels within the Custard Apple Swamp as well as in the adjacent Sawgrass Plains were well below pre-drainage levels, and below ground surface already by 1915 (see **Figure 3.3**).

28. Only three years after the opening of the North New River canal, Baldwin and Hawker noticed a southward spread of willow, associated with drier, drainage-induced conditions. This reflects the lowering of Lake Okeechobee through the combined influence of Disston's earlier efforts to the west and the State Canals to the southeast:

> "Two or three miles south of the lake willows are gradually encroaching upon ground which under former conditions of poorer drainage supported a heavy growth of saw grass." (Baldwin & Hawker 1915).

29. Baldwin and Hawker considered the Custard Apple Swamp to be narrow, and mapped it as two parallel strips of "Muck" and "Peaty muck" soil, each approximately one mile wide. It is not clear whether the "higher rim" would have been present under pre-drainage conditions or whether it was a post-drainage artifact of greater subsidence in the sawgrass soils than in the custard apple soils:

> "These poor drainage conditions existed over the entire area of the Everglades surveyed, with the exception of one extremely narrow higher rim bordering Lake Okechobee." (Baldwin & Hawker 1915).

30. A survey of Township 42 Range 37 reported an area of high ground with custard apple in Sections 8 and 9, directly adjacent to the northeast shore of Pelican Lake, and about 1/2 mile inland from the Lake Okeechobee shore. It may have been a local high spot associated with Pelican Lake rather than a continuous ridge associate with Lake Okeechobee, as high ground is not mentioned in the adjacent Sections to the north or south:

> "Run South along west side of Sec. 9
> 55.00 [chs.] from custard apple along the edge of the Lake [Okeechobee]
> 70.00 from low to high land
> 77.00 high land to low land
> 80.00 … In the edge of Pelican Lake
>
> Run west along the south side of Sec. 8
> 11.50 to high land in custard apple
> 70.00 to Lake Okeechobee" (Hardin 1916-T42 R37, p. 7)

31. Two former river beds reported during a 1916 survey of Township 42 R 37 were likely part of the eight short rivers mentioned by the Times Democrat expedition. The surveyor's referral to them as "old" and "Dead," i.e., dried out, suggests that by 1916, water levels in Lake Okeechobee and in the surrounding Everglades had already decreased sufficiently to drain these rivers. The width of the "old river" in Section 29 was 5.43 chains or about 360 feet, at a location at least 3/4 of a mile from the shore of Lake Okeechobee:

> "Run north along west side of Sec. 32
> 20.00 set 1 x 3 x 5 in custard apple
> 37.45 to dead willow
> 40.00 set 1 x 3 x 5 north bank of Dead River
> 75.00 custard apple to willow
>
> North along the west side of Sec. 29
> 31.33 willow to custard apple
> 54.57 old river bed

60.00 set 1 x 3 x 5 north bank old river
69.20 custard apple to alder and willow"

(Hardin 1916-T42 R37, p. 9)

32. A river or creek, "Forked River," connecting with Lake Okeechobee was reported in Township 43 Range 37. It was shown in dashed lines on the plat map, suggesting it may have been dry at the time of the survey. The wider width, 260 feet, was close to a bay of Lake Okeechobee; the narrower width of 32 feet about 1/2 mile from the bay:

"West along the North side of Sec. 18
37.68 East bank of creek
38.16 west bank of creek

North along the East side of Sec. 7
27.60 south branch [probably 'bank'] of Forked River
31.60 north bank of Forked River" (Hardin 1916-T43 R37, p. 7-8)

33. The plat map for Township 44 Range 36 indicates mouths of eight different creeks or rivers. Measured widths are given for two for these where they crossed surveyed section lines: for an unnamed "slough" and for the Maines River. The slough was about 60 feet wide, 1/4 mile from the shore; the Maines River was 178 ft wide, about 1/4 mile from lake shore and narrower (138 ft) closer to the lake, about 1/8 mile from shore:

"East along North side section 14
34.00 West side slough
34.93 East side slough, into alder thicket." (Hardin 1915-T44 R36, p. 8)

"East on North boundary section 13.
12.50 into custard apple and alder thicket.
16.30 West side Maines River, running N.W.
19.00 East side Maines River.

North on West boundary section 12.
17.60 From custard apple into open joint grass.
20.93 South side Maines River
23.02 North side Maines River.
26.00 into dense custard apple. (Hardin 1915-T44 R36, p. 6)

34. In Township 44 Range 36, survey notes from 1915 suggest the presence of a transitional marsh between the Sawgrass Plains and the Custard Apple Swamp. Reference to "open glade" and "[water] lillies" suggests an area wetter than sawgrass. It is not clear what species is meant by "wild millet." Elsewhere in the same notes the transitional marsh is described as "open glade millet and flags." The Times-Democrat expedition of 1883 also mentioned an intermediate marsh in this same township, so perhaps their "yma grass" is wild millet:

"North from S.W. corner section 21
20.00 … in open sawgrass

North along West side section 16.
3.50 from open glade into willow
7.85 from willow into open glade wild millet and lillies.
62.40 From willow into scattering custard apple." (Hardin 1915-T44 R36, p. 10).

35. Vegetation mapped along the subdivision lines of Township 44, Range 35 in 1915 (Hardin 1915-T44 R35) were used to map the extent of the Custard Apple Swamp and the associated band of elderberry/willow. The relevant north-south lines are included below. The other subdivision lines were labeled "In open saw grass / Soil: black muck, 10' to rock." A southern boundary line for the Elderberry/Willow area estimated from the subdivision information agrees very closely with a southern boundary of "Willow & Custard Apple Swamp" shown on Kreamer (1892). In both cases the combined width of custard apple plus willow averaged about one and a half miles:

"North along West side Section 12.
6.00 from open glade of wild millet and flags into willow
46.10 from willow into custard apple.
80.00 In dense custard apple / Soil: black muck, 10' to rock.

North along West side section 1.
75.00 from custard apple into open ground.
Low Water lake Okeechobee.

North along West side Section 11.
5.80 from alder [elder, *Sambucus*] into open sawgrass [this elder is likely along the Miami Canal]
45.57 from saw grass into willow
67.00 from willow into custard apple.
80.00 …In custard apple / Soil: black muck, 10' to rock.

North along West side section 10.
74.00 from saw grass into willow
80.00 …In thick willow / Soil: black muck, 10' to rock.

North along West side section 3.
78.75 from willow into custard apple." (Hardin 1915-T44 R35, p. 2-6).

36. Pre-drainage vegetation near the Lake Okeechobee shore was mapped from subdivision information from Hardin (1916)-T43 R34. The relevant north-south lines are shown below. Other lines were labeled "In saw grass, soil muck, 8' to10' to rock." When compared with Kreamer (1892), Hardin shows a much wider forest of custard apple and willow. The combined width on Kreamer (1892) was 0 to 3/4 mile; on Hardin the custard apple 1/8 to 1 mile and the willow was ½ to 1 ¼ miles. In contrast to Township 44, Range 35, the 1916 township survey widths are much wider than the width on the1892 Kreamer map. This likely reflects post subsidence expansion of both the custard apple and the weedier willow bands:

"North along the West side of Section 25
80.00 …In custard apple, soil muck, 8' to rock.

North along the West side of Section 26
80.00 … In willow, soil muck, 10' to rock.

North along the West side of Section 23
80.00 … In custard apple, soil muck, 10' to rock.

North along the West side of Section 22
80.00 … In willow, soil sandy loam.

North along the West side of Section 15
80.00 …In willow, soil muck and sand.

North along the West side of Section 10
20.00 set 1 x 3 x 6 in custard apple
51.02 meander corner to Lake Okeechobee.

North along the west side of Section 16
20.00 set 1 x 3 x 5 in willow
80.00 …In willow, soil muck, 3' to sand

North along the west side of Section 9
20.00 set 1 x 3 x 5 in custard apple / …
49.02 set meander corner to Lake Okeechobee
65.00 edge of water Lake Okeechobee" (Hardin 1916-T43 R34).

37. In a later botanical exploration of Lake Okeechobee, (May 5 -15, 1917), J. K. Small gives a vivid impression of the substantial lowering of Lake water levels that had occurred between November 1913 (his previous visit) and May 1917:

    "Upon entering the lake [from the North New River Canal] we were lost. The water level was from five to seven feet lower than it formerly had been, and instead of an uninterrupted expanse of water, great areas of lake bottom extended as far as the eye could see, with uncertain channels running here and there between them." (Small 1918, p. 687-689).

38. The lowering of Lake levels from five to seven feet by May 1917 apparently dried out the peat of the bordering Everglades so much that it was subject to fire:

    "…we found many parts of the country afire. Over a large area fire had eaten into the 'peat,' and numerous subterranean fires were revealed by the smoke which came up through craters where the substratum had burned away and the superimposed 'peat' and ashes had caved in. ...

    Fires were so numerous that the region might well be designated 'The Land of Thousand Smokes.'" (Small 1918, p. 691).

39. In addition to allowing the bordering peat to burn, the lowered Lake levels allowed the peat to de-water and compact:

    "The lowering of the water in the lake had naturally lowered the water table in the 'peat,' which normally contained a very large percentage of water. Being deprived of this moisture, the 'peat' had shrunk, and in many instances the root systems of the trees were clearly exposed, particularly in the case of the cypress, where the connected system of roots and 'knees' was beautifully demonstrated." (Small 1918, p. 694).

40. Small described the Custard Apple swamp as "impenetrable except with the aid of a machete." He also noted that it varied between dense, exclusively custard apple forest and a more mixed forest of custard apple, elder, and ash. This variation is consistent with the descriptions from the State Township Surveys executed by Hardin in 1914-1916. The only difference is that Small did not mention the willow extensively found by the Township surveyors:

    "In some places pond apple trees and ferns existed in association to the exclusion of nearly all other woody and herbaceous vegetation. Other areas were densely clothed with an impenetrable growth of southern elder, which bears flowers and fruits continuously throughout the year. Here and there were groves of the pop ash (*Fraxinus*), or of the live oak (*Quercus*). The cypress was represented usually by isolated trees." (Small 1918, p. 694).

41. In 1918, the naturalist Willis S. Blatchley noticed extensive changes in the vegetation of the southern shore of the lake, similar to those described by Small one year earlier:

    "Thursday, March 7, 1918. ... The one feature of the trip which brought sorrow unto my soul was the sight of the changes wrought by man in the Lake Okeechobee as I knew it in 1911 and 1913. Where then it spread free and unhampered over a vast area with shores of living green, now scores of square miles of its southwestern shore have been drained, the old lake bottom now showing as tracts of bare muck and ooze, or in part cultivated to cabbages and tomatoes. On its southern and southeastern sides the shores and marshes are now dry, the custard-apple, elder and other shrubs mostly dead, hideous, sprawling, scrawling ghosts of the living green of days agone." (Blatchley 1932).

42. A 1919 resurvey of the south boundary of Section 33, Township 41 South, Range 37 East encountered a sandy ridge, about 150 feet wide and less than 250 feet from the shoreline. This ridge was within the cypress forest bordering Lake Okeechobee. The forest was reported as "dense timber and undergrowth," with cypress of 14 to 30 inches diameter, bays of 7 to 12 inches and a cabbage palm. No custard apple was mentioned. Course west:

    "40.40 ... enter dense timber bears N and S.
    41.50 chs to sandy ridge 2 to 4 ft. above general level of the land. bears N. 30° E.
    44.30 chs. leave timber, road from Canal Point to Pahokee...enter dense sawgrass and weeds 4 to 8 ft. high.
    45.78 chs. to the meander corner [on shoreline Lake O.]" (Livingston and Heister 1919-T41 R37, p. 11-12).

43. Alvin Whitney, professor of forestry at the New York School of Forestry in Syracuse and also an Everglades land buyer echoes Small's concerns about the peat fires associated with lowering of Lake Okeechobee:

    "I cannot imagine any worse calamity than the burning of the very soil. It seems to me that both County and State authorities must be criminally negligient, and their drainage development worse than a farce." (Whitney 1924, in Meindl 1996).

44. Scientists from the Everglades Agricultural Experiment Station note the different soils in the Custard Apple Swamp and adjoining Sawgrass Plains, relating the difference to lake overflows. As noted earlier, the "slight elevated rim" may, especially as late as 1927, be an artifact of differential soil subsidence:

    "Along the southern and eastern shores of Lake Okeechobee there is a narrow and slightly elevated rim from 1 to 2 1/2 miles wide of a true muck, locally known as "custard apple" land. On the average this muck contains about 40 to 50 percent of inorganic matter, or ash, in contrast with 9 to 12 percent in the case of the raw saw-grass peat of the open Glades. Since this area of true muck is in the line of natural overflow from the lake, it appears to have had its mineral content developed largely as outwash of silt and fine sand from the lake." (Allison et al. 1927, p. 38).

45. The same scientists also described a drainage-induced pattern of plant succession that widened the band of woody vegetation bordering the lake. This echoes an observation made twelve years early by Baldwin and Hawker (1915):

    "In this connection ["poor plant response usually associated with ... raw saw-grass soils at the Everglades Station"] it is interesting to note that a number of weeds and other non-agricultural plants are found to thrive luxuriantly in this soil environment after it has been exposed to the influence of drainage for a time. Among these, elder (*Sambucus intermedia* Carr), "careless weed" (*Amaranthus* sp.), dog fennel and others seem to follow in the displacement of the original saw-grass growth which becomes naturally weakened as the water recedes." (Allison et al. 1927, p. 39)

46. In the 1925-1926 Biennial Report to the Everglades Drainage District, the chief drainage engineer, F.C. Elliot, clearly stated the importance (albeit negative, from his perspective) of Lake Okeechobee outflow into the Everglades:

    "Since the drainage of the Everglades depends in so large degree upon the control of Lake Okeechobee to prevent overflow of Everglades lands by this lake, ... attention is invited to the subject." (Elliot 1927, p. 30).

    Elliot also noted a drainage-induced decline in Lake level for the period 1915 to 1918. [In the report, Elliot makes clear his impatience with the slow pace of canal drainage of the Lake, so Elliot's estimate of two to three feet lowering is unlikely to be an overestimate.] This decline suggests that Lake overflows into the Everglades through the Custard Apple Swamp were reduced, possibly eliminated, as early as 1918:

    "[The] cumulative effect [of the "long drainage canals"] in a period of four years probably represents a total of two to three feet." (Elliot 1927, p.).

47. In a 1929 comparative study of the soils near Lake Okeechobee, Hammar, like Allison et al. (1927), ascribed the high mineral content of the custard apple soils to outflows from Lake Okeechobee:

    "The presence of the larger amounts of silicon, aluminum, and iron in the custard apple soils could be explained by assuming that these elements were washed in by over-flow water from Lake Okeechobee. This agrees well with the fact that the custard apple soil is found in a narrow strip parallel to and adjoining the lake shore and is found to be much wider on the southeastern side where the low sand ridge, which practically surrounds the lake, is absent." (Hammar 1929, p. 9).

    Hammar's observation of the absence of a sand ridge in front of the custard apple shore line appears to be correct (c.f. Small 1914), but he over generalizes in suggesting that the sand ridge was present practically everywhere else. While there was definitely a sand ridge along the eastern shore in front of the cypress, and possibly also along the northern shores, the western and southwestern shores were banks of organic soil (see Sawgrass Plains section; this chapter).

48. In a book published in 1929, J. K. Small noted continued loss of the Cypress Swamp along the eastern shore, apparently due in part to lowering of water levels in Lake Okeechobee. Only fifteen years after his 1914 description of the cypress swamp portion, he lamented its destruction:

> "The two processes [of drainage and fire] are tending to eliminate all native life from the state. We [Small's party] made incursions into the remains of the old marginal hammock of the lake. This hammock has been referred to in its virgin condition, and after it had been ravaged by the axe and fire. The wanton destruction continues! We walked through the skeleton of the hammock. The once deep humus was gone. In its place white sand met the eye. Even the ashes of the humus had been washed away. Some of the giant cypress trees (*Taxodium distichum*) were prostrate, some were standing, either dead or alive, but only to emphasize the almost complete destruction. Where the root systems of the big cypress trees were once buried in several feet of humus so spongey that one could walk in it only with difficulty, not a bit of humus remained. ... There the magnificent monument that took ages to construct has been wrecked with the fraction of a generation." (Small 1929).

49. Dachnowski-Stokes, a soil scientist and peatland ecologist working closely with the Everglades Agricultural Experiment Station around 1930, studied soil pits and profiles throughout the northern part of the Everglades:

> "A striking and important feature of the Everglades is the raised form of the southern shore of Lake Okeechobee. In cross section the surface forms a curve, abrupt at the margin of the lake, sloping gently southward from twenty-one feet just south of Lake Okeechobee to about six feet above sea level west of Miami." (Dachnowski-Stokes 1930).

Dachnowski-Stokes' description of the cross section of the soil surface southward from Lake Okeechobee is very likely accurate for 1930, but not necessarily for pre-drainage conditions. The soil had almost certainly subsided during the fifty years of drainage that preceded 1930 (c.f. Chapter 3 and Herr 1943), which notes five feet of subsidence at the lake shore by 1943). As only the organic fraction of the soil subsides, the much lower organic fraction in the Custard Apple soil (50% vs. 90% in the Sawgrass Plains) likely resulted in less subsidence, forming an artificial, anthropogenic custard apple "rim." Dachnowski-Stokes himself notes an effect similar to this:

> "Extensive drainage operations have caused, however, compression of the canalward edge of the Everglades, often changing the characteristic position above sea level of the main layers of peat. The profile sections along the south shore of Lake Okeechobee and the canals of the Everglades, it will be noted, show the discrepancy due to settling from drainage and the differences in the surface contour which now conform partly with the bedrock topography, but chiefly are the result of fires and oxidation." (Dachnowski-Stokes 1930).

50. Dachnowski-Stokes hypothesized an origin of the Custard Apple Swamp in the context of the geological origin of Lake Okeechobee. His observation that the enlarged bases were found in the older trees suggests a distinction between wetter pre-drainage conditions (older trees) and drier post-drainage conditions (younger trees without enlarged, water–adapted bases):

> "When the waters again fell and withdrew to a lower level, the present Lake Okeechobee came into existence. Lowering of the water table exposed a narrow zone of sedimentary mud flats on the south shore of the lake, and was accompanied by the rapid invasion of deciduous broad-leaved trees and shrubs. A dense growth of custard apple trees (*Anona glabra*) became dominant and formed a forest in which other tree-like vegetation was scant. Many of the older trees had enlarged bases induced by the influence of submergence in water." (Dachnowski-Stokes 1930).

51. Dachnowski-Stokes' estimated depth of Lake Okeechobee outflows is similar to that of Sanford and Matson (1913). His description of outflows along "the entire south shore" suggest simultaneous outflow through the Custard Apple Swamp as well as through the Sawgrass Plains that bordered the Lake just west of the custard apple:

> "Prior to drainage operations the lake did not rise to a higher stage than 22 1/2 feet because the lake overflowed its banks along the entire south shore." (Dachnowski-Stokes 1930, p.93-94).

Note however that there are a number of descriptions of the lake level exceeding 22.5 feet (c.f. Chapter 5, Lake Okeechobee section).

52. George B. Hills, an engineer, conducted the 1913 survey party that crossed the Everglades from West Palm Beach to Lake Okeechobee (Florida Everglades Engineering Commission 1914; Hills 1931), and was involved in Everglades drainage issues for many years. His description of Lake Okeechobee water levels being at about

the level of the "muck lands along its shores" applies to the overflowing portion of the shoreline, that is, the Custard Apple Swamp to the south and east, and the Sawgrass Plains to the southwest and west. Hills' description of the Everglades being "continuously saturated and constantly subject to inundation" by outflows from Lake Okeechobee is very consistent with the historical sources described in the Sawgrass Plains landscape:

> "Under natural conditions preceding any reclamation of the Everglades, the muck soil about the lake had a general depth of ten to twelve feet and a surface elevation about 21 feet above sea level. …
>
> Under those natural conditions the normal elevation of Lake Okeechobee was approximately that of the surface of the muck lands along its shores. Any increase in height of the lake resulting from floods in its tributaries resulted in the discharge of such flood waters upon the muck lands of the Everglades, there to remain until they had evaporated or gradually worked their way to the sea. The Everglades, therefore, functioned as the natural outlet for Lake Okeechobee and its tributary waters.
>
> Under such conditions it is apparent that the muck lands of the Everglades were continuously saturated and constantly subject to inundation by waters of outside origin." (Hills 1931, p. 3).

53. In a paper with a soil scientist from the Everglades Experiment Station, Dachnowski-Stokes described the southward spread of shrubby vegetation similar to that mentioned by Baldwin and Hawker 15 years earlier:

> "At present a displacement of the sawgrass vegetation ... is going on due to the encroachment of broad-leaved and evergreen shrubs and trees as well as elder growth and miscellaneous weed growth. ... On the Everglades side of this [custard apple] belt a transition zone of shrubs, bordering the Custard Apple belt and invading the sawgrass marsh, consists of willow, *Salix longipes* (Fig. 6) and elder (*Sambucus intermedia*), as well as dense growths of weeds, especially pigweed, *Amaranthus* sp. (Fig. 7), *Eupatorium* sp., *Boehmeria* sp., and others. Among the coarser grasses, Bristly foxtail, *Chaetochloa magna*, *Panicum dichotomiflorum*, *Echinochloa walterii* and para grass, *Panicum baibinade*, are most common in the drained or partially drained sections." (Allison and Dachnowski-Stokes 1932).

This expansion of the willow-elder band likely explains the increased width of the Custard Apple Zone estimated by Davis (1943) (Plate 4) as compared to the narrow width described in the 1915-1916 State Township surveys. The following comments on southward encroachment reinforce the impression that the original tall, dense sawgrass of the Sawgrass Plains was dependent on deeper water conditions than those found in the 1930s:

> "The interesting manner in which these [encroaching] plant groups appear upon the higher land or in better drained positions, as along canal banks, is extremely interesting from the standpoint of ecology of the region as well as that of soil development. They compete with the sawgrass both directly and through its weakened condition brought about by the lowering of the water table that has followed drainage. In consequence of these conditions of competition the sawgrass growth in the Everglades is receding rather rapidly from the higher land near the lake and from positions adjacent to drainage lines, and its place is being taken by the other plants referred to." (Allison and Dachnowski-Stokes 1932).

54. B. S. Clayton, a drainage engineer at the University of Florida, Agricultural. Experiment Station in Belle Glade who studied the custard apple and sawgrass soils of the northern Everglades, confirms that the sawgrass soils subsided more than the custard apple ones. This makes it very likely that the commonly referred to "custard apple rim" was in fact a man-made artifact of drainage:

> "In the heavier muck soils, such as the 'custard apple' belt adjacent to Lake Okeechobee, the subsidence appears to be less than that in the sawgrass peat farther out from the lake. This is due to the higher mineral content and greater density of the custard apple soil." (Clayton 1936, p. 14).

55. Clayton's description of an intermediate soil between the [former] Custard Apple Swamp and the Sawgrass Plains makes it clear that this is a post-drainage phenomenon. "Weed" land reflects the well-documented invasion of formerly dense sawgrass by weedier annuals and shrubs; the partially decomposed sawgrass peat reflects lowered water tables exposing the topsoil to aerobic decomposition, and the presence of weeds or

elderberry on a sawgrass soil confirms a shift in vegetation. The description of the sawgrass subsoil as brown fibrous peat matches the description from Capt. Menge's 1880s excavations of the Thirteen Mile Canal:

> "Between the Okeechobee muck and the saw-grass peat soil is an intermediate type commonly called 'elderberry' or 'weed' land. The top soil is of a fibrous material more decomposed by weathering than the typical saw-grass soil. The subsoil, though principally composed of the brown fibrous layers of saw-grass peat contains layers of plastic, sedimentary muck. The area of 'weed' or 'elderberry' land is small." (Clayton 1936, p. 2).

56. By the 1940s, the soils of the northern Everglades had subsided about 5 feet (Herr 1943, Endnote ; Davis 1943; Jones et al. 1948). The fact that the soils of the former Custard Apple Swamp remained "relatively high" despite such drastic subsidence most likely reflects differential subsidence, that is, greater loss of elevation in the higher organic matter sawgrass soils. This further reinforces the impression that the so-called "custard apple rim" may have been an artifact of drainage:

> "Being relatively high, it [the Okeechobee Muck] becomes very dry in winter and irrigation is necessary, especially for truck crops." (Evans and Allison (1942).

57. Ben Herr was Chief Engineer of the Okeechobee Flood Control District from 1929 to sometime after1943. His description of the original shoreline condition is similar to that of Small (1914). Herr's description of the 1943 elevation of the former custard apple swamp indicates a dramatic decline--five feet--from the pre-drainage elevations of 21 to 22 feet:

> "In the original state, the south shore of the Lake was not clearly defined[,] being low, irregular and swampy. The elevation of the land is now from 16 to 17 feet above sea level which is about level with the normal lake level." (Herr 1943).

58. Herr's description of Lake Okeechobee outflows keeping the Everglades flooded "most of the year" is very similar to Hills (1931) and to the pre-drainage descriptions of the Sawgrass Plains bordering the lake:

> "Originally the Lake had no direct outlet to the sea. The excess of water from rainfall and inflow over evaporation spilled over the low southern shore into the Everglades. This water together with the rainfall kept the Everglades flooded most of the year." (Herr 1943).

59. Herr's estimate of the elevation of lake overflow at 21 to 22 feet is very similar to ones given earlier by Sanford and Matson (22 feet), and by Dachnowski-Stokes (22.5 feet):

> "The maximum elevation of 19.1 for the period 1915-1924 is probably lower than the maximum for prior [i.e., pre-drainage] periods. The shore growth, high water marks and previous reports on the Everglades all appear to agree that the Lake reached an elevation of from 21.0 to 22.0 at times of flood prior to 1915." (Herr 1943).

60. An analysis by an engineer with U.S. Army Corps of Engineers, Jacksonville, (Schrontz 1942) indicates that, for the period 1916 to 1936, the typical range in elevation of the lake between the dry and wet seasons of any given year was on the order of two feet.

61. Lawrence Will, a businessman in Belle Glade and at one time a dredge operator on Cape Sable (Will 1967) writes a vivid account of Lake Okeechobee and the Custard Apple Swamp in his book, *A Cracker History of Lake Okeechobee*. However, although it might seem to describe pre-drainage conditions, a number of details strongly suggest that Will first saw the area well after the first influences of drainage:

> "Before the dredges crashed through the custard apple woods to start the first canals, the lake most always stood high and clear, unbroken except for those islands Kreamer, Torrey, Ritta and Observation. From the Lone Cypress at Disston's Three Mile Canal a boatman could lay a straight course to most anywhere on the lake without a thought of reefs or shoals or bars.
>
> When I first saw this lake it was still wild. Excusing the trifling settlements at Utopia, Ritta and Tantie, a score of fishing camps, and the openings to four unfinished canals, its swampy shores hadn't changed a whit since Zachary Taylor fought the redskins ... But I tell you boy, it was beautiful, and sort of inspiring too.
>
> ... whether you were stalking wild hogs under the shadowy, vine roofed custard apple trees, or ..., you couldn't help but feel the grandeur of the lake's expanse and the beauty of its unspoiled wooded shores.

> Dense forest ringed the lake around. ... On the southwestern arc they [trees] were more sparse, with great stretches of willow and elder bushes. Here the lake bottom was so flat, grown over with flags, bonnets and high grass, that when the lake rose after the summer rains, the shore line could move back for a half dozen miles or so. But the south shore and half way up the eastern side was something else again.
>
> Here were the custard apples, a solid belt of tropical trees, blanketed with a moonvine cover, which stood, two miles or more in width, without break or opening, from near Clewiston' Sand Point, slap around to Port Mayaca. 32,000 acres of custard apple woods there were, the most of these trees, I wouldn't doubt, on the whole blamed continent of America.
>
> Although the shores were for the most part black muck, low and flat, there were some fine sandy beaches too. Along the east side for eighteen miles lay beautiful East Beach,...
>
> ... Originally, no rivers flowed out from the lake, unless you count the Caloosahatchee, connected indirectly by its chain of lakes and sawgrass marshes. The lake's main outlet, when it was brimming full, was the overflow, trickling and spilling over its whole south side across the custard apple ridge and flowing through the dead rivers there." (Will 1967).

The "great stretches of willow and elder" that Will describes on the southwestern shore are definitely a post-drainage observation, as pre-drainage sources (Sawgrass Plains section, this chapter) make it clear that this shoreline was originally dense sawgrass only, while numerous post-drainage sources remark on the invasion of willow and elder onto drained sawgrass land.

The reference to a belt of custard apples, "two miles or more in width" reflects post-drainage expansion, as the 1916 State surveys show only one to one and a half miles.

The reference to "dead rivers" and to "no rivers flow[ing] out from the lake" contradicts pre-drainage reports of water flowing out of Lake Okeechobee into the Everglades through the "eight short rivers." Will saw only dead rivers and no flow because lake levels had already been lowered far enough to prevent any outflow.

Will's description of overflow "across the custard apple ridge" neglects the continuous outflow from the lake into the sawgrass west of Sand Point, likely again because these outlfows had already been eliminated by lowering of the lake. Reference to a custard apple ridge may already reflect the influence of differential subsidence, greater in the sawgrass soils, less in the custard apple soils.

Sawgrass Plains

General Description

At 1,026 square miles, the Sawgrass Plains landscape was the second largest within the Everglades (**Plate 13**) once stretching from the shores of Lake Okeechobee southward 30 miles to the Ridge and Slough landscape. Essentially all observers described the Sawgrass Plains as "impenetrable;" a fact easily understood in light of the density, height, and sharpness of the vegetation as well as the presence of surface water much of the year. This might have left a dearth of information regarding the "Big Sawgrass," but a fortunate combination of pre-drainage and early post-drainage sources makes it possible to reconstruct considerable detail.

Sources include U.S. General Land Office township survey notes (pre-drainage), State township surveys (for Trustees of the Internal Improvement Fund; post-drainage), accounts of navigation on Lake Okeechobee, drainage reports, botanical accounts, soil surveys, and studies of soil cores. U.S. Surveyors reaching the Sawgrass Plains from the east or west universally declared the landscape "impracticable" and relinquished their lines. Some noted water depths at the edge; all noted the location of the edge, so the eastern and western pre-drainage boundaries can be mapped with considerable (surveyed) accuracy. The northern boundary extended directly to Lake Okeechobee, or, along the southeast shore, to a thin intervening band of Custard Apple or Cypress Swamp landscape (see previous section; this chapter). The section directly bordering the lake is documented by numerous navigational accounts (see Chapter 5; Lake Okeechobee Outflows), by a detailed agricultural map (**Plate 6**) (Kreamer 1892), and by a variety of point observations. The southern border, with the Ridge and Slough landscape, is the least precisely known, having been mapped by the authors from post-drainage aerial photographs (USDA-SCS 1940), with supporting evidence from a pre-drainage and two early post-drainage expeditions; Harshberger (1914) and Small (1914) (see also Chapter 3).

The presence of uniform sawgrass within the interior of the landscape was established from two pre-drainage expeditions (Meigs 1879 and Hopkins 1884), from numerous State surveys for the Trustees of the Internal Improvement Fund, mostly by Otis A. Hardin between 1914 and 1919, and by inspection of 1940s aerial photographs (USDA-SCS 1940). Soil cores analyzed by Dachnowski-Stokes (1930) further support the ubiquitous presence of uniform sawgrass. Even more significantly, his analysis suggests that the Sawgrass Plains had been dominated by sawgrass throughout the history of the Everglades (**Figure 4.12**), with the exception of 1-2 periods, corresponding perhaps to climate changes during the Medieval Warming period (Willard 1999).

Understanding of the pre-drainage hydrologic connection between Lake Okeechobee and the Sawgrass Plains is greatly enhanced by the numerous sources documenting the area sometimes called the "Okeechobee Marsh." This portion of the Sawgrass Plains began along the southwest shore of Lake Okeechobee, encompassed Lake Hicpochee and extended west to the headwaters of the Caloosahatchee River (**Figure 4.13**). Transects of peat depths within the Okeechobee Marsh (Kreamer 1892 as shown in **Plate 6**) indicate that it had formed within a westwardly narrowing, sand-based valley, accumulating a level peat surface nearly to the valley's brim, and opening onto the southwest shore of Lake Okeechobee. Pre-drainage U.S. Surveyors noted that the waters of Lake Okeechobee extended over the whole of this sawgrass marsh, and in fact high enough to not only inundate the peat-based marsh, but also the adjacent and higher, sand-based wet prairie landscape:

> "Land low, level, wet prairie - liable to overflow to the depth of from 1 to 2 feet by the waters of Lake Okeechobee & unfit for cultivation without artificial means [of drainage]. Beyond 80 chains [i.e., into the impracticable Okeechobee Marsh] -- dense sawgrass at all times overflowed & worthless." (Tannehill 1871-T41 R32, p. 349).

The presence of two landscapes, both regularly inundated by Lake Okeechobee, but one accumulating peat and the other not, provides an indication of the lengthy fraction of the year that Lake Okeechobee water flowed out over the peat-based marsh. This is discussed further in Chapter 5.

Chemically, the presence of Sawgrass Plains directly adjoining an extensive portion of the lake shore indicates that sawgrass was able to persist under nearly year-round exposure to pre-drainage Lake water. The presence of an intervening transition zone, with differing soil type, or differing vegetation was apparently not necessary for sawgrass persistence. No evidence was found of pre-drainage cattail (*Typha* sp.)stands along or near the shore.

The pre-drainage extent of the Sawgrass Plains corresponds closely with the present Everglades Agricultural Area (**Figure 1.1**), with a short extension southeastward between the present Miami and North New River canals.

The detailed historical sources available for the Okeechobee Marsh area help clarify the pre-drainage connection between Lake Okeechobee and the Sawgrass Plains. However, this is only true as long as the timeline of drainage is kept firmly in mind. As documented in Chapter 3 and especially Chapter 5 (Lake Okeechobee outflows section), the efforts of Hamilton Disston's Atlantic and Gulf Coast Canal and Okeechobee Land Company successfully lowered water levels both within Lake Okeechobee and within the Okeechobee Marsh portion of the Sawgrass Plains. By 1884, observers were already reporting water tables below ground surface, and the encroachment of dryland species:

> "Taking a general view of the whole subject I am constrained to say from observation taken on the spot that a radical and recent change has taken place in that portion of Florida ["the great prairies of Lake Hickopochee and Okeechobee"], for the vegetation is rapidly changing its character, from the aquatic to the dry land varieties. The saw-grasses are disappearing before the highland prairie grasses while the saw palmetto, fresh and new born is vigorously hurrying forward its monopoly in spreading out its meshes of concatenated roots, far and wide over the reclaimed prairies." (Duval 1884).

Even though water levels may have risen again after the collapse of Disston's company, it is necessary to critically examine any post-drainage (post early 1880s) observations in light of Duval's comments.

The uniformity of the Sawgrass Plains was remarkable. All aspects–soils, microtopography, vegetation, and hydrology–appear to have varied little over the 50 mile wide and 30 mile long landscape):

> "The surface of the upper part of the large area of this type is flat and nearly level. No natural drainage channels are apparent, and the flatness is broken only by infrequent alligator holes and runways." (Baldwin and Hawker 1915, p. 782).

The slight variation that was present, a downward slope to the southeast of about four feet in thirty-five miles, paralleled the slope of the bordering uplands.

The uniformity of this landscape appears to be the result of its aquatic origin, that is, the process of peat soil (fibric histosols) accumulating under a water body leveled by gravity. The peat, formed from partially decomposed sawgrass remains (Miller 1918), consisted of 85-90% organic material (Baldwin and Hawker 1915; Miller 1918; Forsaith 1917, 1918; Hammar 1929). Further decomposition (and loss) of the peat was limited by anaerobic conditions in the soil profile. The profile remained anaerobic much of the time because the landscape was covered with water during the greater part of most years. The extreme flatness of the Sawgrass Plains reflects the flatness of the pre-drainage water surface.

The soil depth measurements shown in **Figure 4.2**, 150 of which are from the Sawgrass Plains, were made by soil scientists in 1915, three years after the opening of the North New River Canal. While water levels at each end of the canal were already lowered by that time (see **Figure 3.1**), soil conditions along the central reaches were most likely still similar to pre-drainage ones. **Figure 4.2** indicates that deep peat, 10 to 6 feet thick, formed a wedge, with the peat surface sloped more steeply than the bedrock surface. Thirty years earlier, an engineer leading the New Orleans Times-Democrat expedition of Nov.- Dec. 1883 described the same peat wedge:

> "[we] enter the saw grass ocean in which we find but a few inches of water not sufficient to float our light boats, but flowing perceptibly in a southerly direction. I sounded regularly with a 10-foot rod and for 30 miles ... I found no evidence of rock or sand... 30 miles south of lake I found rock at 8-1/2 feet below surface..." (Col. Chas. F. Hopkins, 1884 in Stewart 1907, p. 100).

The peat slope, actually only 0.004%, appears to have paralleled the south southeastward slope of the surrounding uplands that formed the rim of the Everglades basin (c.f. Corps of Engineers 1960). It is likely that this reflects a tendency of the water surface to remain parallel to the downward slope of the basin rim. It seems likely that by the 1800s (or before), accumulation of peat had come to equilibrium with the surrounding uplands; in other words, that the basin had filled sufficiently with peat that typical water depths on top of the peat brought the water surface to within a foot or two of the surrounding upland surface (Wright 1911; Lodge 1994).

The flatness of the Sawgrass Plains land surface, and the uniformity of hydrologic conditions might be expected to produce uniform vegetation, and this was in fact found:

> "The upper or northern Glades being a solid body of dense saw grass extending 30 miles East and West and 40 miles North and South, and which has hitherto been considered impenetrable." (Col. Chas. F. Hopkins, 1884 in Stewart 1907, p. 100).

Occasional patches of flags (*Pontedaria cordata* and *Sagittari*) were reported (see **Appendix E**), but the dominant plant was sawgrass (*Cladium jamaicense*). Conditions were apparently ideal for sawgrass, as it formed a dense stand, six to ten, even twelve feet high, and invariably described as impenetrable. The dense sawgrass stand was continuous -- unbroken by sloughs, channels, or tree islands. Although further south the Indians crossed the Ridge and

Slough portion of the Everglades regularly, they understandably avoided the Sawgrass Plains (Simpson 1920; Sturtevant 1959; Tebeau 1974; see also **Plate 8** and **Plate 9**). The only exploring expedition to cross this landscape resorted to burning the sawgrass ahead of their passage (**Appendix E**).

The Sawgrass Plains as defined and mapped in this study, does not correspond closely with other authors' classifications, partly because of drainage-induced changes, and partly because some authors did not draw a distinction between the Ridge and Slough and the Sawgrass Plains landscapes. The Sawgrass Plains landscape defined here is a subset of the following: Harshberger's (1914) "Everglade Formation" (no distinction from Ridge and Slough landscape, although differences were noted along the course of New River Canal); Harper's (1927) "Saw-grass marshes" (no distinction from Ridge and Slough landscape); Small's (1929b) "Saw-Grass Prairie;" and Davis'(1943) "Saw-grass Marshes (medium dense to sparse)." Two other categories mapped by Davis (1943), the "Saw-grass Marshes (dense)" and the "Saw-grass Marshes (with abundant ferns and cat-tails)", were found only within the extent of the Sawgrass Plains landscape of the present study. The Sawgrass Plains categories of Davis et al. (1994) and of this study are similar in extent.

The transition between the Sawgrass Plains and the Ridge and Slough landscape to the south was a progressive one, with the unbroken plain giving way along the southern edge to breaks made by increasing numbers of open water sloughs and channels. The sawgrass of the Sawgrass Plains continued southward in the form of sawgrass ridges. These ridges likely experienced water depths and hydroperiods similar to those present in the Sawgrass Plains.

Several authors have commented on annual weedy species that invaded the Sawgrass Plains after the canals began lowering water levels and decreasing the hydroperiod (Wright 1912; Harper 1927; Loveless 1959; Cornwell and Hutchinson 1974; see also Chapter 3). These include dog-fennel (*Eupatorium capillifolium*), pigweed or "careless weed" (*Amaranthus* spp.), and goldenrod (*Solidago* spp.). Historical accounts suggest that some of these species may occasionally have been present prior to drainage as well, during exceptionally dry years.

<u>Hydrology</u>

Descriptions of the pre-drainage Everglades hydrology often emphasize the portion of Lake Okeechobee overflows that passed first through the Custard Apple landscape and only subsequently into the Sawgrass Plains. In fact, an almost equally long (20 miles) portion of the Sawgrass Plains landscape bordered directly on the lake and was subject to regular outflow (**Plate 13**; Meigs 1879; Heilprin 1887; Kreamer 1892; TIIF 1902; see also **Figure 4.14**)

The fact that the Sawgrass Plains bordered Lake Okeechobee directly is highly significant hydrologically. The presence of sawgrass abutting the lake suggests a peat surface that was level with the lake surface; i.e., the absence of any sort of rim. If an elevated rim had been present, it would have been colonized by woody species.

The continuous, rim-less connection with Lake Okeechobee also suggests that variations in lake levels usually occurred within the two to three foot range that supports tall, dense sawgrass. If lake levels had frequently decreased and remained below ground elevation in this area, the sawgrass would have been invaded and replaced by species such as dog fennel, careless weed, and shrub thickets that prefer drier conditions. Such an invasion pattern was in fact reported after drainage began (Baldwin and Hawker 1915; Wright 1907; Allison 1928; Graham 1950; Dachnowski 1930; see also **Figure 3.11**) when Disston's company lowered lake levels. The presence of deep, sawgrass peats (Meigs 1879; Menge in Stewart 1907; Kreamer 1892; and Jones et al. 1948) suggests that lake levels, in fact, remained high enough to regularly inundate the sawgrass, thus supporting a continuous sawgrass presence. We estimate seasonal water levels in this landscape to range from 0.5 feet below land surface at the end of the dry season to 1.5 feet above land surface at the end of the wet season, with a hydroperiod of 9 to 10 months.

<u>Hindcasting</u>

The spatial extent of the Sawgrass Plains landscape, as indicated by the area of Everglades Peat soils, changed between ca. 1850 and 1940. Overall, there was a substantial increase in apparent area of the Sawgrass Plains after drainage (**Table 4.2**) reflected by sawgrass expansion within the newly drained portions of the Ridge and Slough landscape. To the northeast, the long thin slough bordering the Eastern Pine Flatwoods (L-8 canal area) was drained sufficiently by 1930 to be classified as a Sawgrass Plains-like landscape (Dachnowski-Stokes 1930). Similarly, sawgrass expanded into small areas along the western sides of the present Water Conservation Areas 1 and 2. The main, and major, expansion occurred to the southeast, in the area between and surrounding the Miami and North New River canals, and extending almost to the Atlantic Coastal Ridge (**Plate 11**). Expansion would have continued all the way to the ridge except that this area had by the 1940s already lost essentially all of the peat profile, forming Davie mucky fine sand and Davie fine sand soils (**Figure 3.16**). These specific areas of increase are discussed in more detail in the Ridge and Slough section as they were hindcasted to Ridge and Slough.

Post-drainage decreases in the extent of the Sawgrass Plains occurred due to drainage in the northwestern, western, and northern portions of the landscape. To the northwest (T 41-42 R 32 and T 43 R 33-34), Everglades peat was lost to oxidation, creating new areas of Davie mucky fine sand and Davie fine sand (Jones et al. 1948). Davis (1943) mapped these same areas as wet prairie. These areas were hindcasted to Sawgrass Plains on peat, based on information from pre-drainage township survey maps, supplemented by a detailed vegetation and land suitability map (Kreamer 1892). Regions marked as sawgrass and as “First Class Sugar Land” on Kreamer (1892) were assumed to have been Everglades peats. Kraemer (1892) distinguished four main categories: (1) “First Class Sugar Land,” also labeled as “A Very Fine Piece of Saw Grass Marsh, ” and “First Class Marsh;” (2) “Slough Land Bordering on Saw Grass,” also labeled as “Good Slough Land for Rice, Pard Grass, and Vegetables;” (3) “2nd and 3rd Class Prairie for Pasture;” and (4) several grades of pine lands. Based on land classification information from Township surveys, we assume that the sugar land (saw grass) would have been mapped as Everglades Peats; the sloughs as either Everglades or Loxahatchee Peats; the prairies as Wet Sands; and the pine lands as Upland Sands.

Soil cores taken by Dachnowski-Stokes about 1928, within areas later mapped by Jones et al. (1948) as Davie fine sands, indicated several feet of peat on top of the sand and confirmed our hindcasting to Everglades peat (Dachnowski-Stokes 1930).

A very narrow band of Davie mucky fine sand along the western border also was hindcasted to Everglades peat, based on association with the northwestern areas, and on a government township map (Stearns 1874-T47 R34). In the northern portion, the Sawgrass Plains decreased slightly with drainage due to southward expansion of the outer (Okeelanta peat) portion of the Custard Apple and Cypress Swamp.

Sawgrass Plains Endnotes

1. U.S. Surveyor A. H. Jones extended township lines westward from the Atlantic coast through the Eastern Flatwoods and into the Sawgrass Plains for several years prior to 1847. He responded to a request for information from Buckingham Smith as follows:

   "Throughout the whole distance [in the northeast Everglades] examined by me this extraordinary deposit of decayed vegetable substance existed, the whole being covered by a very high and thick growth of saw grass." (A.H. Jones, U.S. Surveyor, 1847, in Senate Doc. 89 1911).

2. U.S. Surveyor George MacKay also surveyed many townships east of, and bordering, the Everglades in 1845. Responding to Buckingham Smith, he described the Sawgrass Plains, including typical water depths. "Boggy" refers to peat soil without any standing water, but still too wet to support much weight:

   Very little can be known of the north Glades. They are uniformly saw grass. It is impossible to penetrate them with canoes in high water, and in low water they are generally so boggy it is impossible to explore them on foot." (Geo. MacKay, U.S. Surveyor, 1847, in Senate Doc. 89 1911).

3. The dense sawgrass of the "Okeechobee Marsh" bordering Lake Okeechobee was located an average of about two miles east of the western boundary of Township 41 S, Range 32 E. Even though 1860 appears to have been drier than average, U.S. Surveyor John Jackson found that the wet prairie along the western border was too wet for cultivation. The description of "land rich" in the third mile suggests hydroperiods long enough to accumulate organic soil. These wet conditions in the wet prairie give some indication of hydroperiods and water depths in the lower-lying Okeechobee Marsh:

   "North between Ranges 31 & 32 T. 41 S & E.
   1st mile ... Wet prairie land
   2nd mile ... Wet prairie land
   3rd mile ... Wet prairie land rich if drained
   4th mile
   30 Came to dry prairie
   75 Came to Boggy Slough ... 3rd rate Prairie Land
   5th mile 15 x Boggy Slough ...
   46 Came to wet Prairie
   50 Came to dry Prairie
   80 Set post & raised mound ... 3rd rate Prairie Land
   6th mile
   60 Came to grass Pond
   80 Set post ... 3rd rate Prairie land. There are no lands on the last 6 miles fit for cultivation.
   Survey'd January 5th 1860" (Jackson 1860-T41 R32, p. 207-212).

4. U.S. Surveyor John Jackson, worked in Township 42, Range 31, west of Lake Hicpochee and near the southwest corner of Lake Okeechobee in January, 1860. The Caloosahatchee River ran west through the middle of this township, and was directly flanked by dense sawgrass marsh and peat soil. Further from the river, the sawgrass and peat gave way to slightly higher sandy ground with "low, wet prairie" vegetation. Almost all of the north boundary of the township ran through this sandy wet prairie, reaching sawgrass only at the east end, where the sawgrass marsh widened. Substantial water depths appear to have been present in the sawgrass, as Jackson reports that even the higher wet prairie along the north boundary would have required drainage to be made fit for cultivation. The description of the sawgrass portion of the south boundary as "very rich lands if drained" suggests deep organic soil and long hydroperiods:

   "[North Boundary:]
   15 [chs] Came to Sawgrass
   40 Set 1/2 mile post in Sawgrass
   75 x Sawgrass to wet maiden cane prairie
   80 Set Post [NE] Township corner. Could not raise mound on account of the depth of water.

There are no lands on the last six miles fit for cultivation without artificial means [of drainage]. Surveyed January 4th 1860." (Jackson 1860-T42 R31).

"[South Boundary:] The Sawgrass portion of the last six miles is very rich land if drained. Surveyed January 10th 1860." (Jackson 1860-T42 R31).

5. As U.S. Surveyor John Jackson continued further east, along the north border of Township 42, Range 32, dense sawgrass forced him to relinquish the survey line after only one mile. This was the extensive, dense sawgrass marsh bordering Lake Okeechobee and surrounding Lake Hicpochee, sometimes called the "Okeechobee Marsh." Later surveys locate the shore of Lake Okeechobee at mile 3.5 along the north boundary, so at the time of Jackson's survey the sawgrass marsh was 2.5 miles wide along this line:

3 Came to Sawgrass prairie
35 x Sawgrass to maiden cane prairie
40 Set 1/2 mile post and made pit 10 links S
70 Came to Sawgrass
80 Set post corner of Secs 5, 6, 31 & 32. / raised mound pit 10 links N.
It was impracticable to proceed further East with this line on account of the density of the Sawgrass.
Survey'd January 4th 1860" (Jackson 1860-T42 R32).

6. In mid-April 1871, U.S. Surveyor J. D. Tannehill surveyed the subdivisions of Township 40, Range 32, as far east as the sawgrass marsh bordering Lake Okeechobee and north of Fisheating Creek. As the sawgrass marsh was too "dense and impracticable," he did not survey it, instead running meanders to map its western edge. The shoreline of Lake Okeechobee could not be reached due to the sawgrass, and was therefore not mapped until 1907, when a boat was used (Hancock 1907-T40 R32). The sawgrass marsh, "at all times under water" was bordered on the west by slightly higher "low wet prairie." This prairie was "subject to inundation to the depth of from one to two foot," and apparently included some organic soil, as it was described as "First rate," a description not applicable for a simply sandy soil. The depth of inundation in the dense sawgrass was presumably greater than the 1-2 feet reported on the wet prairie. The following description was typical for lines through the prairie to the sawgrass, while the general description applies to the whole township:

"East between Secs. 22 & 27 ...
18.00 to dense sawgrass marsh / set meander post ...
Land low wet prairie subject to inundation to the depth of one to two feet and unfit for cultivation without artificial means [of drainage]. Land 1st rate." (Tannehill 1871-T40 R32, p. 399).

"General Description [of Township 40 S, Range 32 E]
The Northern portion of this township is dry prairie with a few small hammocks. The remainder is principally low wet prairie subject to inundation and unfit for cultivation without artificial means [of drainage]. All East of the meander lines on the margin of the sawgrass marsh is at all times under water and unfit for cultivation. The inundation is caused by the overflow of Fisheating Creek. Fisheating Creek is a deep and sluggish stream about two chains [132 feet] broad. Soil in dry prairie is second rate - in the hammocks and wet prairie generally first rate. Timber - some cabbage [palm] and small live oak in hammocks or islands." (Tannehill 1871-T40 R32, p. 461).

7. Township 41 South, Range 32 East borders the west side of Lake Okeechobee north of Lake Hicpochee, sloping down toward the former. The lowest 1 to 2 miles adjacent to the Lake was part of the "Okeechobee Marsh," an area of dense sawgrass that "at all times overflowed" and formed on deep peat soils (Kreamer 1892). In his April 1871 survey of the subdivisions of T 41 R 32, U.S. Surveyor J. D. Tannehill provides useful descriptions of water depths in the low wet prairie, on the ground that is higher than the Okeechobee sawgrass marsh. The edge between this wet prairie land and the dense sawgrass was sufficiently distinct that Tannehill ran a set of meanders to map it: "Meanders of the Sawgrass Marsh bordering on Lake Okeechobee in T. 41 S. R 32 E." (p. 369). The description of the line between Sections 29 and 32 is typical of all of Tannehill's lines running east or south to the Okeechobee Marsh:

"East between Secs 29 & 32 ...
80.00 Set post in mound for cor. ...Land low, level, wet prairie - liable to overflow to the depth of from 1 to 2 feet by the waters of Lake Okeechobee & unfit for cultivation without artificial means [of drainage].

Beyond 80 chains -- dense sawgrass at all times overflowed & worthless." (Tannehill 1871-T41 R32, p. 349).

"General Description [of Township 41, Range 32]

The northwestern portion of this township is dry prairie. The remainder is low wet prairie unfit for cultivation without artificial means [of drainage]. All that portion of East of the meander lines [i.e., the Sawgrass Marsh bordering Lake Okeechobee] is at all times under water and unfit for cultivation. The soil is generally second rate -- but first rate in the hammocks and a portion of the wet prairie. Timber some cabbage [palm] and live oak in hammock[s]." (Tannehill 1871-T41 R32, p. 374).

8. The plat map of Township 42, Range 31 mapped and drawn by U.S. Surveyor J. D. Tannehill in March-May 1871 clearly shows the westward narrowing of the "Heavy Sawgrass Marsh bordering on Lake Okeechobee" (i.e., the Okeechobee Marsh) to a ca. 1 mile wide swath of sawgrass flanking the Caloosahatchee River. This narrowing, and the band of wet prairie shown bordering the NW side of the sawgrass together suggest a valley that was mostly filled, prior to anthropogenic drainage, with a level surface of sawgrass peat. The Kreamer (1892) map includes two north-south transects across this valley that reinforce the impression of a peat-filled valley. The longer (3.5 mile) transect shows a cross-section with 8 to 10 feet of peat in the middle, tapering to 1 to 2 on the sides. The shorter one, further west, shows a one mile cross-section with 4 to 6 feet in the middle, tapering to 1 feet north and south. Even in mid March, Tannehill found too much water on edge of sawgrass marsh to establish mound or pits:

"[Course E, passing "low level wet prairie" to reach sawgrass marsh:]

Set post for cor.[ner] to Secs. 34-35, 2 & 3 [T42 R31] (all traces of the old post & pit destroyed) on the west edge of dense Sawgrass marsh. Beyond this point the Sawgrass extends S.E.-E-NE & N.W. in an unbroken and dense marsh with two feet or more of water at all times. Could not establish mound or pits on account of water." (Tannehill-1871-T42 R31, p. 129).

9. Surveyor Tannehill provided two overall descriptions of the sawgrass marsh that encompassed the Caloosahatchee River and Lake Hicpochee and in fact, covered more than 50% of Township 42, Range 31:

"All that portion of the township situated between the meander lines [i.e., the sawgrass marsh] I judge to be under water at all times. A large proportion of the remainder [i.e., the wet prairie on ground higher than the sawgrass marsh] is unfit for cultivation without artificial means [of drainage]." (Tannehill-1871-T42 R31, p. 142).

"I was unable to reach the Caloosahatchee Creek or River on any [subdivision] line in this Township being obstructed on every line by dense Sawgrass. Therefore I was unable to determine the nature of the connection between the Caloosahatchee and Lake Okeechobee with absolute certainty, if indeed any such exists. All the data that I can gather by observation, indicate that the dense Sawgrass marsh bordering on the Caloosahatchee, joins, and is a part of the Sawgrass marsh bordering upon Lake Okeechobee; and that the water drains through the Sawgrass from Lake Okeechobee and thus feeds the Caloosahatchee." (Tannehill-1871-T42 R31, p. 142-143).

10. U.S. Surveyor J. D. Tannehill, working in Township 42, Range 32, which bordered Lake Okeechobee, on March 17, 1871 found the same conditions as Jackson (1860-T42 R32), namely that only the upper NW corner was practicable to survey, the remainder was sawgrass marsh, described as "under water at all times:"

"General Description [of Township 42, Range 32:]

The small portion of this township that could be surveyed [i.e., NW corner of NW 1/4 of Section 6] is all low wet prairie subject to inundation to the depth of about two feet from the waters of Lake Okeechobee and unfit for cultivation without artificial means [of drainage]. The remainder [i.e., > 99% of township] is Sawgrass marsh -- inpracticable, being under water at all times. There are a few islands to be seen in the distance, but I could not reach any of them." (Tannehill-1871-T42 R32, p. 155).

11. U.S. Surveyor W. L. Apthorp, working in 1872 eastward from the Pine Flatwoods in Township 45, Range 34 came first to level, open prairie and then to the impracticable Sawgrass Plains:

"1st Mile Hence East on S. B'd'y Sec 31 T 45S R 34E.
14.00 Sawgrass

23.00 Cross Sawgrass
40.00 Set 1/2 mile post in palmetto patch
59.00 Grass pond
64.00 Cross it to thicket
66.00 Open thicket to prairie open as far as the eye can reach
80.00 Made Mound & pits -- 3rd rate prairie land

2nd Mile. East on S B'd'y Sec 32
40.00 1/2 mile Made mound & pits
80.00 Made mound & pits -- 3rd rate Prairie

3rd Mile. East on S B'd'y Sec 33
20.00 Big Sawgrass bordering the Everglades. Impracticable. Relinquish line. -- 3rd rate prairie land" (Apthorp 1872-T45 R34, p. 284-285).

12. Six miles further south, in Township 46, Range 34, Surveyor Apthorp again found level sawgrass, stretching to the horizon:

"2nd Mile East on S. Bdy Sec 32 [T 46 R34]

40.00 1/2 Mile. Made mound & pits in edge of impracticable Sawgrass bordering Lake Okeechobee or the Everglades. The sawgrass stretches as far as the eye can see, forming a perfectly level horizon eastward. Tuesday March 19th [1872]. Relinquish line." (Apthorp 1872-T46 R34, p. 39).

13. U. S. Surveyor Hamblen, March 1873, in T43 R31 describedhigh land bordering sawgrass plains, a cul de sac of sawgrass marsh and also notes willow:

"General Description [of Township 43, Range 31:]

The quality of the land in this Township is generally 3rd rate -- Timber pine good size and quality - Land is quite high dry and sandy except a large area in East part of Township which is an impracticable sawgrass slough with willow swamp. The Northern part of Township extends into prairie and containing low slough and detached belts of sawgrass." (Hamblen 1873-T43 R31, p. 327).

14. U. S. Surveyor Hamblen, March 1873 in T43 R32 (twp south of Lake Hicpochee). Note that "shoal water" in Hamblen's survey of T44 R33 seems to be 12-15 inches in depth. This is substantial water for March:

"General Description [of Township 43, Range 32:]

The quality of the land in this Township is 3rd rate. The Northern and Eastern portion heavy and impracticable sawgrass covered with shoal water and forming part of the Everglades.

Sections 19 20 21 22 and 29 and parts 15 16 17 18 27 28 29 and 30 31 32 and 33 are mostly dry prairie. The remainder on the South part of the Township pine timber." (Hamblen 1873-T43 R32, p. 475).

15. U. S. Surveyor Hamblen in March 1873 described T44 R33 (border runs diagonally through the middle of the township):

"North between Sec 35 and 36
40.00 Set post for 1/4 Sec cor in mound ...
47.00 To point of pine from the West
58.00 To wet prairie with sawgrass
80.00 Set post in water 12 in[ches] deep ... Could not raise mound ...
The character of the land to North and East is impracticable on account of its being boggy and bordering on Everglades." (Hamblen 1873-T43 R33, p. 638).

"North between Sect 26 and 27
9.00 To wet prairie

17.00 To cypress swamp bordering on Everglades which is impracticable and I relinquish line...” (Hamblen 1873-T43 R33, p. 640).

“North between Sect 20 and 21
37.00 To flag pond
40.00 Set post for 1/4 Sec cor. in pond Could not raise mound
55.00 Cross pond to wet prairie
71.00 To prairie with sawgrass
80.00 Set post in water 15 in[ches] deep Could not raise mound” (Hamblen 1873-T43 R33, p. 646).

“East on true line between Sec 8 and 17
12.00 To prairie
31.00 To wet prairie with sawgrass
40.00 Set post in sawgrass and water ...
Could not raise mounds. At this point it is impracticable to proceed further and I relinquish line...” (Hamblen 1873-T43 R33, p. 654)

“General Description [of Township 44, Range 33:]

The quality of the land is 3rd rate - The Northern and Eastern part is low and covered with shoal water and impracticable to survey. The Western portion is mostly pine land - The Southern is grassy pine land with some palmetto. There are several small prairies or glades in the South Western portion of no great extent. Timber in this Township is chiefly pine of average size and quality.” (Hamblen 1873-T43 R33, p. 658).

16. Ober was apparently aware of a hydrologic connection through the sawgrass present between Lake Okeechobee and the upper reaches of the Caloosahatchee River. Water passed through the extensive intervening sawgrass area and through Lake Hicpochee within the sawgrass (Meigs 1879; Kreamer 1892), so this is likely the identity of the lake he mentions:

    “Southwest I can see a row of palms, and a beautiful, glassy lake lifted up into the sky--a mirage, occasioned, I think, by the presence of some lake miles west of Okechobee; probably the head-waters of the Carlosahatchee, which connects with Okechobee at wet seasons.” (Ober 1874b, p. 593).

17. Between March 3 and April 8, 1879, under the leadership of J. L. Meigs, a party from the U.S. Army Bureau of Engineers explored the Caloosahatchee River up to its origin in the sawgrass marsh surrounding Lake Hicpochee, i.e., the “Okeechobee Marsh” portion of the Sawgrass Plains. Meigs’ detailed observations are very useful, as they were made prior to any drainage, and because they report on the marsh from the inside out, aptly complementing the earlier township surveyors’ observations from the outside in. Meigs confirms the surveyors’ observation of dense sawgrass. Meigs’ description of the Caloosahatchee channel as 5 to 8 feet deep at Sugarberry Hammock can be compared with Kreamer’s (1892) N-S transect of peat thicknesses two miles further east in T42 R31. The marsh, and underlying valley, was wider and likely deeper at Kreamer’s transect than at Sugarberry Hammock, so Kreamer’s peat thicknesses of about 6-10 feet in the center of marsh suggest that the river bed at Sugarberry Hammock was scoured completely down to the underlying bedrock or sand:

    “Sugar Berry Hummock ... about 3 1/2 miles west of Lake Hikpochee ... situated on the western half of section 28, township 42 south, range 31 east. ... The channel of the river here is about 15 feet wide and from 5 to 8 feet deep, the water flowing westward with a strong current. …

    The river was then explored eastward from Sugar Berry Hummock in a light canoe for 1 1/2 miles, and found to divide into many prongs, running from the east with a slow but very perceptible current; these grew narrower and shallower as they were ascended, until the canoe could be forced no farther through the dense [saw] grass.” (Meigs 1879, p. 864-865).

18. Meigs’ (1879) observations confirm the land surveyors’ descriptions of an extensive, dense and tall (“10 to 15 feet”) sawgrass marsh. The observation of 10 to 12 inches of water on the marsh well into the dry season support the surveyors’ description of the area being covered with water “at all times:”

> "On either side [of the headwater channel of the Caloosahatchee River] the channel is bounded by a wide margin of tall and dense saw-grass, growing in water from 10 to 12 inches deep. From a lookout in the [Sugar Berry] hummock 35 feet high nothing could be seen eastward, northeastward, or southeastward but saw-grass, which proved to be from 10 to 15 feet in height. The saw-grass bordering the western shore of Lake Hikpochee completely masked the water of the lake, which was only 3 to 3 1/2 miles distant. After wading with difficulty through the mire and saw-grass 2 1/2 miles northeastward to a palmetto hummock, in hope of obtaining a view of Lakes Hikpochee and Okeechobee, the party were again disappointed, nothing but saw-grass being visible eastward from a lookout 32 feet high." (Meigs 1879, p. 865).

19. Closer to the west side of Lake Hicpochee the water depth appears to have been somewhat greater:

> "Everywhere the water in the saw-grass marsh at the head of these rills was from 10 to 20 inches deep, and was observed to flow slowly westward. No one of these prongs of the Caloosahatchee furnished an entrance into Lake Hikpochee, though it was manifest that the water in them was supplied by the lake." (Meigs 1879, p. 865).

20. Meigs' observations confirm what the surveyors had suggested, namely that the sawgrass marsh flanking the upper Caloosahatchee, surrounding Lake Hicpochee, and bordering Lake Okeechobee was all of one continuous piece:

> "...a party of citizens from Fort Myers ... had encamped on the savanna bordering the saw-grass marsh south of Lake Hikpochee, and had opened a way, by burning off the grass, into the lake. They forced a skiff through the mire and stubble into the lake, crossed the latter in a northeast direction, and commenced firing the saw-grass in the marsh northward and eastward of Lake Hikpochee, and which separated it from Lake Okeechobee. These fires caused a vast conflagration and seemed to have opened the space between the lakes.
>
> ... on the 14th of March the united parties [i.e., citizens plus U.S. Engineers] attempted to force a skiff, by wading, dragging, and pushing, through the burnt [sawgrass] stubble across the marsh intervening between Lakes Hikpochee and Okeechobee. After a day of exhausting toil, struggling through water and mire for the most part 2 feet deep, they arrived late in the afternoon within 1/4 of a mile of the western shore of Lake Okeechobee, but their progress was arrested by vast beds of water-lilies, careless and frog weeds, and wild lettuce, filling the entire space between them and the lake, across which they were unable, by their united strength, to force the boat." (Meigs 1879).

21. This "Okeechobee Marsh" portion of the Sawgrass Plains extended northward along the shore of Lake Okeechobee as far as (and considerably past) Fisheating Creek:

> "Two of the party were sent 15 miles northward to Fish-eating Creek, ... with instructions to ... fire the saw-grass growing on the western shore of the lake. It was hoped that the strong northeast wind then prevalent would carry the fire across the wide saw-grass marsh which lies between Lake Okeechobee and the head of the Caloosahatchee. In that way a route might be opened by which a light Seminole [Indian] canoe might be dragged through the saw-grass stubble to the lake. ... The bed of Fish-eating Creek was found to be nearly dry, and the effort to procure canoes there failed." (Meigs 1879, p. 865).

22. In Nov.- Dec. 1883, the New Orleans Times-Democrat expedition, heading south from Lake Okeechobee, passed through the Sawgrass Plains. Col. Hopkins, an engineer with the expedition (see also **Appendix E**), describes the distinction between the plains of the northern or Upper Glades and the Ridge and Slough landscape of the Lower Glades. Peat depths greater than 10 feet, dense, continuous sawgrass, and an absence of either tree islands or sloughs were characteristic of the Sawgrass Plains:

> "[we] enter the saw grass ocean in which we find but a few inches of water not sufficient to float our light boats, but flowing perceptibly in a southerly direction. I sounded regularly with a 10-foot rod and for 30 miles (our course being south [from the south shore of Lake Okeechobee]) I found no evidence of rock or sand; how much deeper this rich soil or muck extended I had no means of determining. At that distance 30 miles south of lake I found rock at 8-1/2 feet below surface, at 35 miles rock 7-1/2 feet below surface, at about 40 miles from 2 to 4 feet; the lake [or "sea" of

> sawgrass] at this point reached the northern limit of the lower Everglades; and Genl. Childs route as represented on the maps from Miami to Waxy Hadjos Landing. This route may be considered as the dividing line between the upper and lower Everglades. The upper or northern Glades being a solid body of dense saw grass extending 30 miles East and West and 40 miles North and South, and which has hitherto been considered impenetrable. The dividing line above alluded to is not defined except by an entire change in the character of the country which consists simply in numerous islands and sloughs; by taking advantage of which you may wind your way through the saw grass." (Col. Chas. F. Hopkins, 1884 in Stewart 1907, p. 100).

23. Capt. H. S. Duval, State Engineer for the State of Florida, was asked in 1884 by the Trustees of the Internal Improvement Fund to inspect the areas drained by Hamilton Disston's company. Two extracts from his report refer to the portion of the Sawgrass Plains bordering Lake Okeechobee:

> "[We] proceeded by land examining alternately, both sides of the Caloosahatchie River, and specially the region in the vicinity of Fisheating Creek and the great saw-grasses on the margin of [Lake] Okeechobee." (Duval 1884, p.)

> "On reaching the margins of the great prairies of Lake Hickopochee and Okeechobee, formerly covered with saw-grass, but now partially clothed in a new vegetation, I was surprised to see them after so much rain, otherwise than thoroughly inundated, but for miles and far away, we rode over them, dry-footed, in our two horse vehicle leaving the woods faintly outlined in the distance." (Duval 1884, p.).

24. In a statement made to Capt. Duval, a long time resident of the Caloosahatchee valley described the annual pre-drainage rise in water levels on pasture areas that appear to correspond to the wet prairies described by U.S. Surveyor Tannehill:

> "I have resided on the Caloosahatchie River for many years. Have been engaged in the Cattle business, and other service requiring frequent trips into the country north and south of the Caloosahatchie river, and in vicinity of Lake Hichpochee and Okeechobee. … Prior to the construction of the drainage canals, the river at Fort Thompson would rise rapidly and the water would remain at a depth of several feet for weeks and months, covering large areas and injuring the pasturage, etc." (Frazier 1884, p. 322).

25. Will Wallace Harney was the "Professor" referred to in the accounts of the Times-Democrat expedition. The next year, in a detailed article on the drainage of the Everglades in Harper's Magazine, Harney notes the deep sawgrass peat found in the Sawgrass Plains along the newly dredged Three Mile Canal:

> "The stratification as developed in the cutting beginning from the bed-rock is clay and marl under white sand, overlaid by a deep bed of muck [i.e., peat]. The depth and rankness of this superficial deposit are extraordinary." (Harney 1884, p. 604).

26. In March of 1886 the geologist Angelo Heilprin explored the Caloosahatchee River, from the newly cut canals from the falls at Fort Thompson all the way up to the shores of Lake Okeechobee, and across Lake Okeechobee itself. Here he described the Okeechobee Marsh surrounding Lake Hicpochee as well as some of the hammock vegetation on the higher ground adjacent to the sawgrass marsh:

> "As far as the eye could reach this almost boundless expanse of [saw-]grass, relieved at intervals by oases of the most luxuriant verdure of palms and cypresses, constituted the landscape; the general growth was about six to eight feet in height, dense to impenetrability, but in some places it was very much higher, and completely shut off from view all but the narrowest vistas." (Heilprin 1887, p. 404-405).

27. Although it is not known whether alligators would have originally been abundant within the "impenetrable" sawgrass of the Okeechobee Marsh, Heilprin notes that they were plentiful along the canal only a few years after its excavation:

> "We were very much surprised at the abundance of alligators, whose freshly made, or but recently deserted, 'beds' appeared all along the banks [of the canal]. At intervals of almost every few hundred feet one of these grim monsters of mail ... would rise, and ...plunge from its sunny retreat

> into the cooler shades below... As many as six or seven of these animals could at one time be observed from our vessel, lazily crossing and recrossing the canal." (Heilprin 1887, p. 405).

28. Dr. D. H. Wiley at the U.S. Dept. of Agriculture, Bureau of Chemistry, in 1891 studied the land bordering the west and southwest sides of Lake Okeechobee; the "Okeechobee Marsh." Like the surveyors twenty and thirty years earlier, he found sawgrass on deep muck (peat) soils:

> "I have had samples collected of the principal vegetable growths which cover the muck lands at the present time. The whole of the Okeechobee muck lands is covered almost exclusively by saw-grass. …
>
> In regard to the depth of soil, it varies from the merest covering at the edges of the sand to from 15 to 16 feet in its deepest portions. The greater part of the muck lands, as before indicated, will vary from 3 to 6 feet in depth, while along the Okeechobee the average depth is much greater. The soil varies in color from almost jet black to black brown." (Wiley 1891, p. 166-167).

29. Wiley also noted that the sawgrass vegetation can burn during the dry season. Similar observations by others suggest that this was a natural phenomenon even prior to drainage:

> "During the winter and early spring months this dense growth of [saw] grass often becomes dry enough to burn, and large areas are often burned over." (Wiley 1891, p. 166).

30. Kreamer (1892) (see **Plate 6**) includes "muck depths," i.e., thickness of the peat soil along the Lake Okeechobee shoreline, along the Three Mile and Nine Mile Canals, and two north-south transects across the sawgrass marsh forming the headwaters of the Caloosahatchee, west of Lake Hicpochee.

31. An engineer involved in the early canal construction described the watery consistency of the peat soil of this landscape in 1906. The description is very similar to those made twenty years earlier during the Times-Democrat expedition (**Appendix E**):

> "This sawgrass frequently grows to a height of 8 or 10 ft., and the greater part of the Everglades for the first 40 miles south of Lake Okeechobee is covered with it and a bush called the "custard apple," which forms a jungle that is almost impenetrable. It is impossible to make a survey except in boats, as every step a man takes he sinks to his knees in mud and water, and in some places, if he goes overboard, he has trouble in extricating himself.
>
> ...heading [southeast from Lake Okeechobee] in the direction of the Hillsboro, New and Miami rivers, no natural obstacles present themselves. All the way is a sawgrass marsh, interspersed near the lake with custard apple swamps, and further out in the Glades are willow thickets, neither of which would present any difficulty to the dredges which will be used. The greater part of the way the muck is very deep..." (Lupfer 1906).

32. U.S. Surveyor J. T. Hancock's survey of the south boundary of Township 40, Range 32 passed eastward through the same low, wet prairie reported 36 years earlier by Tannehill (1871)-T40 R32. Comparison of the two surveyor's plat maps show that both encountered the transition from wet prairie to dense sawgrass marsh on muck (peat) soil at the same location in Sect. 32, about 1.3 miles from the shore of Lake Okeechobee. Kreamer (1892) draws the sawgrass marsh here with similar width (1.7 miles) and gives muck depths from 2 feet near the wet prairie to 4-8 feet near the Lake shore. Hancock's observation of the wet prairie and sawgrass in Section 32 being "subject to inundation of 2 to 3 ft" is similar but somewhat deeper than Tannehill's observations. Note especially Hancock's description that sawgrass marsh near Lake Okeechobee was subject to lake overflow of "4 or 5 ft:"

> "3.00 to high Prairie
> 37.20 cross Road (but very dim)
> 40.00 ... / 80.00 ...Land level. Soil sand. Low and wet 3rd rate. No timber.
>
> E. on S. bdy Sec 32
> Through Low wet Prairie
> 40.00 Point for 1/4 sec. cor. in edge of Saw grass and Maiden cane Prairie ...
> 80.00 ... Sawgrass high and decayed Leaves on grass and Muck being (?) too deep could not make

much search water 15 ins. deep ...Land Low and subject to inundation 2 to 3 ft. Dense sawgrass and Deep muck. No timber. Last 1/2 mile very rich muck Land if drained.

From this cor. I survey S. Bdy T 40S [Sec. 33]
E. through dense undergrowth and Deep muck and Exceptionally difficult to survey
40.00 ... no bearing trees. Pits and mounds impracticable.
74.70 To Western shore of Fisheating Creek Bay Lake Okeechobee. ...No trees in reasonable distance. Pits and mound impracticable. The shore is only a Muck bank(?). Deep, shaky and subject to overflow of the Lake 4 or 5 ft. Bay bears northly at this point. Land Low muck, good if drained. No timber. July 29, 1907" (Hancock 1907, p. 28-32).

33. During a survey of the sawgrass marsh bordering Lake Okeechobee between Township 40 and Township 38, U.S. Surveyor J. T. Hancock noted an area subject to overflow of 3-4 feet. This is probably not a depth reached annually, but is plausible as an occasional extreme:

    "The small tract of Land on N. side of Eagle Bay is dense Sawgrass and Low Muck Land subject to inundation to 3 or 4 feet." (Hancock 1907-T38 R34, p. 24).

34. At the end of March 1907, the second dry year following wet years in 1900, 1901, 1903, and 1905, (**Figure 2.10**) Stewart comments that,

    "At the present time the Glades are lower than they have been for several years as nearly all saw grass land is above water. I am told that the Glades have been practically dry." (Stewart 1907, p.55).

    Stewart's observation suggests that it was common knowledge that in March water typically would still be covering the surface of the Sawgrass Plains. This would also be consistent with descriptions from pre-drainage township surveyors. It is not clear to what extent the low water levels observed in 1907 where simply the result of weather or the combined influence of weather and the Lake drainage that began in the 1880s.

35. Stewart interviewed Fred Menge, captain of the dredge used to excavate the 13-Mile Canal, a portion of which later became the northernmost section of the Miami Canal. Despite a seven foot deep excavation in this part of the Sawgrass Plains, the network of sawgrass roots interweaving the fibrous peat provided a sufficiently cohesive structure to prevent "cave ins." The 13-Mile Canal was excavated as part of Disston's efforts, probably between 1884 and 1891:

    "Had charge of the dredge excavation for the Disston Company. ... All the excavation done was in muck. Cut a channel 7 feet deep, 20 feet wide with vertical banks. ... If the Everglades soils are drained it will require a system of gates and dams or some method of irrigation to prevent the soil from becoming too dry.

    The 13-mile canal was in a continuous reach of saw grass with little open water. The saw grass was often 12 feet in height. The material excavated was all of one kind, being a stringy rooty nature and would burn if dry and did not cave after excavating." (Stewart 1907, p.40-41).

36. In a report on the drainage of the Everglades, J.O. Wright, adrainage engineer for the Trustees of the Internal Improvement Fund, describes a 1908 peat soil profile from a point in the Sawgrass Plains on the shore of Lake Okeechobee. The soil was well decomposed, suggesting the influence of a number of years of drainage:

    "On the west shore of Lake Okeechobee, at the entrance of Three-mile Canal, another cultivated tract was inspected. The vegetation has been removed from a typical piece of saw-grass muck, the surface of which was flooded during the period of high water; but at the time of the visit, March 25, 1908, it was 28 inches above water level. The muck on this tract was firm on top and soft below for a depth of 12 feet. ... The muck at this place was well decomposed and contained more mineral matter then the fibrous soil in some other localities." (Wright 1911, p. 173).

37. In the same report, Wright notes the downslope direction of the Sawgrass Plains:

    "The surface of the upper Glades slopes southeasterly." (Wright 1911, p. 159).

38. The surveyor R. F. Ensey, working for the Trustees of the Internal Improvement Fund in 1911, describes the eastern edge of the Sawgrass Plains where they joined the Ridge and Slough landscape to the east:

> "The last six miles of this line [north along a line between Sections 35 and 36 in Township 45, Range 39] lies in sawgrass -- striking no timber of any nature whatever -- Clumps [smaller tree islands] are very scarce -- the line is clear & open to the north -- There are several small clumps to N.W. and about six to the S.W. To the Eastward [in the Ridge and Slough landscape] they lie massed in a solid bank. The 'Big Sawgrass' lies to the Westward with nothing in sight on the line but sawgrass and a few scattering scrub myrtle bushes. This point is corner to Sections 35 and 36 of Twp. 44 S, Sections 2 and 1 of Twp. 45 S." (Ensey 1911-T45 R39).

39. J.O. Wright, a drainage engineer initially with the U.S. Dept. of Agriculture, Office of Experiment Stations and later with the Trustees of the Internal Improvement Fund, described the flat surface of the Sawgrass Plains landscape, and the tapering depth of the peat soil:

> "As a general proposition, the muck is deepest near Lake Okeechobee, and shallowest in the southern portion of the Everglades. For a distance of about twenty miles south from Lake Okeechobee, the underlying material is practical[ly] level on top." (Wright 1912, p. 18).

40. Although the North New River Canal was operational by 1912, drainage apparently had not yet altered the Sawgrass Plains landscape substantially when the plant ecologist J.W. Harshberger described it during a trip made in 1913-1914 (see also **Appendix J**):

> "The [northern] Everglades is a vast saw-grass marsh, ... extending in unbroken formation in all directions to the horizon. ... Upon the muck rests a sheet of water. ... The whole area is covered with a rank growth of a coarse sedge, 2 to 3 meters (8 or 10 feet) high, having leaves with a fine, serrated edge like a saw, hence the common name." (Harshberger 1914).

41. Evidence of the original extensions of the Sawgrass Plains up the west side of Lake Okeechobee, as noted forty and fifty years earlier by U.S. Surveyors Reyes, Jackson, Tannehill, and Hancock, was apparently still present in 1913-1914:

> "Two arms of saw-grass vegetation extend northward on both sides of Lake Okeechobee, so that the lake is almost completely surrounded..." (Harshberger 1914, p. 155).

42. Two years after the opening of the North New River canal, the botanist J. K. Small commented on dry season water depths in the Sawgrass Plains. His observations are likely reduced from pre-drainage depths, due to previous lowering of Lake Okeechobee:

> "[The view upon the Everglades from the North New River Canal] consists of a monotonous expanse of water and saw-grass extending to the horizon in all directions; in dry seasons the visible water is more or less eliminated, except in depressions; then nothing is in sight but saw-grass." (Small 1914).

43. In 1915, the soil scientists Baldwin and Hawker also noted the same lack of channels that Col. Hopkins described in 1884:

> "The surface of the upper part of the large area of this type is flat and nearly level. No natural drainage channels are apparent, and the flatness is broken only by infrequent alligator holes and runways." (Baldwin and Hawker 1915).

44. In spite of lowering of Lake Okeechobee as well as three years of Everglades drainage by the North New River canal, Baldwin and Hawker (1915) still found standing water in January-March 1915 on most of the Sawgrass Plains area within a six-mile wide band surrounding the canal (**Figure 3.1**). The drawdown visible at each end of the canal in **Figure 3.1** suggests that water was flowing both north and south, into Lake Okeechobee and into the Atlantic Ocean. Typical pre-drainage water depths for January-March would have been deeper than the average of four inches recorded by Baldwin and Hawker for Mileposts 17 to 29.

45. In 1917-18, State Surveyor Merriam surveyed the subdivisions of the township that encompassed Lake Hicpochee and bordered the southwest shore of Lake Okeechoobee, T42, R32. Half a century earlier, prior to the drainage beginning in the 1880s, U.S. Surveyor Tannehill had found all but 1/4 of 1/4 of the northwest square mile of the township to be sawgrass marsh, impracticable to survey, being "under water at all times"

(Tannehill 1871-T42 R32). Eleven years earlier, Jackson (1860)-T42 R32 had found the same impracticable, dense sawgrass marsh. This township was part of the "Okeechobee Marsh" portion of the Sawgrass Plains.

Sometime between the 1880s and 1917, the dramatic lowering of Lake Okeechobee had also lowered water levels in the bordering marsh sufficiently to allow the township to be subdivided and even to permit establishment of a new town in Section 11, directly on the deep peat soil of the former marsh (Merriam (1918)-T42 R32).

46. Observations by the botanist J. K. Small in May of 1917 confirm the drainage implied by Merriam's plat and the establishment of the new town of Moorehaven. With drainage, the shoreline of Lake Okeechobee had apparently receded, as Small indicates that the Three Mile Canal had recently been extended another eight miles into the Lake:

> "newly established settlement of Moore Haven, which is situated at the mouth of Three Mile Canal…
>
> "... we decided to run on a southwesterly course [from the north end of the reef extending north of Observation Island], which would take us to the mouth of a canal recently dredged in the lake for a distance of about eight miles northward of the mouth of the old Three Mile Canal." (Small 1918, p. 689).

47. Small provides a vivid impression of the drained state of the peat soil of this portion of the former Okeechobee Marsh/Sawgrass Plains in 1917 and confirms that Moorehaven was built on peat soil:

> "We had finally reached an extraordinary portion of the earth's surface. There was present neither soil nor rock! All the dry land was built up of pure humus. We were in a land of 'peat.' For many miles in all directions there was nothing but vegetable matter in all degrees of decomposition, derived from both herbaceous and woody plants. This accumulation of 'peat' extends around Lake Okeechobee. ... At the southern and southwestern side the accumulation of peat is more massive than elsewhere, varying from three to fifteen feet in depth--or even more. …
>
> From the vicinity of Moorehaven around the southern side of the lake, the 'peat' formation is remarkable. It resembles a gigantic sponge and walking on it is tiresome. The mass trembles under foot with each step; yet, the concrete sidewalks, the houses, and other structures in Moorehaven are built directly on it." (Small 1918, p. 690).

48. Exploring southwest of Moorehaven along the original section of the Three Mile Canal, Small found more of the decayed peat. This peat was sufficiently amorphous and wet so that the lower profile would not support walking. The decay likely reflects the effects of drainage that began in the 1880s. The description of the soil in this and the previous endnote is similar to Wright's description from nine years earlier. There is a striking contrast between Wright's and Small's post-drainage descriptions of an amorphous, black, highly decomposed peat and Capt. Menge's pre-drainage description of a fibrous material that was strong enough not to cave in when excavated seven feet deep:

> "It was interesting .. also because of the uncertainty of the footing. Of course, walking was out of the question except where the dredge had dug into the bottom of the lake below the 'peat' and thrown out some of the sand underlying the decayed vegetable matter. Even on this coating of sand one could not tell when he would break through and, in the twinkling of an eye, find himself waist deep or up to the armpits in the black oblolly--as one member of our party can testify." (Small 1918, p. 691).

49. Small also noted a post-drainage change from sawgrass to what were likely drier habitat plants:

> "Later in the afternoon we collected on the prairie-like regions west of Moorehaven and also in the open places in and about the settlement, which probably a year or two before had been covered with saw grass." (Small 1918, p. 695).

50. Field notes from a 1919 survey of the south boundary of Township 43 Range 39 indicate that peat depths in the eastern part of the Sawgrass Plains were as substantial as those reported by Col. Hopkins on the western side: five of the six standard corners were set in muck described as "10' to rock", the remaining corner as "9' to rck" (Hardin 1919-T43 R39). All corners were described as "In saw grass."

51. The naturalist Charles Simpson related variations in water depths of the Sawgrass Plains to overflows from Lake Okeechobee. Having moved to the Miami area in 1902, his observations are from the post-Disston drainage period, and likely somewhat underestimate the contribution of the Lake. C.f. for example U.S. Surveyor Tannehill who in 1871 indicated that the waters of Lake Okeechobee covered the adjacent sawgrass marsh "at all times."

> "Whenever Okeechobee becomes filled to overflowing the surplus water pours out and over the Glades. The dense growth of sawgrass and other herbaceous vegetation prevents it from running rapidly to the sea although there is a gradual fall all the way. For this reason most of the region becomes covered with water which moves slowly seaward. When the water of Okeechobee is confined within the lake the water slowly drains off and the glades may become dry." (Simpson 1920).

52. The following 1926 post-drainage account contrasts two adjacent areas in the Sawgrass Plains: one is subject to regional, but not local drainage, and the other is subject to field-scale drainage for cultivation. At this time, the peat soil is still brown, apparently not yet having been sufficiently oxidized to turn black (see Chapter 3). The observation of sawgrass rising from "little pools of water" would of course still be too wet for agricultural use, but is likely considerably drier than natural conditions had been prior to regional drainage:

> "In many places in the Everglades one sees, on one side of the road, broad brown acres of land, bone dry and producing wonderful crops of sugar cane, bananas, beans, and all sorts of vegetables--so bone dry, it might be added, that the ground can be set afire and will burn until a heavy rain comes along to put it out.
>
> On the other side of the road the prairie will be covered by a sea of saw-grass rising from little pools of water that ripple gayly in the breeze, so that for all agricultural purposes it is nothing but a vast marsh.
>
> The soil beneath the saw-grass is just as rich and just as deep and just as brown as that on which the bananas and sugar cane are growing; but to the small farmer, in its underdrained state, it is worth exactly nothing as an income-producer." (Roberts 1926, p.153-154).

53. Despite almost fifty years of intervening drainage, a description of the Sawgrass Plains given in 1932 by two soil scientists is very similar to previous descriptions extending back almost one hundred years. The "densely interwoven rootlets" are reminiscent of dredge Captain Menge's pre-drainage description of soils in the vicinity of the 13-Mile Canal. The principal difference is that the height of the sawgrass seems to have decreased from pre-drainage descriptions of eight to ten or twelve feet, down to four to eight feet. This reduction might be expected from the reduction in water table:

> "The tall sawgrass, *Cladium effusium (Mariscus jamaicensis)* is everywhere the common and typical plant. In many places its growth is so dense as to be almost impenetrable. The rank growth of this coarse sedge reaching to a height of from 4 to 8 feet is still contributing to the accumulation of peat, chiefly through its heavy rootstock and the densely interwoven rootlets." (Allison and Dachnowski-Stokes 1932, p.227).

54. The Chief Engineer of the Okeechobee Drainage District, from 1929 to approximately 1943, in describing the pre-drainage relation of Lake Okeechobee to the Everglades, notes that the latter were wet most of the year. He is likely referring to the portion of the Everglades closest to Lake Okeechobee, the Sawgrass Plains:

> "Originally the Lake had no direct outlet to the sea. The excess of water from rainfall and inflow over evaporation spilled over the low southern shore into the Everglades. This water together with the rainfall kept the Everglades flooded most of the year." (Herr 1943).

55. Davis (1943), based on his extensive field observations in the 1930s and 40s, estimated the likely pre-drainage hydrology of the Sawgrass Plains, relating it to that of the Ridge and Slough landscape:

> "Rainfall probably kept enough water on the saw grass marshes to maintain surface water most of the year, but it is also probable that dry periods and dry years occurred when these marshes were not inundated and only the sloughs, ponds, and small lakes had surface water. As alternating dry and wet periods are favorable to saw grass growth, as compared to the growth of aquatic plants and

> swamps or hammocks which prefer more stable water conditions, this plant became the most abundant and increased at the expense of other types of vegetation, and, saw grass marshes finally covered most of the northern and central Everglades." (Davis 1943a).

Davis' distinction between the unbroken sawgrass of the northern Everglades and the alternating dense sawgrass ridges and open sloughs of the Ridge and Slough landscape closely resembles the description by Col. Hopkins in 1884. However, Davis' estimate of Sawgrass Plains hydrology neglects the influence of Lake Okeechobee outflows, perhaps because such outflows had not occurred naturally for more than fifty years. The expansion mentioned by Davis of Sawgrass Plains-like landscape into the central Everglades was also a post-drainage effect of lowered water levels in the Ridge and Slough landscape (Chapter 3).

56. Based on field observations during the 1950s, Ralph Andrews, biologist at the Loxahatchee Wildlife Refuge, confirms Davis' view of optimal hydrology for sawgrass growth:

> "[Sawgrass] seems to grow best where water covers the ground for a large portion of the year, but where the water table sinks below the ground late in the dry season. Once established, sawgrass can withstand rather deep water for extended periods, but gradually thins out as water of 3 feet or more is held for periods of 2 - 3 years without drawdown. When water tables remain well below ground level for extended periods, the sawgrass seems to become sparse and stunted and does not put on fruiting heads. Fires at such times will burn a surface layer of peat and kill the sawgrass. However, when the soil remains moist fire destroys only woody competitors and the sawgrass seems to grow back more luxurious than before." (Corps of Engineers 1957).

This description appears to be quite consistent with the pre-drainage U.S. Surveyors' descriptions of the sawgrass marsh directly bordering Lake Okeechobee. Following Andrews' criteria, the dense, 8 to 10 foot tall sawgrass then found there would suggest that the area neither dried out for extended periods, nor that the water depths persisted above three feet for multiple years. Tannehill (1871)-T42 R31 described the area as dense [sawgrass] marsh with "two feet or more of water at all times." Tannehill's description "at all times" can be tempered by Meigs (1879) note that the river had been observed to go dry during a drought. The presence of water much of the time, and of a direct connection between the Lake and the marsh water level comes from Wright (1911), who noted that a 1907 team surveyed a line through sawgrass marsh into Lake Okeechobee, finding "no slope" in the water surface for several miles and continuing out to the Lake.

57. Lawrence Will, who grew up around Lake Okeechobee beginning about the time of the first dredging of the State Canals (1900's), gives an idea of water levels in the Sawgrass Plains. His description is reminiscent of those of the U.S. Surveyor Tannehill in the 1870s:

> "Beyond the lake's encircling ridge, on east and south and west, except during the driest years, water stood over all the land from knee deep to waist deep nearly all the time.
>
> ... On the south--and reaching half way up the lake's east side beyond the elevated custard apple ridge, sawgrass in water reached unbroken nearly to the State's south tip. This was--and still is called, the Everglades." (Will 1964, p. 7-10).

Ridge and Slough

The Ridge and Slough landscape is the heart of the Everglades. The largest landscape, it stretched across the full 40 mile width of the basin, from the pine flatwoods on the east to Big Cypress on the west; and for 70 miles from north to south -- from the Sawgrass Plains southward to the mangroves at the foot of Shark Slough. The name “River of Grass” captures certain pre-drainage aspects of this landscape: “river” reflecting the overall directionality of flow and absence of stagnation noted by many early observers, and “grass” of course reflecting the plentiful, tall sawgrass. However, to the extent this name suggests a uniform, unvaried landscape, it falls short of the actual landscape’s pre-drainage complexity as a patterned peatland. The use of the undiscerning term “sawgrass marsh,” in more recent scientific literature is the result of post-drainage blurring of the original pattern. Davis *et al*. (1994) characterized this landscape more accurately as a wet prairie, slough, tree island, sawgrass mosaic. To better reflect the pre-drainage nature of the landscape, and to distinguish it from the other peat-based, sawgrass-containing landscape, the Sawgrass Plains, we reintroduce an old name (Baldwin and Hawker 1915): the landscape of ridges and sloughs.

At the same time that this landscape was horizontally extensive, it was also remarkably flat throughout most of its extent, with only a slight slope from an elevation of about 15 feet above sea level at the north end to about 2-4 feet above sea level where it merges with the the mangrove communities at its southern extent. In strong contrast to the adjacent Sawgrass Plains, the peat of the Ridge and Slough landscape had distinct localized elevation differences of as much as four feet (1.2 m) due to differences in soil depth. These differences in elevation and soils are the key to understanding this landscape. They supported the different vegetation types, provided important aquatic and seasonally aquatic habitats, and made navigation possible.

The main components of the Ridge and Slough landscape are differentiated by elevation, soils, hydrology and vegetation. Channels occur less frequently and are deeper than sloughs. Ridges are elongated, slightly elevated areas that are occupied by sawgrass. Tree islands occur as large, lenticular (“tear drop-shaped”) strand tree islands, and also as much smaller, but still elevated areas of oval shape. These smaller high spots, sometimes called “clumps” in the early literature, that are occupied by different vegetation types, ranging from sawgrass to substantial trees. The range of vegetation gives rise to diverse names for these clumps, e.g., "bayheads," "willowheads," and "tropical hammocks."

The structure and composition of the landscape have changed considerably in recent years as a result of canal construction and drainage activities. In this chapter, information from historical surveys and descriptions of the area by early explorers is combined with information from recent detailed studies of existing hydrology, soils and vegetation patterns to describe the conditions that were likely to have existed in the early 19th century.

General Description

A description from 1841 by one of Col. Harney's engineers mentions the three main elements composing the landscape—sawgrass ridges, channels (i.e., sloughs), and tree islands—and gives an impression of its vastness:

> "The appearance presented upon entering the Everglades is that of an immense prairie, stretching farther than the eye can reach, covered by thick saw-grass, rising six feet above the surface of the water, which conceals . . . the monotony varied by numerous snake-like channels and verdant islands, scattered few and far between . . . the average depth of water over the whole extent being from two to four feet." (Brooks 1880, p. 253).

The same engineer gives a clear impression of the open and apparently vegetation-free nature of the aquatic sloughs — deep enough even in January (dry season) to move swiftly and to allow the use of paddles — as well as the contrast with the density of the sawgrass ridges:

> "We then moved forward swiftly and noiselessly, at one time following the course of serpentine channels opening out occasionally into beautiful lagoons, at another forcing our way through barriers of saw-grass. After several hours of hard paddling, we came in sight of Chitto's Island, . . . " ." (Brooks 1880)

The descriptions of navigable, open water alternating with much less passable sawgrass ridges are consistent with early photographs of the Ridge and Slough (King 1917; Sellards 1912) (**Plate 23, Plate 24, Plate 25**, and **Plate 27**; **Figure 4.15**). Narrative descriptions of this landscape indicate that the contrast between sloughs and ridges was distinct. Township surveys also suggest that this was the case: numerous surveys conducted for the Trustees of the Internal Improvement Fund around 1911-1912 recorded each transition between slough and ridge along their survey lines (e.g., **Figure 2.3**). The extra work involved in measuring and recording the location of these transitions—as many as ten in a mile—would only have been plausible and possible if boundaries were distinct and the vegetation and/or elevation are significantly different.

J.O. Wright, a drainage engineer involved with Everglades drainage, described the muck (peat soil) area south of the Sawgrass Plains, that is, the Ridge and Slough landscape. Wright provides considerable and important detail, particularly regarding the relation between the peat thickness and the different landscape elements (i.e., ridges and sloughs):

> "Beyond this ['practically level' area of the Sawgrass Plains], [the underlying soil material] becomes uneven, being marked with irregular depressions and ridges. As the surface is level, this unevenness of the sub-stratum causes a varying depth of muck within a limited area.
>
> The surface of the Everglades, taken as a whole, appears to be a level plain, having a slope of three inches per mile toward the south and east, yet this statement is subject to slight modification. Throughout the entire area there are numerous winding shallow depressions or channels 100 to 500 feet wide, and one to three feet lower than the land through which they pass. These depressions, locally called 'Strands,' [sloughs] wind through the 'Glades in all directions, though their general trend is from north to south. In other places there are slight depressions, like ponds or lagoons, covering one to forty acres. These are most numerous along the eastern margin and throughout the southern portion. The muck in these depressions is usually less firm than the land on either side. These irregularities of the surface also affect the depth of muck at these points, as the underlying hard material [i.e., bedrock] is no lower in these surface depressions than under the adjacent land. These low places are usually filled with water, while the general surface of the Everglades is comparatively dry." (Wright 1912, p.18-19).

Wright's description clearly points out that the Ridge and Slough landscape can be best described using measurements that span different scales. At the scale of the Everglades basin, the Ridge and Slough landscape resembled the adjacent Sawgrass Plains. Both landscapes were extremely flat and level, over tens of miles, with a very slight downstream slope of only about 3 inches per mile (0.000047). At a more detailed scale, individual sloughs, ridges, or tree islands, were not level. Wright describes the bottom of the sloughs as being 1 to 3 feet lower than the elevation of the surrounding ridges; a few years later Baldwin and Hawker (1915) give 2 to 3 feet for the same dimension. Tree islands rose even higher above ridges and surrounding sloughs.

Physical Dimensions

Once the different elements comprising the pre-drainage Ridge and Slough landscape are identified, a task greatly assisted by the many narrative descriptions, the key remaining task is to quantitatively estimate the physical dimensions of these elements. All three dimensions are important. The areal extent of the landscape is defined by its total length, extending from the sawgrass plains on the north, southward to the mangrove swamps. The eastern and western edges were defined by the elevated lands and terrestrial plant communities associated with the rock ridges. The lengths and widths of the different components vary considerably but are generally small relative to the overall size of the landscape and reflect the linear pattern of the landscape, since the width of each component is generally much less than the length.

Vertical dimensions of the landscape components are ecologically critical, determining the available water regimes for each landscape element. As vertical dimensions have been altered by peat oxidation and subsidence, the present day system may no longer reflect the original dimensions. These dimensions must therefore be estimated from the pre-drainage record.

The horizontal dimensions of the landscape elements are important, as a basis to understand the geomorphological processes that formed and maintained this peatland. Prior to construction of drainage canals, the Ridge and Slough landscape was the most extensive landscape in the Everglades (**Plate 13**; **Table 4.2**). Two characteristics of this landscape -- the presence of a persistent pattern in the layout of sloughs, ridges and tree islands and the uniformity of the pre-drainage system -- appear to be primarily determined by the horizontal features of this landscape. Peat subsidence has obviously altered vertical dimensions, but seems to have had less effect on horizontal dimensions. Examination of the horizontal features and dimensions of the presently existing landscape is therefore more likely to help determine these pre-drainage spatial patterns.

Visual inspection of early aerial photography suggests that both the spacing (cross-flow direction) and the widths of sawgrass ridges are much more regular than random. The predominant spacing is about 300 meters, centerline to centerline. Widths frequently are about one third of this. Spacing in the cross-flow direction of strand tree islands also seems to be fairly regular, peaking at about 500 m (Brandt). Like the repeatability of the vegetation, the regular, non-random aspect of these spatial observations and their repetition across the landscape argue for an organizing force that has been remarkably uniform for such a large area.

Elevation and Topography

The name ridge and slough, first published by Baldwin & Hawker (1915), reflects this landscape's corrugated microtopography, created by a linear mosaic of aquatic sloughs alternating with more elevated sawgrass ridges (**Plate 14**). The pre-drainage Ridge and Slough landscape can in fact be imagined as a sculpted or eroded version of the Sawgrass Plains to the north. The sawgrass ridges represent southward extensions of the Sawgrass Plains land surface and the sloughs are gouges that separate the individual ridges. Historical descriptions support the concept that sawgrass ridges are extensions of the Sawgrass Plains.

A summary of vertical and horizontal measurements of features within the ridge and slough landscape is presented in **Table 4.3.** The vertical estimates are based on pre-drainage and early post-drainage sources (**Appendix B2**), while the horizontal dimensions are based mostly on measurements from selected portions of the remaining landscape, combined with historical observations.

Table 4.3 Physical dimensions of elements of the pre-drainage Ridge and Slough landscape. Based in part on historical observations compiled in **Appendix B2.**

Landscape Element	Dimension	Estimate
Sawgrass Ridge	Width	100-2500 feet
	Length	1-5 miles
	Height	1-2 feet[1]
Strand Tree Island	Width	400-2500 feet
	Length	0.5-1.5 mile
	Height	2-4 feet[2]
Bayhead	Diameter	50-100 feet
	Height	2-4 feet[3]
Slough	Width	300-1300 feet
	Length	> 6 miles[4]
	Depth	1 foot; 3 feet [5]
Channel [6]	Width	3-300 feet
	Length	> 1 mile ?
	Depth	3-5 feet[7]

1. Refers here to the height of the average ground surface of the ridge above the average bottom surface of the surrounding sloughs.
2. Height of the center of the elevated north end of the island above average bottom surface of the surrounding sloughs.
3. Height of the center of the island above average bottom surface of the surrounding sloughs.
4. As the sloughs, together with the channels, formed a continuous flow network through this landscape, the length of sloughs and channels are somewhat ill-defined.
5. Depth" refers here to the average annual low and high water depths in the sloughs
6. Also referred to as "creeks," "runs," "streams," "gullys," or "leads."
7. Note that the authors cited in Appendix B2 give channel depths as the depth from water surface to bottom of the channel. We estimated the elevation of the bottom of the channels by subtracting the water depth from the average slough water depth, 2 feet; thus the channels extended 1 to 3 feet below the slough bottom

.

The observation of ridge height above sloughs (2 to 3 feet) recorded by Baldwin and Hawker deserves additional comment. These two soil scientists took approximately 300 soil cores along the length of the newly opened North New River Canal in 1915. Further confidence is gained in noting that their estimate overlaps with an earlier estimate of 1 to 3 feet made by Wright (1912). Wright's estimate appears to reflect that drainage engineer's extensive (but unfortunately unpublished) experience over a number of years.

The magnitude of these early post-drainage elevation differences illustrates the double challenges of characterizing pre-drainage conditions in this landscape and of deciding how best to restore it. Not only has the regional elevation and the regional slope of this landscape been altered in places by peat subsidence, but more critically from an ecological perspective, the differentiation of the individual elements has decreased. This flattening or blurring of the originally distinct landscape elements was already noted 50 years ago. As the elevation difference between ridge and slough decreased, water depths in sloughs became shallower, restricting navigation and allowing emergent species to invade the sloughs:

> "General Considerations: Prior to intensive drainage much of the Glades area was dissected by relatively deep open water "sloughs". These natural drainage channels permitted traverse into the interior of the Glades by "pole-boat" [probably dugout cypress canoes]. Journey by "pole-boat" for example from Dania on the east coast to the Big Cypress, forty miles to the west, or from Ft. Pierce south through the Glades to Ft. Lauderdale were not uncommon. A "pole-boat" trip such as this would be a remarkable feat indeed at the present time even during periods of high water. The major portion of these open water "sloughs" have now reverted to Rhynchospora sp. or maidencane or have been invaded by sawgrass, making navigability possible only by airboat and then only during the wet season." (Wallace 1955, p.2).

In the context of this post-drainage flattening, Wallace's observation regarding water depths in the previous quote is integral to understanding the pre-drainage ecology of the Ridge and Slough landscape. Wright (1911) notes (at a time when the original elevation differences, or "microtopography" were still present) that even when the "general surface," i.e. the ridges, was comparatively dry, the "low places"--the sloughs--were "usually filled with water." This was a critical difference between the patterned peatland of the Ridge and Slough landscape and the unpatterned Sawgrass Plains. In the latter, there was only one "general surface," so when water levels dropped below ground at the end of the dry season, surface water disappeared from the entire landscape, leaving behind 1200 square miles of boggy peat, with no water to be found above ground.

The ecological importance of the Ridge and Slough landscape in its pre-drainage condition derives from the elevation differences associated with the original microtopography. One can imagine that at least three planes of “general surface” exist in this landscape: one associated with the bottom of the sloughs, another defined by the surface of the sawgrass ridges, and a third passing through the slightly higher surface of the tree islands. Tree island elevations range in elevation from 2-4 feet above the surrounding sloughs and thus overlap with the height of ridges, suggesting that there may be a logical evolution or transition between high ridges and low tree islands over time. The water surface formed another plane that seasonally oscillated up and down relative to the peat surfaces. Although these planes were all tipped slightly to the south or southeast to form the 3 inch in one mile regional slope, several pieces of evidence suggest that, under pre-drainage conditions, all four planes (land and water surfaces) were parallel.

The relative topography of the ridges, sloughs, channels, and tree islands was different prior to drainage than it is at present, or even when it was described in detail in the 1950s. Peat oxidation and fires, occurring between the 1920s and 1950s and made possible by water levels lowered by drainage, diminished the elevations of tree islands and sawgrass ridges relative to the bottom of the sloughs. In addition, reduced water flow in the impounded, post-drainage Everglades may have allowed sloughs and channels to partially fill in, further decreasing the elevation differences between the sloughs and the tree islands and ridges. In short, the topography of the Ridge and Slough landscape has tended to flatten since the initiation of drainage. The flattening of this landscape after drainage and the attendant problems of tree island flooding have obscured understanding of pre-drainage slough water depths. This flattening also presents a challenge for the restoration of pre-drainage water depths in the sloughs.

Landscape Features and Vegetation

Early explorers ascending the swiftly running coastal rivers left vivid descriptions of suddenly emerging from the closed canopies of the coastal forests into the wide, open expanse of the Everglades. The vista they gazed out upon was the Ridge and Slough landscape, as this landscape extended eastward to the bordering cypress or pinelands (**Plate 13**; see also **Plate 36** and **Plate 38**). They frequently described the landscape as a vast lake, partially covered by tall, dense sawgrass and numerous tree islands (**Figure 4.5**). As they poled, paddled, or even sailed canoes through the landscape, these explorers found a network of sloughs and channels between the ridges of sawgrass, and noted tree islands that range in size from 1/4 to hundreds of acres. In the sloughs, which in places expanded into wider ponds ("lagoons" in the early literature), the water was sufficiently deep to remain open or be dotted on the surface with water lilies (c.f. **Plate 23**, **Plate 24**, **Plate 25**, **Plate 27** and **Figure 4.15**). "Lilies," *Nymphaea odorata*, and "bonnets" or lilies, *Nuphar luteum*, are frequently mentioned. Floating heart, *Nymphoides aquaticum*, is not mentioned, but may have been present as well. When the course of the travelers was parallel to the alignment of the landscape, the early explorers could easily pole or paddle canoes through the sloughs, frequently covering as much as seven miles per day (**Plate 8** and **Plate 9**). However, when travelling cross-wise to the landscape, the same explorers reported significantly slower going, being forced to push boats through the dense sawgrass and boggy soil of the sawgrass ridges, as shown in **Plate 24**.

<u>Sloughs</u>

Sloughs were the truly aquatic element: covered by surface water throughout the duration of almost all years. This created a network of elongated waterways winding through the landscape (**Figure 4.16**). The sloughs were either open water ("open sloughs," "ponds," or "lagoons"), open water partially covered with water lilies and/or flags ("lily pad sloughs," "flag sloughs"), or covered with a thin growth of a graminoid species ("grassy sloughs").

Open water sloughs partially covered with emergent macrophytes were the most common. Reported indicator species for this landscape element include the white water lily (*Nymphaea odorata*), spatterdock (also called bonnets; *Nuphar luteum*) and flag, (*Sagittaria lancifolia* and *Pontederia cordata,* also called duck potato and pickerel weed). Emergent vegetation ranged from sparse to thick patches.

Grassy sloughs were less common than open water sloughs and limited to areas of shallower water. Indicator species include spikerush *Eleocharis* spp., beak-rush *Rhynchospora* spp. and maidencane (*Panicum hemitomon).* These species are included as indicators of what are now called wet prairies (Craighead, 1971; Loveless, 1959; Gunderson, 1994). Prior to drainage, accounts indicate that sawgrass seems to have been restricted to ridges and was generally absent from sloughs.

The mechanisms that form and maintain sloughs are unknown. Alligator trails, periodic flushing by high water, and fire have been suggested as possibilities. The distinct orientation of sloughs in the direction of regional water flow suggests water flow was an important direct or indirect influence. The sloughs give the impression of having been “carved out” of the surface plane of the regional wedge of thick peat soil. Multiple observations of a clear difference between the firm, stable peat of the sawgrass ridges and the loose, flocculent peat of the sloughs (Wright 1912, p.18; Harshberger 1914, p. 159; Baldwin and Hawker 1915; p. 785; Allison and Dachnowski-Stokes 1932, p. 227; Stewart 1907, p. 40-41), suggest that the sloughs may have been kept open as aquatic areas by occasional flushing during periods of high water flow. Baldwin and Hawker (1915) and Parker *et al.* (1955) remarked on flows sufficient for sediment transport within the Ridge and Slough landscape. A more detailed discussion of Ridge and Slough shaping forces appears in Chapter 5.

Under post-drainage conditions, sloughs have in places “grown shut,” either with wet prairie species (see **Plate 20**), or with sawgrass, as seen in the northern portions of Water Conservation Areas 2A and 3A (**Figure 3.22**), and much of WCA 3B (Rutchey 1999). Lateral expansion of sawgrass into sloughs can be recognized from aerial views as well (**Plate 28**).

<u>Channels</u>

Channels (also called “creeks,” “runs,” “streams,” “gullys,” or “leads” in early accounts) resembled sloughs, but were narrower and deeper. In addition to sloughs, early explorers as well as land surveyors reported occasional channels of deeper water. Where the network of sloughs constricted, narrow and often deeper channels were formed, probably accompanied by faster water flow. Deep water depths and possibly periodic scouring during high flow events tended to maintain the sloughs and channels as open water or as water with an open covering of white water lily (*Nymphaea odorata*) or bonnets (*Nuphar luteum*). Deeper water in the channels kept them largely free of vegetation, allowing significant, unobstructed water flow. Many of the pre-drainage references to “perceptible currents” are from channels (**Table 5._**). The fact that channels had significant depth is supported by observations made after the completion of the first major canals. Surveys of a number of Everglades townships include references to 5 feet of water, in what were almost certainly channels (see **Appendix A**). Pre-drainage accounts frequently refer to these channels as having rock or sand bottoms. This may reflect the influence of water flow: the removal of the loose peat derived from aquatic plants (compared with the more solid peat of the sawgrass ridges) by scouring. References to channels generally disappear after the government township surveys of the 1910s, possibly because drainage and impoundment reduced flow and water depths so much that the channels filled in, became indistinguishable from sloughs, and ultimately disappeared.

Sawgrass Ridges

Sawgrass occurred on slightly elevated ridges of the underlying peat substrate. No evidence has been found to link sawgrass ridges to underlying bedrock features. This elevation above the sloughs created a hydropattern similar to that of the Sawgrass Plains: inundated most of the year, but with the water table dropping below ground at the end of the dry season. As a result, the vegetation on the ridges resembled that of the Sawgrass Plains and consisted of dense, tall, and nearly monospecific stands of sawgrass, usually fairly uniform in elevation, occurring along the length, although the ridge may be slightly convex in cross-wise profile. Scattered shrubs of buttonbush or myrtle may be found on this higher ground in the middle. The pre-drainage Ridge and Slough landscape can, in fact, be thought of as a southward extension of the Sawgrass Plains, dissected by a network of deeper water sloughs carved out of the plain of peat.

Maximum elevations of the sawgrass ridges were likely determined by a feedback mechanism controlled by prevailing water levels. As accumulating sawgrass leaf litter formed peat, elevations of the ridges would increase and the uppermost peat would rise above surrounding water levels--and hence be increasingly exposed to oxidation and fires -- during a greater portion of each year. Due to increased oxidation, the ridge elevation would then remain level or decrease in elevation.

Pollen and morphological analyses of soil cores from sloughs (Willard 1999, Cohen *et al.*, 1999) show several alternating bands of sawgrass and water lily peat, suggesting that both ridges and sloughs have been present for at least 2000 years, and that each persisted for several hundred years at a time. A spatial network of cores would be needed to determine if the alteration back and forth over time reflects lateral shifts in ridges.

Tree Islands

Tree islands were a conspicuous part of the Ridge and Slough landscape, being the only place trees were found. Tree islands were present in several variations (Gleason & Stone, 1994), but only two types will be discussed briefly here--large, elongated strand tree islands and smaller, round tree islands, often called bayheads. Tree islands are considerably younger features than the surrounding marsh, and rose above the surface plane on mounds of woodier peat soil or on rock outcrops. While the exact mechanism(s) of tree island formation are still undetermined, the flow of water was very likely involved, whether as an initiating or as a maintaining agent (VanderValk and Sklar, 2002) South Florida Ecosystem Restoration Working Group 2003; see Chapter 5). Tree islands south of approximately Tamiami Trail tend to be related to a rise in the bedrock underneath the head of the island. However, similarly shaped islands in the northeastern part of the landscape occur on deep peat with apparently no connection to bedrock. Dating of soil cores from tree islands suggests origins that range began as early as 3200 years before present (BP) in WCA-3B (Willard et al. 2002). Work by Gleason and Stone (1994) suggest that tree islands in the northern Everglades (Loxahatchee NWR) may be younger, originating less than 1300 years BP and as recently as 800 years BP (Stone et al. 2002). Such features may be "old" relative to the present, but represent only 10-30% of the lifespan of the Everglades. This also implies that older strand tree islands in southern areas of the system may have formed under different topographic, climatic and hydrologic conditions than islands that formed more recently.

Tree islands of varying sizes were reported throughout the historical accounts. Sizes were given mostly as areas, in units of acres. As both the smaller tree islands and the elevated "heads" of the larger strand tree islands were approximately round, **Table 4.4** can be used to estimate diameters from the historical descriptions of island acreage.

Table 4.4 Approximate relation of tree island area and diameter ($A = \pi$ r2 and an assumed circular outline).

Area (acres)	Diameter (feet)
1/10	75
1/4	120
1/2	170
1	240
2	330
5	530
10	750
20	1050
100	2350

For comparison, measurements from the Jones *et al.* (1948) soil map indicate that elevated heads of the strand tree islands located in the present Water Conservation Areas 3A and 3B, and in Everglades National Park measured as much as 1000 to 2000 feet in diameter, or about 20 to 70 acres in area. This is based on measurements of widths of elongated polygons of Gandy Peat, and on the assumption that the head was of approximately equal width. This may be an overestimate. Total area of these strand tree islands (i.e., including tails) was 100 to 500 acres.

<u>Strand Tree Islands</u>

Strand tree islands have a characteristic tear drop shape, typically having a small, elevated head area, an oval "near-tail" area trailing downstream, and an oval "tail," often of sawgrass and concentric around the near-tail. A fraction of the strand tree islands found in the Loxahatchee Wildlife Refuge (Water Conservation Area 1), however, do not have an elevated head, being instead level and low throughout (Gleason and Stone 1994; pers. comm., Laura Brandt 1998). Tree species on the heads differed with latitude. The more southerly included primarily tropical hammock species, and the more northerly resembled bayhead vegetation. Strand tree islands were (and still are) aligned in the direction of pre-drainage regional water flow, often with a characteristic "tear-drop" shape. The blunt ends faced upstream and the long tail extended downstream (**Plate 17**). The named tree islands visited during Col. Harney's expedition (**Appendix D)** were strand tree islands and the elevated heads were cultivated by Indians. Examination of aerial photographs suggests that if the characteristic tear drop shape is ignored, i.e., if only long, thin ridge-shaped polygons are examined, then there is a continuum between ridges and tree islands. The distinction is the degree of colonization of the sawgrass by woody vegetation and formation of the circular head. **Plate 18**, **Plate 17** and **Figure 2.8** show the oriented, directional pattern of the strand tree islands within the landscape.

<u>Bayheads</u>

Bayheads are small, round or ovoid tree islands dominated by swamp bay (*Persea borbonia forma*). Post-drainage information indicates that the bayhead substrate was elevated, by Everglades standards, rising 2 to 4 feet above the bottom of the surrounding marsh (**Appendix B2**). Measurements of pre-drainage bayhead soil elevations are not available. However, based on peat oxidation and documented tree island burns, it seems likely that they were as high or higher than the post-drainage measurements of 2 to 4 feet. In pre-drainage accounts, bayheads (often referred to simply as "clumps") are frequently described as being wet or overflowed. This suggests that water depths in sloughs were 2 to 4 feet — near or above the level of the bayheads.

Pre-drainage elevations of the tree islands were likely controlled similarly to elevations of the sawgrass ridges -- by a feedback mechanism based on water levels and peat oxidation rates. The formation of these elevated areas by tree species would result in deposition of peat with a higher lignin content, perhaps making these peats more resistant to oxidation than the sawgrass peats and allowing higher peat elevations to form on the islands and more trees to colonize these locations. Tree islands may have also been more resistant to the effects of fire (and associated peat loss) than the surrounding sawgrass. Another mechanism that may explain the stability of tree islands as elevated features is the deposition of nutrients. Willard *et al*. (2002) in their study of two tree islands in WCA-3B determined that soils on these islands had much higher concentrations of phosphorus than soils in the surrounding marshes during the entire period of island formation. The dryer soil, trees and higher shrubs may have provided suitable locations for bird, reptiles and small mammals to rest and roost, resulting in deposition of feces that would further stimulate plant growth and soil formation.

Two groups of former islands located west of Ft. Lauderdale in Township 50, Ranges 40 and 41 (Plate 38), deserve separate mention. Prior to drainage, Pine Island and Sam Jones' Seven Islands were both tree-covered islands, but were neither strand tree islands nor bayheads. The substrate was not peat, but Pleistocene sand of much older geological origin. Parker et al. (1955) noted that "Pine Island, so called from the fact that prior to drainage of the glades this large, pine-covered dune was entirely surrounded by water, is the best developed of these ice-age dunes."

<u>Soils</u>

The varied topography that distinguished the Ridge and Slough landscape-- channels and sloughs at the lowest elevations, ridges rising slightly above, and strand tree islands yet still higher -- was formed almost entirely by different depths of accumulated organic materials (fibric Histosols). These materials were the sawgrass peats on the ridges; the woodier "Gandy Peats" (Jones et al. 1948a) on the tree islands; a looser, more flocculent peat in the sloughs; and little or no soil in the channels. At the regional scale, peat filled the bedrock basin of the Everglades from east to west (**Figure 4.1**) and formed an enormous wedge in the northwest-southeast direction

(FEEC 1914; Mitchell 1932; Davis 1946). By the 1800s, peat accumulation in the Everglades had essentially filled the geological basin to capacity. Particularly in the northern part of the Everglades basin, variations in surface topography therefore had little or no relation to the underlying bedrock topography (**Figure 3.10**; Mitchell 1932). Soil samples collected and analyzed from tree islands indicate that some are centuries old (Valk and Sklar 2002)

In the southern parts of the landscape, where the north-to-south wedge of peat thinned, some of the sloughs were deep enough to have hard rock bottoms; heads of some of the strand tree islands were based on rises in the bedrock; and patches of marl were found in the landscape. Parker *et al.* (1955) suggest that water flow may have periodically flushed out any loose peat and exposed the underlying bedrock (see also Chapter 5). The presence of marl soil in the Everglades is generally associated with shallower water, shorter hydroperiods and a source of calcium (Browder and Gleason 1994), whereas peat soil is generally associated with deeper, softer water. However, there are exceptions in the southern part of the Ridge and Slough landscape. Soil surveys, township surveys, and road profiles reveal areas with alternating horizontal layers of peat and marl, such as the Hialeah Mucky Marl (**Plate 3**), as well as mixed areas where vertical "columns" of marl (**Figure 2.9**) occur in the midst of peat profiles. The two township surveys shown in **Figure 4.19.** Further confirm the co-location of marl and peat at multiple points in the vicinty of Tamiami Trail. These surveys are particularly significant as the surveying grid (1 mile section corners) can be assumed to have been unbiased, without preference either for marl over muck, or slough over ridge. The average total thickness of the soil profiles seems to have been similar between the two townships, but the westernmost one (T54 R37) included more marl and less peat. (**Table 4.5).** Overall, it is clear that the factors controlling marl vs. peat formation in the more southern portions of the Ridge and Slough landscape are complex, and determined by more than hydroperiod alone. These variations suggest a complex relationship, with the relative placement of marl vs. peat determined by vegetation patterns, hydroperiod, water quality, extreme events and other factors.

Table 4.5. Average soil layer thicknesses in two townships from within Shark River (feet).

Soil Layer	T54 R37	T54 R38
Muck (peat)	2.3	3.0
Marl	1.6	0.6
Total	3.9	3.6

Patterns in the Landscape

By landscape pattern, we refer to the size and spacing of Ridge and Slough landscape elements. Although the linear arrangement of tree islands and of ridges and sloughs is apparent in aerial views, the scale of the pattern makes it much harder to discern on the ground. The only vantage points are climbable trees, and these do not generally offer enough height to see the pattern. Inspection of a time series of aerial photographs and comparisons with old maps suggest that where post-drainage changes to the Ridge and Slough landscape have affected spatial patterns, they have primarily by "erased" them, rather than altered or shifted them prior to erasure. That is, the original spatial pattern appears to persist until the vertical dimension is completely flattened, at which point the spatial pattern disappears.

Thus areas where aerial imagery show distinctive patterns over time can be used to infer the pre-drainage horizontal dimensions and pattern. A typical arrangement of these elements can been seen in a scale drawing of a representative 1 mile by 1 mile section of the Ridge and Slough landscape (**Plate 14**). The dimensions shown in **Plate 14** and in the related cross-section view (**Figure 4.18**) were taken from **Table 4.3**. **Plate 32**, **Plate 33** (top), and **Plate 28** (left one-third), show aerial views of the pattern formed by the sawgrass ridges and the sloughs. These post-drainage views were selected from areas where the spatial pattern appears to be closest to pre-drainage conditions. **Plate 30** shows the same pattern viewed from space. A similar pattern is seen on a hand drawn map of approximately 12 square miles of NE Shark Slough drawn in 1917, showing "sloughs," "sawgrass prairies" (ridges), and "hammocks" (tree islands) (**Figure 4.16**).

The section on topography, above, noted that ground elevations and water surface levels in the Ridge and Slough landscape tipped slightly to the south and southeast. This slope of the land and water surfaces provides the basis for two additional features of the landscape that will be discussed in more detail; directionality and uniformity.

<u>Directionality</u>

The main components of the Ridge and Slough landscape can easily be recognized in the earliest available (1917) ground photographs (**Plates 23-25**, and **Plate 27)**. However, while the differentiation is clear, no particular spatial pattern or organization of the components is obvious. Despite the absence of any aerial perspective, early explorers often described a definite orientation to the landscape, frequently also noting that the current flowed in the same direction:

> "[This] part of the area is very gently undulating or hummocky, owing to a series of ridges and sloughs with local differences of 2 to 3 feet in elevation, having a general northwest-southeast direction.
>
> The natural drainage conditions of the Everglades followed the general southeastward slope through the sloughs which trend in that direction…" (Baldwin and Hawker 1915).

Plate 32, **Plate 33** (top), and **Plate 28** (leftmost one-third) show aerial views of the directional pattern formed by sawgrass ridges and sloughs. These patterns of long, linear ridges and sloughs alternating with each other match the early descriptions of crossing the landscape at angle approximately perpendicular to the ridges:

> "...Chadwick [surveyor on the 1907 party across the Everglades] mentioned saw-grass ridges alternating with open leads of water running approximately in a southeastern direction." (Harshberger 1914).

The many sets of field notes from township surveys from 1910-1918, which describe ridges alternating with sloughs and tree islands, also appear to match well with aerial photographs of the better-preserved portions of the landscape.

In addition to the pattern formed by ridges and sloughs, the shape and alignment of the large strand tree islands also form a directional pattern across the landscape (**Plate 17** and **Plate 18)**. Two early post-drainage maps show similar patterns of oriented tree islands and sawgrass ridges (King 1917 ref 152; Newman 1908 ref 334). Even though they occur at different scales, the directional patterns formed by the tree islands and by the combination of ridges and sloughs, when compared, appear to show essentially the same directionality. The similarity and nature of these patterns suggest that some sort of organizing force, not necessarily occurring at the same temporal scale for ridges and tree islands, is responsible. Gleason and Stone (1994) identify this organizing force as pre-drainage flows through the Everglades. Flows will be discussed further in Chapter 5.

<u>Uniformity</u>

It was suggested earlier that the Ridge and Slough landscape was remarkably uniform across its full extent, notable for such a large area. The drainage pattern found in the pre-drainage Everglades was also unusual. Neither a deeper central drainage channel nor a hierarchy of dendritic drainageways was present. Instead, both flows and depths within the Ridge and Slough landscape were distributed evenly across the full width of the landscape. This is reflected in the regular spacing of ridges and in the widespread similarity of vegetation. While there were certainly differences from place to place, the vegetative differences among ridges and among sloughs were both much smaller than the differences distinguishing a ridge from a slough. The landscape directionality mapped from the pattern of ridges and sloughs also suggests a uniform and regular flow field in which flow directions changed very gradually over distance (**Fig. 5.7**).

Even where the bedrock basin narrowed to form Shark Slough, the vegetation of the Ridge and Slough landscape remained the same: sawgrass ridges and open, water lily sloughs. The *shapes* of ridges and sloughs (plan view) did elongate, much as would be expected if the narrowing cross-section had increased flow velocities. The narrowing might have also or instead increased water depths, but this does not appear to have been the case, as the vegetation does not reflect deeper water.

<u>Hydrology</u>

As the largest, topographically most varied, and deepest water portion of the Everglades, the Ridge and Slough landscape significantly influenced Everglades hydrology. At the same time, as a patterned peatland, the regional hydrology strongly influenced the microtopography and spatial patterns of this landscape. The interaction between landscape and hydrology therefore extended in both directions, with directionality of the landscape influencing direction of flow, water flow perhaps helping maintain the landscape. Similarly, water depths helped to maintain the peat microtopography, and the microtopography allowed the persistence of specific water conditions.

Focusing first on water flow, it is helpful to compare the Ridge and Slough landscape with the Sawgrass Plains, where surface water covered the entire landscape in a sheet of uniform thickness, and downstream movement of this sheetflow was uniformly retarded by the dense growth of sawgrass. In contrast to this even distribution of sheetflow across the full width of the Sawgrass Plains, surface water in the pre-drainage Ridge and Slough landscape water moved through a system of many parallel flow paths (sloughs), seasonally separated by long sawgrass ridges. A term such as “sloughflow” may be more appropriate in this landscape. Even when surface water was present across the full landscape (i.e., on top of the ridges as well as in the sloughs), the slough flow paths were still partially separated from each other by the shallower water and much higher plant stem density on the ridges. If the ridges contributed minimally or not at all to surface water flow, then the cross-section for downstream flow in the pre-drainage system would not have been the full width of the landscape but instead only the slough fraction. We estimate this to have been about 60% of the landscape.

Reports from early observers strongly suggest that ridges and sloughs were aligned in the downslope direction. If so, the orientation of the landscape "grain" visible in early aerial photographs can be used to estimate pre-drainage flow directions.

Estimating pre-drainage water depths and hydroperiods within the Ridge and Slough landscape involves synthesis of information from many different sources, including pre-drainage recorded water depths from varying locations, years and seasons (**Appendix A**); descriptions of pre-drainage slough vegetation (this section, **Appendix A** and accounts of cross Everglades excursions); comparisons with post-drainage vegetation and accompanying water depths; descriptions of pre-drainage navigability of the landscape; estimates of pre-drainage slough, ridge, and tree island elevation differences; and soil core records of pre-drainage frequency of peat fires. **Figure 4.18** shows estimated end-of-wet and end-of-dry season water depths (i.e., typical minimum and maximum) and their relation to sloughs, ridges, and tree islands. The estimates shown in **Figure 4.18** are consistent with early descriptions, which suggest that the sawgrass on pre-drainage ridges was similar in canopy height and stand density to that of the Sawgrass Plains. For the ridges, we therefore adopted the hydrologic estimates of water depth and hydroperiod previously made for the Sawgrass Plains.

If one assumes a level water surface across ridges and sloughs (crossflow direction), then the ridge height of 1.5 feet above the sloughs defines the typical annual minimum and maximum water depths within the sloughs. **Figure 4.18** shows that this works out to a typical annual low of one foot of water in the sloughs and a typical annual high of three feet. These depths appear to be quite consistent with reported pre-drainage and early post-drainage depths (**Appendix A**). Note that these estimates imply that the sloughs typically had water in them throughout the year. This would be consistent with indications of large pre-drainage populations of alligators within the Everglades (e.g., Kersey 1975), where at present they are primarily concentrated in the deeper water of canals. It would also be consistent with continuous, multiyear populations of larger fish. The presence of year-round water within sloughs is also consistent with the soil core record, which, though limited, suggests that the peat soil rarely dried out enough to support frequent soil fires (peat burns). The many peat fires reported in the 1920's, 1930s, 1940s, and even 1950s very clearly reflect a lowering of water levels from pre-drainage conditions.

The presence or absence of wet prairie species (e.g. grasses and sedges) supports the water depth estimates shown in **Figure 4.18**. Pre-drainage descriptions, photographs, and recorded travel times of seven or more miles a day suggest that while sloughs did contain patches of emergent vegetation, wet prairie species were largely absent from sloughs prior to drainage. An increase, beginning about 1900, in wet prairie species pollen, found in soil cores, further suggests that the current abundance of wet prairie species is a post-drainage phenomenon associated with lowered water levels. At present, emergent wet prairie species cover much of the sloughs in the remaining Everglades. Their presence tends to diminish as one travels from north to south in the Water Conservation Areas, suggesting that the deeper water typically found in the southern (downstream) end of these impoundments may more closely approach pre-drainage water depths.

In conclusion, we estimate a typical annual low water depth of 1 foot in the sloughs and a high of 3 feet. For the ridges we estimate a low of 0.5 foot below ground and a high of 1.5 feet above. Hydroperiods in the sloughs would extend across multiple years until an exceptionally dry year occurs. On ridges, hydroperiods would typically be 9-10 months.

Hindcasting

As a bi-modal landscape (channel/slough, ridge/tree island) with modes distinguished by elevation and hence water depths, the Ridge and Slough landscape was particularly prone to anthropogenic changes once regional water depths were lowered by drainage. The changes reported in each mode (**Chapter 3**) are consistent with drier conditions. Tree islands became more subject to peat fires (Simpson 1920; Loveless 1960; Craighead 1971; Alexander and Crook 1974) and peat oxidation, which causied a decline in tree island elevation. Sawgrass ridges became subject to invasion by woody species (Simpson 1920; Johnson 1958; Robertson 1953), blurring their original distinction from tree islands. Sloughs became shallower and open to invasion first by wet prairie species (Wallace 1955b; Loveless 1959; Goodrick 1974) and subsequently by sawgrass (Wallace 1955a,b; Florida Game and Freshwater Fish Commission 1956; Loveless 1959; Olmsted and Armentano 1997). Invasion of sloughs by sawgrass of course blurred the distinction between ridges and sloughs. Such changes can ocur in relation to changes in managed water depths but also seem to be linked to changes in water flow (SCT 2003).

The persistant assumption that the Ridge and Slough landscape originally existed only in two distinct areas, separated by a wide band of sawgrass similar to that of the Sawgrass Plains was not confirmed. Ridge and Slough appears on maps from the 1940s in the "Hillsboro Lakes" area (present Arthur R. Marshall Loxahatchee Wildlife Refuge) and in "Shark Valley" (Shark Slough in Everglades National Park and Water Conservation Area 3) (e.g. **Plate 4, Plate 5** and **Plate 11**). This configuration is often thought to represent pre-drainage conditions, probably because the soils are assumed to have preserved the pre-drainage configuration, even if post-drainage changes to the vegetation are acknowledged. **Chapter 3** explains in more detail that the soil pattern seen in the 1940s may not reflect the pre-drainage configuration, and in fact represents post-drainage alterations that were most pronounced in the area between the Miami and North New River Canals. A vegetation transect from 1912 (Harshberger 1914) and a soil transect from 1915 (Baldwin and Hawker 1915) confirm the original presence of a single, continuous area of Ridge and Slough landscape and this is reflected in our hindcasted landscape. Other hindcasting changes to the Ridge and Slough landscape were fairly minor, and were similar in nature.

Ridge and Slough Endnotes

1. William Cooley settled near the New River in 1827. From the headwaters of that river he explored the Everglades for almost a decade. A lengthy letter written in 1851 to Florida Governor Thomas Brown describes Cooley's activities in the area and includes his recommendations for further development of south Florida (Knetsch 1989). This letter provides some of the earliest detailed descriptions of the Ridge and Slough landscape. In addition to small cocoplum islands, Cooley found rock-bottomed channels with 2 to 4 feet of water, open water lakes, and 1 to 1.5 feet of water on the sawgrass ridges and the areas of maidencane (*Panicum hemitomon*):

> "From 1827 to 1836 I often visited the Everglades with the Indians who lived on New River – we often tried to go to what the Indians called Micaco or Big Water which I suppose is Okechobee – We passed through several fine Lakes and saw a number of small Islands covered with cocoaplum tree – we came to a lake full of Water Lettuce about 15 miles West from the head of New River – on this route the water on the Everglades is not more than 12 to 18 inches deep except in the channel where it is 2 to 2 1/2, 3 to 4 feet, rocky bottom - The Everglades are covered here with a growth of Saw Grass and Maiden Cane ... as far as we went we found a well defined rocky channel having a greater depth of water than the surrounding Glades with considerable amount setting towards New River..." (Cooley, 1851, in Knetsch 1989).

Cooley's starting point, the headwaters of the South Fork of the New River (Sections 24 and 25, T 50 R41), as well as the first 9 miles of the Ridge and Slough, are depicted on **Plate 38.** His observations of a "considerable amount [of water] setting towards New River..." is reflected in the northwest-southeast orientation of the tree islands shown on **Plate 38** in Township 50 Range 41 and in the same orientation shown in the landscape "grain" visible on aerial photographs from 1940 (**Plate 35;** see Townships 49 and 50).

2. During the Seminole Wars, Col. William S. Harney made a number of forays into and across the Everglades. He traveled in large, dugout cypress canoes of the kind used by the Indians. In December, 1840, an officer of his expedition from Ft. Dallas (mouth of the Miami River) to Shark River wrote a day by day account describing the southeastern Ridge and Slough landscape, including Shark Slough. The broad landscape was composed of sawgrass; small, wet tree islands; larger and drier tree islands inhabitated by Indians; and sloughs. The continuous network of aquatic sloughs allowed Harney's party to travel quickly, without portages through the sawgrass, and afforded ample deep water for easy paddling of the large canoes:

   Dec. 6/to Station 3:"Nothing now presents itself to view except one boundless expanse of saw-grass and water, occasionally interspersed with small islands, all of which are overflowed, but the trees are in a green and flourisheing [sic] state." [This location was to the east of the present L-31N canal (**Figure 1.1**).]

   "We have plenty of water at present, and go along with a great deal of ease."

   Dec. 6/to Station 3:"[To reach the island] we had to wade through mud and water three or four hundred yeareds, up to our waists, before we gained dry land... here we found a corn field of about an acre, and the richest land I have ever seen, being one black heap of soil of endless depth."

   Dec. 7/Station 6:"...the thousand channels which flowed and wound in every direction..." (Anonymous 1960).

   Detailed analysis of Col. Harney's expedition (**Appendix D**) indicates that water depths in the sloughs were at least 2.5 to 3.5 feet.

3. In a subsequent expedition in January 1841, Col. Harney led 50 men in four large cypress canoes from Fort Dallas (Miami) to Fort Lauderdale along a route through the Everglades (T51-52, R41), just west of the Atlantic Coastal Ridge. An officer of his party described a similar topography of alternating open sloughs ("lagoons") and higher ridges of sawgrass, apparently with ample water:

   "We then moved forward swiftly and noiselessly, at one time following the course of serpentine channels opening out occasionally into beautiful lagoons, at another forcing our way through barriers of saw-grass." (Anonymous, 1841, in Brooks 1886).

4. In 1847, Buckingham Smith asked Col. Harney to comment on the likelihood of draining the Everglades. In his response, Harney described channels, sawgrass, and numerous small tree islands, and gave the general water depth as 2 1/2 to 6 feet. From Harney's routes, we conclude that his observations apply principally to the pre-drainage Ridge and Slough landscape:

   "During the late Seminole War I was repeatedly in the Everglades and on the rim or margin at various points, and crossed it from Miami to Shark River. It is a vast, fresh-water lake, of shallow depth, from 60 to 90 miles in length, and from 25 to 50 miles in width. Its general depth is from 2 1/2 to 6 feet of water, over (say from 2 to 6 feet of) soft mud, or vegetable deposit. It is interspersed with thousands of islands, from a quarter of an acre to several acres in area and generally having a few trees on them. Water grasses of several feet in height above the water cover its entire surface, except in a few channels or where there are small ponds of water with sand bottom from 3 to 5 feet deep. There are no trees in the waters of the interior of the Everglades, but the margin of the "Glades," running out about on an average 1 mile, is full of fine cypress trees." (Harney, 1848, in Senate Doc. 89 (1911).

5. In addition to requesting descriptions from other first-hand observers, Buckingham Smith himself drew the following remarkably vivid picture of the Ridge and Slough landscape. Dix and MacGonigle (1910) described Smith's expedition into the Everglades in September of 1847. The route, from the Miami River to Prophet's Island (toward western side of the Everglades; **Figure 2.6**), was likely all within the Ridge and Slough landscape:

   "On September 10, Mr. Smith, Lieutenant Martin, and Lieutenant Herndon, accompanied by four seamen and a boy, entered the Glades by the south fork of the Miami River. The time was opportune, as it offered the advantage of the highest water. ...the party succeeded in making a course westward for two days. Then the heavy growth of the saw-grass and the trend of the moving water compelled them to change to a course leading north-northwest. Although considerable time was given to exploration and observation along the route, the party in five days reached Prophet's Island, several miles east of Prophet's Landing. ... Owing to the height and density of the saw-grass, progress west of this island was found to be impossible, even with the advantage of high water." (Dix and MacGonigle 1910, p. 517).

6. Comparison of Smith's description with others of this section suggests it represents typical Ridge and Slough conditions. Smith's observations of water depths of 3 to 6 feet are similar to Col. Harney's. Sawgrass on the sawgrass ridges was tall (10 feet), and water movement was apparent:

"The appearance of the interior of the Everglades is unlike that of any region of which I have ever heard, and certainly it is in some respects the most remarkable on this continent.

Imagine a vast lake of fresh water extending in every direction from shore to shore beyond the reach of human vision, ordinarily unriffled by a ripple on its surface, studded with thousands of islands of various sizes, from one-fourth of an acre to hundreds of acres in area, and which are generally covered with dense thickets of shrubbery and vines. Occasionally an island is found with lofty pines and palmettos upon it, but oftener they are without any, and not unusually a solitary majestic palmetto is seen, the only tree upon an island, as if to guide in approaching it, or as a place of signal or lookout for its former denizens. The surrounding waters, except in places that at first seem like channel ways (but which are not), are covered with the tall sawgrass, shooting up its straight and slender stem from the shallow bottom of the lake to the height often of 10 feet above the surface and covering all but a few rods around from your view. The water is pure and limpid and almost imperceptibly moves, not in partial currents, but, as it seems, in a mass, silently and slowly to the southward. The bottom of the lake at the distance of from 3 to 6 feet is covered with a deposit of decayed vegetable susbstance, the accumulated product of ages, generally 2 or 3 feet in depth on the white sand and rock that underlies it over the entire surface of the basin. The flexible grass bending gently to the breeze protects the waters from its influence. Lilies and other aquatic flowers of every variety and hue are to be seen on every side, in pleasant contrast with the pale green of the saw grass, and as you draw near an island the beauty of the scene is increased by the rich foliage and blooming flowers of the wild myrtle and the honeysuckle and other shrubs and vines that generally adorn its shores. The profound and wild solitude of the place, the solemn silence which pervades it, unless broken by the splashing of a paddle of the canoe or light batteau, with which only can you traverse the Payayokee, or by the voices of your 'Campagnons du voyage,' add to awakened and excited curiousity feelings bordering on awe." (Buckingham Smith, 1848, in Senate Doc. 89, 1911).

7. Dr. James A. Henshall, a physician later with the U.S. Fish Commission (Tebeau 1973), canoed and sailed from the headwaters of the South Fork of the New River to an Indian village on one of the sand islands, either Pine Island or Sam Jones' Seven Islands [Also known as "Long Key" from the proximity and linear orientation of these seven islands. The eastern portion of these former islands are presently protected as an "Environmentally Sensitive Land" in public ownership by Broward County.] slightly further west. On this date well into the dry season (approximately 22 February, 1882), waters would be expected to have been low. His route from the New River to the island can be traced on **Plate 36** and **Plate 38**:

"... we finally emerged into the Everglades [i.e., emerged from the closed canopy hammocks and the thick swamp of large cypress bordering the New River], seemingly a sea of waving green grasses, with innumerable islands of all sizes. But these grasses are all growing in water, clear and limpid, with channels a few feet wide, diverging and crossing in every direction, through which a canoe can be sailed or poled; there was then two feet of water in the Everglades. [Henshall states that "in the fall there is from four to six feet of water in the Everglades, caused by the heavy rains of summer, but in the late spring 'navigation closes.'" (Henshall, 1882, in Reiger 1971).] A brisk breeze blowing, we unfurled the sail and went skimming along, greatly to our satisfaction and relief, for we were quite tired after paddling up stream for some six hours. ...

Seeing smoke several miles away, we sailed in that direction through intricate and narrow channels, often making short cuts by plowing through masses of lily-pads... (Henshall, 1882, in Reiger 1971).

His description of water lily sloughs with 2 feet of water during the dry season, 4 to 6 feet during the wet, is consistent with township survey descriptions of this area (**Plate 38**; see also **Plate 36**). It is also consistent with classification of the area as Ridge and Slough landscape (**Plate 13**). All three plates show the landscape extending eastward to the headwaters of the New River (T50 R42, Section 19).

8. Henshall's account of his stay at the Indian village helps one visualize this area as a high sand island surrounded by an aquatic Ridge and Slough landscape:

> We soon came in sight of the Indian village, a cluster of twenty-five or thirty huts on the ridge of pine woods...
>
> These Indians lead a quiet, peaceable and semi-pastoral life, cultivating fields of corn, pumpkins, sweet potatoes, beans, bananas, etc. in the rich hamaks [hammocks] on the adjacent islands, their villages being in the pines or the border. They also make starch from the 'comptie,' or wild arrowroot, which grows abundantly in the pine woods, and in the winter they hunt deer and bears.
>
> As ... darkness closed around, the night was filled with wonders. ... The young moon hung low in the west, ... across the mysterious wastes of the Everglades. ...Myriads of fire-flies flitted and flashed their tiny lanterns over the slender spires of reeds, rushes and rank grasses, their reflections gleaming and sparkling with the stars in the still reaches of the channels. ...the great horned owl woke the solemn echoes of the dense pine forest, while an incessant twittering and chattering of waterfowl, the piping of frogs, and the occasional bellow of an alligator came from the marshes." (Henshall, 1882, in Reiger 1971).

Drainage and diking dramatically changed this area. By the 1930s, the marshes surrounding Pine and Sam Jones' Seven Islands had been completely drained and replaced by citrus groves (Mitchell 1932). The 1940s soil map of this area (**Plate 3**) makes clear how effective the North and South New River canals had been. Not only was all the water gone, but by the 1940s, most of the peat soil as well (see also Chapter 3).

9. Beginning at the southernmost point of Lake Okeechobee, the Times-Democrat expedition of November-December 1883 (**Appendix E**) followed an almost straight course south through the western portion of the Everglades. Between Stations 18 and 23, the expedition passed through the Ridge and Slough landscape (**Plate 8**). After the very shallow water (2 to 3 inches) of the southern Sawgrass Plains, the water deepened in the Ridge and Slough area to 2 to 3 feet. At the same time, the thickness of the underlying peat layer began to decrease, with rock appearing at the bottom of the sloughs between Stations 21 and 23. Flowing water was observed during this expedition. Observations are recorded in **Table 5.__.** The landscape included open sloughs separated by narrow strips of sawgrass, numerous small and wet tree islands, and in the shallower water, sloughs or channels with a thin covering of "marsh grass:"

> Nov. 28/Stn. 19:"...water about eighteen inches deep...we find ourselves in a species of grassy waters, bounded on each side by a thick wall of saw grass. In other words, a water course an hundred yards wide, with a thin species of marsh grass covering it [The identity of the "thin species of marsh grass" is unclear; perhaps water panic grass (*Panicum paludivagum*, also called *Paspalidium geminatum*). It does not appear to be either maiden cane (Panicum *hemitomon*) or wire grass (*Eleocharis*? sp.), as both of these are mentioned by name elsewhere by Williams.] ... we have no trouble in propelling our boats....we find ourselves on the borders of the island which is three acres in extent, covered with a growth of wild fig and custard apple trees."
>
> Nov. 29/Stn. 20:"To the east, west and south, as far as the eye can reach we see hundreds of little islands, divided from each other by the grassy water already described, and sawgrass marsh."
>
> Nov. 30/Stn. 21:"...first time in many days we are able to use our oars. Many times during the day we come to the end of the water-course we are following, but by pulling the boats through the saw-grass a few yards we are able to go into another, the whole face of the country being a perfect network of such courses, the saw-grass between being only a few yards through. We pass a number of islands, none over two acres in extent, and if any high land is upon them, not more than a few yards in the centre."
>
> Dec. 1/Stn. 22:"...water about 3 feet with rocky bottom. ... numerous islands, all of which are under water." (Williams, 1883, in Wintringham 1963).

Appendix E includes additional detail concerning observations from the Times-Democrat expedition.

10. The Ingraham expedition (**Appendix F**) crossed the Everglades on a southwestward course, from Fort Shackleford to Miami, in March and April of 1892. Almost all of the course was through the pre-drainage Ridge and Slough landscape (**Plate 8**). The late timing of this expedition (70-80% of the way to the end of the dry season) and the fact that both 1891 and 1892 were apparently years of below average rainfall (**Figure 2.10**), indicate very shallow water depths should be expected. Conditions do, indeed, appear to have been drier than those observed during the Harney and the Times-Democrat expeditions. Even so, water depths of "about 2.5 feet on the average, sometimes 4 feet" were reported by the Ingraham expedition. Areas of shallower water on the sawgrass ridges were described as "...grass was high and thick, the ground so boggy that at every step we sank into it up to our thighs..." (Church 1949). Variation in water depths in the Ridge and Slough area can be seen between the different camps, but the overall impression is typical of this landscape--slightly elevated sawgrass ridges alternating with more open sloughs or channels, water lilies, tree islands, and 2 to 6 feet of peat soil. Although this expedition took place toward the end of the dry season, perceptible water flow was observed at some points (see also **Table 5.__):**

    Mar. 24/Camp 8:"The Glades at this point present an endless sea of saw and other grasses, lily pads, a great many of them in bloom, with small patches of water amid clear spots in the grass and small islands here and there. Two large islands of considerable extent can be seen to the eastward from this island"

    Mar. 24/to Camp 9: "The water today averaged somewhat deeper and rather more boggy. Rock still underlies everything and at about the same depths [3-5 feet]. ... Had to make several portages and drag the boats through saw grass."

    Mar. 29/to Camp 14:"No island visible except the one we are making for, --- all saw grass and glades. ... Locomotion is extremely difficult and slow. The bog is fearful and it sometimes seems as though it would be easier to stay in than to go on. Both legs, up to the waist, frequently become embedded in the same hole in the mud... The boats are very necessary to enable one to pull himself out of the mud."

    Mar. 31/to Camp 16:"Found glades to be bearing east of south with plenty of water all day. ...In going from one glade to another through narrow channel we found quite a strong current, flowing towards the S.E. perhaps a mile an hour, but when the center of the glade was reached, the surface broader and shallower, it was not perceptible. After lunch, got into a stream of water, almost a river, with saw grass banks which lead us to another island..." (1892, Marchman 1947).

    Additional analysis of this expedition can be found in **Appendix F**.

11. The naturalist Charles Richards Dodge explored Ridge and Slough vegetation just west of the north fork of the Miami River in March of 1894 (thus well into the typical dry season):

    "When the boat had been dragged over the point at the head of the rapids, and we were rowing again in smooth water, what a surprise was in store for us! I had always associated with the term 'Everglades,' ... the picture of a low-lying, dank, dark, malarial swamp ...

    But instead I found an inland lake, of drinkable water, lying high up in the sunshine, while stretching away toward the sunset as far as the eye could reach was only a vision of blue waters, green isles, and vast areas of sedge-grass or reeds, moving in the balmy breeze like ocean billows. This is the picture of the Everglades in winter; in summer it might be something very different. [Actually Dodge's observations, made in late February/early March, would already have been well into the typical dry season.]" ." (Dodge 1894, p. 361).

    The description of an "inland lake" with "blue waters" likely refers to the sloughs, in this case sufficiently free of emergent vegetation to reflect the sky.

12. The variety of water depths noted by Dodge likely reflect differences between slough, channel and sawgrass ridges elevations. Even in the dry season (Feb./Mar. 1894), water depths were apparently still great enough that Dodge felt a two foot lowering would have left lakes and streams; the "vast prairie" he envisions probably refers to the network of sawgrass ridges:

    "The water in many places is so shallow that if it could be drawn off for a depth of two feet, I fancy the Everglades would resemble a vast prairie filled with little lakes and winding streams.

> Some of these watercourses were too deep for the bottom to be seen; others were only a few feet in depth, the vegetation below the surface clearly visible, and with banks sharply defined, while in many places the levels varied in depth from only a few inches to a couple of feet. In one place when I wished to take a picture I stepped out of the boat, with camera under my arm, and waded to the point of view through not over eight inches of water. The bottom is old coral rock, covered with a shallow substratum of soft mud. It is not safe to enter the glades without a guide, on account of danger of bewilderment, in pushing through the winding channels and tall grass and reeds." (Dodge 1894, p. 361).

The description of "sharply defined banks" between the water courses and the higher elevation areas, most likely sawgrass, is significant. Sharp banks and absence of a gradual transition between ridges and sloughs was also noted in earlier expeditions (e.g., Anonymous 1960; Marchman 1947; Wintringham 1964).

13. Dodge also noted the variety of tree islands sizes, and Seminole Indian presence on the larger ones:

> "The keys or islands, which always form the distance to a picture taken in almost any part of the glades, vary in size from a mere mound to a few feet across, to areas of many acres. Many of them are cultivated by the Seminoles, ... raising of corn and pumpkins. Many of the keys are heavily wooded, and all are interesting. What gives them a particular interest is the fact that they form the abiding-places of these Seminoles." (Dodge 1894, p. 361).

14. From Griswold:

> "The Everglades impress one as a sea of grass growing in shallow water, with countless shallow ponds of clear water in which grow small bulrushes, lilies, and other water plants; the ponds are of most irregular and confusing shapes, so that it is a matter of much difficulty to travel twice over the same route; ponds may have wide connections, narrow connecting channels almost entirely hidden by saw-grass, or may be shut in by saw-grass completely. Oftentimes a tall man is unable to see a pond close at hand, so thick and high is the saw-grass." (Griswold 1896, p.53-54)

15. In January, 1897, Hugh Willoughby and companion Ed Brewer made an expedition by canoe from Shark River to Miami, during which they passed within the edges of both the Ochopee and the Rockland Marl Marshes (**Appendix G**). The middle and last parts of the expedition traversed the Ridge and Slough landscape, mostly within Shark Slough (**Plate 8).** Willoughby's route overlaps considerably with Col. Harney's expedition, made 58 years earlier. Antecedent rainfall appears to have been quite different between the two expeditions. Harney's expedition was most probably made after a period of normal rainfall (see **Appendix D**). Willoughby's, in contrast, was made after a six-year long period of below average rainfall (**Figure 2.10**).

In spite of multiple years of below average rainfall, Willoughby found sufficient water for relatively easy poling of his boats along most of the western and eastern edges of Shark Slough. Numerous small tree islands were encountered. All were described similarly to Col. Harney's descriptions: very wet, with little or no dry land. Only between Stations 8 and 9, in Shark Slough, and between Stations 10 and 12, on a portion of the Rockland Marl Marsh, did Willoughby find progress impeded by low water and pinnacle rock.

Willoughby's description of the interior of Shark Slough is quite different from Harney's. Where Harney's expedition had found open sloughs with sufficient water to paddle easily among the large strand tree islands, Willoughby found a 20-mile long, 2-6 mile wide stand of dense, tall, and inpenetrable sawgrass preventing him from crossing Shark Slough. He was forced to retrace his route southward to Township 57 to find an opening to the east. With the exception of "Willoughby Key" (Station 4 on **Plate 8**), Willoughby never saw the large, dry strand tree islands seen by Harney's party, probably because the edges of the long stand of dense sawgrass blocked any view of these islands. During the six-year dry period preceding Willoughby's expedition, water depths had apparently declined sufficiently to promote vigorous sawgrass growth, at least along both eastern and western edges of Shark Slough, if not throughout:

> 9 Jan/to Stn 2: "There seems to be plenty of water ... the water was in all places clear, even where the grass was thick, with a mile and a half current setting to the southwest ... around...the little islands the mud may be a trifle soft, but pure water is running over it, and no stagnant pools can be found." [Willoughby later comments on the absence of mosquitoes within the Everglades, noting that "the water was not stagnant for [the mosquito] larvae." As recorded in the section on the Miami Rock Ridge, Gifford (1911) reports that while formerly present in the pre-drainage pinelands, mosquitoes were generally absent from the Everglades itself. Dimock (1907) also

reported dispensing with mosquito bars, "as we found the pests so scarce in the Glades as to be hardly worth considering." In contrast, Pierce in Pierce and Curl (1970) mentions "...not being able to take them [the early morning mosquitoes] any longer..." sometime in the 1880s at a location several miles southwest of the head of the south fork of the New River.]

10 Jan/to Stn 3:"The water seemed all to be moving in a southwesterly direction... Sometimes pools would be crossed eight or ten feet wide and five feet deep. ... Occasionally, in the centre of these pools, a dark hole a few inches in diameter could be seen; down one of these I could push my pole to a long distance, and the water was coming out from it with quite a little head. They are to be found all over the Everglades, and are, I believe, one of its greatest water-supplies. ... All this moving water cannot be accounted for by the rain alone..."

11 Jan/Stn 3 eastward: "Our course seemed completely blocked to the northeast, with nothing but heavy saw-grass, into which every water-lead headed up, and nothing beyond that could be travelled through..."

12 Jan/to Stn 4: "a few inches of mud to the hard rock bottom" "[The northward lead] left the worst saw-grass on our right, but by getting further to the northward we hoped to discover some breaks in this terrible barrier..."

13 Jan/to Stn 5: "50 times or more, leads [to the east] that seemed good headed up in saw-grass that was 9 or 10 feet high, with hardly any water at its roots."

14 Jan/to Stn 6: "The rock is everywhere found, usually smooth, in very many places with no mud on top of it. Where it underlies the big saw-grass it is occasionally seven or eight feet under. [Willoughby's observation of frequent rock likely reflects his passage through the more accessible rock-bottomed channels ("leads"). He would have avoided the areas of sawgrass, which, as he describes, was where the rock was covered with 7 to 8 feet of soil, likely sawgrass peat.] ... The character of the Everglades at this point was similar to what it had been for the past two days. The water was still clear and running at the rate of from half a mile to a mile an hour in a southwesterly direction, at times showing a symptom of moving southerly even a little east of south."

18 Jan/Stn 9: "In my conceit as an old camper I had made an error in selecting my canoe for this journey. I expected always to find dry islands; such were conspicuous by their absence. The Seminole when travelling always sleeps in his boat, but not until many nights spent on wet ground did I realize why this was necessary." (Willoughby 1898).

16. The 1907 Survey across the Everglades (**Appendix H**) crossed two northerly portions of the Ridge and Slough landscape (**Plate 8**). A detail of the soil profile mapped in the western portion (**Figure 2.5**) shows an undulating soil surface, corresponding to sloughs, sawgrass ridges, and tree islands. The following quotation paraphrases a letter from one of the surveyors, E. W. Chadwick and gives a description consistent with **Figure 2.5**:

    "...Chadwick mentioned saw-grass ridges alternating with open leads of water running approximately in a southeastern direction." (Harshberger 1914).

17. R. F. Ensey, a surveyor for the Trustees of the Internal Improvement Fund, surveyed a number of townships in Range 40 and 41 during the "summer and fall" of 1911, and possibly during part of 1912. Ensey occasionally included detailed comments on the landscape he was surveying. The following quotations apply to the northern and eastern part of the Ridge and Slough landscape -- just as the first major canals were being opened. Like observers from earlier expeditions, Ensey reports small tree islands ("clumps"; "small scrub myrtle islands"), sloughs with lillies and bonnets (*Nymphaea* and *Nuphar* spp.), sawgrass, and channels ("creeks"). Many of the creeks or "creek sloughs" were flowing to the south or southeast (see **Table 5._**). The reported variation in water depths between locations may be in part a function of differing dates of observation. More likely, it may represent true spatial variation, similar to that noted during the Ingraham expedition:

    North boundary of Section 4, T46 R 40, heading west: "The surface of the Glades thus far is generally a big boggy slough. Stage of water is high - Numerous clumps dot its surface they average from 50' across to single bushes - only the heaviest of these clumps is a few inches out of water - at this point the character of the surface of the Glades seems to be changing - the clumps are still in evidence, although they are lower + more bushy The broad flat sloughs have disappeared. Saw grass flats predominate with numerous shallow creeks - The saw grass is short, animal life is scarce, no topography is possible - it is one excursion of saw grass, creeks + clumps." (Ensey 1911-T46 R40-R36, p. 165)

Middle of west boundary of Section 30, T46 R41 (south middle of Water Conservation Area 1), heading south: "This part of the Glades is somewhat higher on an average than that to the N. There are no deep creeks but the big water N. seeps thru shallow channels lying thru boggy flats. Small clumps are plentiful and extensive myrtle beds are in evidence. Boating very difficult on account of shallow water.

...line runs down broad open grassy + lilly slough - dotted with clumps, small + large, water very shallow." (Ensey 1911-T46 R41, p.160).

North boundary T 47 R 41, heading west:

Section 4: "The territory thru which the E. 1/2 of this mile passes is a succession of creek sloughs, lilly pad + bonnet ponds, alternating with small scrub myrtle islands - the latter all inconsequential"

Section 5: "The country is universally boggy - floating tussocks and isolated scrub Myrtle Islands are dotted over lilly pad flats and creek sloughs"

Section 6: "Country same - deep ponds and sloughs mark the W. part of this mile." (Ensey 1911-T47 R41, p. 134).

West boundary T 50 R 41, Section 6 (appears to have been representative for entire western boundary of this Township): "...slight ridges occur and some saw grass dotted with single Myrtle bushes-but boggy lilly pad flats, ponds and creeks prevail -Where the current exists, the water moves in a general East & South East direction." (Ensey 1911-T50 R41).

18. Wright (1912)

"Beyond this ['practically level' area of the Sawgrass Plains], [the underlying soil material] becomes uneven, being marked with irregular depressions and ridges. As the surface is level, this unevenness of the sub-stratum causes a varying depth of muck within a limited area.

The surface of the Everglades, taken as a whole, appears to be a level plain, having a slope of three inches per mile toward the south and east, yet this statement is subject to slight modification. Throughout the entire area there are numerous winding shallow depressions or channels 100 to 500 feet wide, and one to three feet lower than the land through which they pass. These depressions, locally called 'Strands,' wind through the 'Glades in all directions, though their general trend is from north to south. In other places there are slight depressions, like ponds or lagoons, covering one to forty acres. These are most numerous along the eastern margin and throughout the southern portion. The muck in these depressions is usually less firm than the land on either side. These irregularities of the surface also affect the depth of muck at these points, as the underlying hard material is no lower in these surface depressions than under the adjacent land. These low places are usually filled with water, while the general surface of the Everglades is comparatively dry." (Wright 1912, p.18-19).

19. Observing the Everglades during a boat trip southward through the Sawgrass Plains along the North New River canal, plant ecologist John Harshberger noted the first channels and "slues" (sloughs) appearing at Mileposts 28-31 (**Plate 8**). This marks the northern limit of the Ridge and Slough landscape along this canal:

"Milepost 29: The channels become more frequent and they are filled in part with water-lilies, spider-lilies, pickerel-weed and other aquatic plants, as also the lagoons surrounded by unbroken saw-grass.

Milepost 39: Here was very low, wet saw-grass with lagoons and channel filled with water in which grew *Nymphaea advena* Soland. [According to Wunderlin (1982), *Nymphaea advena* is a former synonym for *Nuphar luteum* (bonnets or spatterdock). Spatterdock generally occurs in deeper water than white water lily (*Nymphaea odorata*).] An occasional clump of bushes was noteworthy and a large hammock of low trees about a mile to the westward." (Harshberger 1914).

On a different trip, Harshberger describes alternating ridges and sloughs, noting that the soils of each were distinct and different. As discussed in the Sawgrass Plains landscape, the fibrous sawgrass peat -- here on the ridges -- appears to have been further stabilized by interwoven sawgrass roots. Soil material in the sloughs was much looser, sufficiently so that one could sink through to the underlying mineral substrate -- bedrock or sand. Loose, unstabilized soil in the sloughs would be consistent with the hypothesis of slough maintenance by periodic scouring, and with observations of rock or sand bottoms in some of the channels:

"The top soil is a turf composed largely of saw-grass roots, except in the leads and shallow basins, where the saw-grass does not grow. Here the vegetation is more completely decayed and [the soil] is so loose when saturated with water that one sinks to the bottom sand, or rock. The 'leads,' filled with water and water-lilies alternating with saw-grass, give a deceptive undulating appearance as one looks across the expanse, though, as will be noted, the slope is gradual. The islands scattered over the Glades form an insignificant part of the whole--probably less than one-half of one per cent. of the entire saw-grass marsh." (Harshberger 1914, p. 159).

20. In 1915 a soil survey, six miles wide, was made along the full length of the North New River canal by Baldwin and Hawker, soil scientists from the U.S. Dept. of Agriculture. They recognized the same landscapes described by Harshberger (1914): the flat Sawgrass Plains closer to Lake Okeechobee and the undulating Ridge and Slough landscape south of Milepost 30 (**Plate8** and **Plate 13**). They described the directionality of the Ridge and Slough landscape as follows, noting that the sloughs, water flow, and regional slope were all oriented toward the southeast:

"[This] part of the area is very gently undulating or hummocky, owing to a series of ridges and sloughs with local differences of 2 to 3 feet in elevation, having a general northwest-southeast direction.

The natural drainage conditions of the Everglades followed the general southeastward slope through the sloughs which trend in that direction and found outlet to the ocean through a few breaks in the rock rim." (Baldwin and Hawker 1915, p. 752).

21. In spite of numerous reasons to expect water levels lower than under pre-drainage conditions (elimination of Lake Okeechobee overflow by lake lowering; opening of the North New River Canal in 1912; observations made in the dry season (January 22 to March 16); and a dry preceding year - see **Plate 2.10**), the soil scientists nevertheless still found "marked currents in the sloughs," and all but the highest ridges inundated, with water depths of 2 to 3 feet:

"There is a marked current of the water in the sloughs moving in a southeasterly direction, and it is probable that the sand [found in the 'Brown fibrous peat, sandy phase, deep over limestone'] owes its distribution in part to the movement of water. [Baldwin and Hawker (1915) distinguished two sandy phases of the Brown fibrous peat which they mapped over most of the length of the North New River canal: a "Sandy phase, Deep over limestone" and a "Sandy phase, Deep over sand." These phases were mapped between mileposts 33 and 50 (**Plate 8)** and are unrelated to the drainage effects describe in Chapter 3.]

At the time of this survey a few of the higher ridges were above water, but in general the entire surface was inundated. The water in the sloughs in many cases was 2 to 3 feet deep. No agricultural use is made of this phase." (Baldwin and Hawker 1915, p. 788).

22. A single soil type, "Brown fibrous peat," of "fibrous or felty character and corky texture" was mapped for both the Sawgrass Plains and the Ridge and Slough landscapes (see also **Figure 3.19**):

"Approaching the interior of the Everglades [from Lake Okeechobee], the material becomes less decomposed [than in the custard apple area], and is nearly pure organic matter. Two and three miles south of the lake the surface material is a brown fibrous peat averaging 85 to 93 per cent of combustible organic matter. This area is uniform in composition and texture for many square miles." (Baldwin and Hawker 1915, p. 763).

Plant roots were apparently tightly interwoven through the fibrous peat:

> "The dense growth and character of the native vegetation makes it difficult to bring this land in proper condition for agricultural use. The roots of the saw grass and lilies are especially difficult to remove, and various machines have been devised and are being used to do this work." (Baldwin and Hawker 1915, p. 785).

23. As might be expected from the previous lowering of Ridge and Slough water levels, vegetation changes were already apparent in the Ridge and Slough landscape:

> "The drainage of the Everglades has proceeded sufficiently to induce noticeable changes in the character of the vegetation in certain places. In the interior of the glades, along edges of the sloughs which once supported a luxuriant growth of water lilies the lowering of the water table is accompanied by the invasion of saw grass and Sagittaria on the lower ground. ... In the 'lower glades' saw grass is giving way to myrtle, maiden cane, and fennel." (Baldwin and Hawker 1915, p.752-753).

24. John King, a civil engineer and naturalist (Larned 1917), was employed by Miami developer, Capt. James Jaudon (Anonymous 1926). King surveyed land in Township 54, Ranges 37-38, along the proposed Tamiami Trail. **Figure 4.1** reproduces the western half of his detailed map of the ridges, tree islands ("hammocks"), and sloughs in Township 54 Ranges 37-38. Six months later, after further exploration, King drew a second, detailed map of the entire Southern Drainage District (**Figure 2.8**). Although general patterns are comparable between the two maps, a discrepancy in the orientation of the tree islands can be seen: north-south in the first map (**Figure 4.16**), northeast-southwest in the second (**Figure 2.8**). We believe King depicted relative dimensions and positions of sloughs, sawgrass, and tree islands accurately in the first map, but the orientations were incorrect. Comparison of King's second map, **Figure 2.8**., with three township plat maps drawn by other surveyors a year later in 1918 confirms that the orientations shown in King's second map were correct. (See also Larned (1917) for an account of the hardships encountered during King's expedition in March 1917 from which King drew **Figure 4.16**.)

    King's map is invaluable as the first quantitative depiction of this system of sloughs, tree islands, and sawgrass ridges as actually arranged on the ground. The interconnected network of sloughs drawn by King, alternating narrower and wider areas (perhaps corresponding to the "ponds" or "lagoons" mentioned by other observers) helps to understand observations from earlier Everglades expeditions. His map depicts dry conditions. It was drawn in March, 1917--well into the dry season of an already dry year, preceded by another dry year (**Figure 2.10**). Water depths in the sloughs would have been at a minimum; to the extent that slough widths changed as a function of depth, widths may also have been at a minimum. The sawgrass ridges would have been close to their maximum extent.

    Looking at King's map of the ridges and sloughs, it is not hard to imagine that under drier conditions, or in different parts of the Ridge and Slough landscape, the narrow places of the sloughs could "pinch off" altogether, forcing more portages through the sawgrass. This was reported during part of the Ingraham expedition of 1892 (**Appendix F**). During years of normal rainfall, the sloughs would have been bigger and deeper, and even more interconnected. Navigation becomes open and easy, as described during Col. Harney's expeditions in 1840-41 (**Appendix D**). During periods with multiple years of below average rainfall, "blind leads" ending in dense sawgrass, as reported by Willoughby in 1897 (**Appendix G**), would have become common.

25. Photographs taken by King during his March 1917 expedition help to visualize the pre-drainage Ridge and Slough landscape (**Plate 23**, **Plate 24** and **Plate 25**). The frequently abrupt edges of the sawgrass ridges, and the resulting sharp transitions between ridges and sloughs are noticeably different from present conditions. A very similar photograph taken approximately 1910 in the Ridge and Slough area west of Ft. Lauderdale also shows ridges with equally crisp edges (Sellards 1912).

26. Depths of peat (referred to as "muck" in these surveys) and marl soils were measured at most corners of the 36 sections of Township 54, Ranges 37, 38, and 39 (**Figure 4.19**) as part of government land surveys in 1918. These measurements were made five to seven years after drainage began significantly affecting the Everglades, while not representing exact estimates of pre-drainage soil depths, these data are valuable because of their early date. Based on subsidence rates from Stephens and Johnson (1951), we assume peat depths are within 0.5 feet of pre-drainage depths. Data support the presence of a deep, peat-filled channel running NE-SW down the center of Shark Slough (see also **Figure. 3.10, Figure 3.11** and **Figure 3.13**). Along Tamiami Trail, the

deepest part of the channel ran through Range 38, to the east of the present L-67 extension. The spatially and vertically mixed profiles of marl and peat are consistent with John King's soil profiles (**Figure 2.9**). The intermixing of peat and marl in close proximity suggests that the controlling mechanism determining which of these soils forms in a given area may depend on more factors than hydroperiod alone.

27. In 1932, Allison and Dachnowski-Stokes, soil scientists, described the wetland plant species they considered the basis of the peat soil in the Ridge and Slough landscape. The presence of "open stands" of sawgrass within the lagoons and sloughs likely reflects the effect of uncontrolled drainage (Chapter 3):

> "Lagoons and sloughs of open water are characterized by more open stands of this plant [sawgrass] though in these locations are to be found herbaceous plants such as arrow arum, *Peltandra virginica;* arrow-head, *Sagittaria lancifolia;* water-lily, *Nymphaea odorata* and pickerell weed, *Pontedaria cordata* which grows in nearly pure communities. More or less scattered as an admixture of less prominent members are found *Rhynchospora divergens, R. corniculata, Andropogon glomeratus, Cyperus speciosa;* and the ferns *Blechnum serrulatum, Acrostichum aureum* and *Osmunda regalis.* The remains of these plants are found throughout the larger part of the telmatic layers of brown fibrous peat." (Allison and Dachnowski-Stokes 1932).

28. Soil scientists participating in the soil survey of the Everglades Drainage District (Jones et al. 1948) described the landscape and the "Loxahatchee Peat" associated with it. They noted that this area was inundated "the greater part of the year:"

> "Loxahatchee Peat is a very soft, felty, brown fibrous material, spongy in character, that has been formed, for the most part, from more succulent plants than the sawgrass that has given rise to the Everglades peats. ... Loxahatchee peat is usually found in more inaccessible sections of the Everglades. ... Most of this area is covered with water the greater part of the year and some larger sloughs and alligator holes have water standing from three to four feet deep most of the year. Fish and frogs are plentiful in these holes and sloughs, and ducks in large numbers winter in the area." (Evans and Allison 1942).

29. By the 1940s, the central portion of the original Ridge and Slough landscape, (between the North New River and Miami canals) had become so dry that it more closely resembled the Sawgrass Plains and was no longer considered part of the landscape. As a result, Davis (1943) describes two separate areas of Ridge and Slough landscape. (The soil surveyors mapping the Everglades (Jones et al. 1948) also observed the dryer area between the North New River and Miami canals, and similarly mapped two separate areas of Loxahatchee Peat, the soil associated with the Ridge and Slough landscape.) He also assumed that the pre-drainage landscape was wetter than when he observed it in the 1940s:

> "(4) The slough and tree-island areas with mainly open water, aquatic vegetation, and groups of trees. Besides these features there are elongated strands or breaks of saw-grass, other mixed marshes, and willow and wax-myrtle bushes. There are two large areas of this mixed type of herbaceous and tree vegetation. One of these is ... now often known as the Hillsborough Lake or Loxahatchee Peat area ... It broadens out into a wide area with numerous ponds or lakes ... The other area of this mixed vegetation lies to the west of the Miami Canal ... Now it is usually recognized as the Tamiami slough and ridge area. The sloughs are usually water filled except in very dry seasons, and on the ridges ["ridges" here refers to the strand tree islands, not the pre-drainage sawgrass ridges] develop the tree-islands that have a characteristic ovoid shape. The northern part of this slough and tree-island area is of peat soils, but the southern part is mostly of marl and marly muck soils. Its southwest trending southern part [presently known as Shark Slough] is shaped like a funnel and it extends southwestward between the two southern mixed marsh and wet-prairie areas [i.e., between the Ochopee and Rockland Marl Marshes]. There are long saw-grass strands as well as tree-islands which are usually separated from each other by sloughs which drain water toward the southwest coast. This slough area ... was no doubt formerly much more continuously flooded before the Tamiami Trail was constructed, as many former boat trails followed these sloughs during most seasons ..." (Davis 1943).

30. The specific species listed by Davis (1943) are the same as those mentioned by pre-drainage observers, including the deep water bonnets ("bonnets" = older name for spatterdock, *Nuphar luteum*) and white water lily (*Nymphaea odorata*). However, the sawgrass ridges in the Loxahatchee Wildlife Refuge (Hillsborough

Lake) area appear to have much more myrtle than when observed by Ensey, government surveyor, in 1911. Note that at this time, before construction of a perimeter levee and canal, a current was still present:

> "In the Hillsborough Lake area the more common aquatic plants are the bonnets, *Nuphar*, swamp-lily, *Crinum americanum* L., white water-lily, *Nymphaea*, bladderworts, *Utricularia*, the maiden-cane, and a number of 'slough grasses' that bend in the water before the current. ...
>
> The tree-islands are mostly of the bay-head type with the red bay, *Persea borbonia* (L.) Pax., some sweet bay, *Magnolia virginiana* L., the wax-myrtle, and dahoon holly, *Ilex cassine* L., usually the most abundant trees. ...
>
> On the intermediate elevations are saw-grass and myrtle thickets which, with winding water courses in this area, form such a maze of thicket vegetation that some parts are known as 'Hell's Nest' areas because of the difficulty of passage through them.
>
> In the western and southwestern slough and tree-island areas, known as the Tamiami slough area, the sloughs are generally shallow, wide, and elongated with patches of *Eleocharis cellulosa* Torr., the needle-grass, common in the marl soil areas. Besides the bladderworts, water lilies, and slough grasses, particularly *Panicum paludivagum* H. and C., there is a peculiar jointed-leaved plant the dropseed, *Oxypolis filiformis* (Walt.) Britton, that is common." (Davis 1943, p.266).

31. Hydrogeologist Gerald Parker described the relationship between the directional orientation of the Ridge and Slough landscape and the direction of regional water flow (see also Chapter 5 and **Figure 5.5**).

> "In the Everglades there are many elongate tree islands, arranged more or less in parallel rows and separated from one another by shallow "swales," "runs," "sloughs," or "lakes," as they are variously called locally. These tree islands and swales trend northwest-southeast in the upper part of the Everglades as far south as the old spillways through the coastal ridge between Miami and Fort Lauderdale [i.e., the Peat Transverse Glades], then they begin to bend to the south, and finally, about 18 miles south [almost certainly an error; it should read "18 miles *west* of Miami..."] of Miami, they swing abruptly to the southwest.
>
> The linear arrangement of this pattern is most noticeable from the air, from which, as Dickerson (1942, p.136-139) says, 'They reveal a decided 'grain' to a broad sweep of country ... as if a great coarse broom had been rudely brushed over the low-lying Everglades region.'
>
> ... The 'grain' of the Everglades ... is believed to be developed entirely on fresh-water peat and muck... It ... represents a drainage pattern produced on a very gentle sloping surface of organic deposits. The 'grain' is composed of tree islands and swales that trend parallel to the regional slope, just as one would expect in an area of consequent drainage." (Parker *et al.* 1955).

Parker's use of the term "consequent drainage" suggests that he was aware that some of the features of this "grain" could be a post-drainage phenomenon.

32. In an appendix to a 1957 Corps of Engineers report, Ralph Andrews, biologist at the Loxahatchee Wildlife Refuge (Water Conservation Area 1), distinguished four main "vegetative cover-types" within the Refuge--sloughs, wet prairies, sawgrass, and tree islands. The species listed after each cover-type are those referred to by Andrews as "major components," in decreasing order of abundance:

> 1. <u>Aquatic Sites - Slough, Lakes and Runs</u> -- White water-lily (*Nymphaea odorata*), bladder-wort (*Utricularia foliosa*), floating heart (*Nymphoides aquaticum*), spatterdock (*Nuphar advena*).
>
> 2. Low-growing, wet-prairie Type or "whitegrass" flats
>
> A. <u>Typical</u> -- Beakrush (*Rhynchospora tracyi),* spikerush (*Eleocharis elongata*), beakrush (*Rhynchospora corniculata*), maidencane (*Panicum hemitomum*), slough-grass (*Panicum paludivagum*), pipewort (*Ericocaulon compressum*).
>
> B. <u>Maidencane flats</u> -- maidencane (*Panicum hemitomon*).
>
> 3. Sawgrass and Related Communities
>
> A. <u>Sawgrass prairies</u> -- Sawgrass (*Cladium jamaicensis*).
>
> B. <u>Sawgrass - myrtle</u> -- Sawgrass (*Cladium jamaicensis*), wax myrtle (*Myrica cerifera*), dahoon holly (*Ilex cassine*).

C. <u>Mixed grasses area</u> -- Broom grass (*Andropogon glomeratus*), giant plume grass (*Erianthus giganteus*), panic grass (*Panicum condensum),* Sawgrass (*Cladium jamaicensis*).

4. <u>Bay-heads or Tree Islands</u> -- Redbay (*Persea borbonia*), dahoon holly (*Ilex cassine*), wax myrtle (*Myrica cerifera*), bamboo vine (*Smilax laurifolia*), muscadine grape (*Vitis monsoniana*), Royal fern (*Osmunda regalis*), Virginia chain fern (*Woodwardis virginica*), cinnamon fern (*Osmunda cinnamonium*).

Of the four main types, only the slough ("Aquatic Sites") and the tree island cover-types correspond directly with pre-drainage categories. Andrews' comments make clear that drainage and/or altered fire regimes influence various wet prairie and sawgrass cover-types. The wet prairie cover-type was a new post-drainage plant community, appearing in the shallower pre-drainage sloughs as a result of lowered water levels:

> "The 'whitegrass flats' occur on the boggy peat soils which are inundated during the greatest portion of most years, but above the water level for a variable period at the close of the dry season. On typical flats, water depths vary from 12" to 18" in October - November to a few inches below ground surface in March - April. ... The ground surface in typical flats remains boggy even during dry periods due to the proximity of the water table and the spongy nature of the soil. ...
>
> The close relationship between sloughs and whitegrass flats was demonstrated in 1954 when water covered the flats throughout the year. By late summer, the pads of water-lily and floating-heart had increased in size and number and dominated portions of the whitegrass flats." (Corps of Engineers 1957).

The Sawgrass - Myrtle cover type seems most likely to be related to the pre-drainage sawgrass ridges. Andrews indicated that Sawgrass Prairies were scarce in the Loxahatchee Refuge and that the Mixed Grasses Area was found only "where land elevations are highest and standing water seldom occurs ... [It is] a relatively new type derived from drainage and possibly fire." The description given for the Sawgrass - Myrtle cover-type and Andrews' difficulty in placing it, ecologically, suggest this type represents remnants of the pre-drainage sawgrass ridges, after being invaded by myrtle:

> "In many places, the myrtle forms nearly solid thickets with much holly, bamboo-vine and some redbay. ... On other parts of the refuge, similar strands of myrtle-holly are intermingled with small sloughs and whitegrass flats forming virtual labyrinths which froggers knew as 'Hell's nests.'
>
> The ecological position of these myrtle thickets is difficult to interpret. ... The answer must be in ... the very slow plant succession under pre-drainage conditions and the rapid changes that have taken place since drainage and peat-destroying fires." (Corps of Engineers 1957).

The "Aquatic Sites - Slough, Lakes and Runs" cover-type is equivalent to a combination of the slough and the channel portions of the pre-drainage Ridge and Slough landscape, with "runs" corresponding to channels. These runs resemble the "creeks" or "creek sloughs" seen in this area by Ensey in 1911, although no current is mentioned in 1957, probably because the area had already been impounded by a levee:

> "These are the wettest portions of the refuge, where water stands throughout the year (during most years). In local parlance, the "sloughs" are shallow water areas, usually narrow and finger-like. The term "lake" is used to distinguish some of the larger, deeper sloughs, which may be free of emergent vegetation in their deepest parts. The "runs" are narrow, meandering waterways that frequently connect sloughs and lakes. ... Water depths at the end of the dry season (usually March-April) vary from a few inches (less in 1956) in shallow sloughs to about three feet in the deeper "lakes" and "'gator holes." At the close of the rainy season (about Nov. 1) water levels are 15-20" higher..." (Corps of Engineers 1957).

Andrews included both the round bayheads and the strand tree islands in a detailed description of the "Bay-heads or Tree Islands" cover-type:

> "Nearly all parts of the Loxahatchee Refuge are dotted with bayheads - most of them only a fraction of an acre in size, but a few approaching 200 acres. The large islands, often a mile in length, are termed 'ridges' by the local 'gladesmen. ...
>
> ... The trees grow on a dome (actually lens-shaped in cross section) of woody soil known as Gandy peat. The centers of the small heads, and the north ends of the larger islands have the highest ground - often 3 to 4 feet higher than ground elevations of surrounding communities. The

> ground is spongey and covered with a luxurious growth of ferns. The tree canopy is a dense growth of redbay with a substantial amount of Dahoon holly usually intermixed. The latter is more plentiful near the edge of the bayhead. A narrow border of wax myrtle or occasionally buttonbush or cocopalm [this is without a doubt a typographical error and should be "cocoplum"] surrounds the head. This may be followed by a fringe of sawgrass or pickerel-weed. Sprawling vines of wild grape or bamboo vine frequently cover many of the trees. Myrsine grows on some heads and occasional large strangle figs tower over the bay trees - usually a good indication of high dry ground for camping. Other plant species are very scarce. ... The Loxahatchee Refuge is the only extensive area in the 'glades where bayheads have not been gutted by fires. [Although apparently even within the Refuge some bayheads had burned, as Andrews presents his species list as one for "unburned bayheads."]" (Corps of Engineers 1957).

The size of bayheads and exterior fringe of cocoplum or dahoon holly correspond well with Ensey's descriptions of numerous "clumps" in 1911-1912. (The "whitewood" shrub or small tree mentioned frequently in the 1910-1912 surveyors' notes, probably refers to dahoon holly on account of its whitish bark (pers. comm., Dr. Dan Austin, 1997).)

33. Soil scientists mapping Miami-Dade County in the 1950s described the portion of the Everglades present in the western part of that county (an area of Ridge and Slough landscape):

> "These marshes...have developed in the deepest parts of the trough formed by the rock floor. The peat mantle varies from 2 to 60 inches in thickness. Drainage is very poor. The excess surface water moves very slowly through broad shallow sloughs interspersed with slight ridges.
>
> The ridge-slough area contains thousands of small oval-shaped islands interspersed with sloughs and small ponds or lakes. During much of the year, the sloughs are filled with water; aquatic plants grow profusely, especially the bladderworts, coontail moss, spiderlily, bonnets and a few grasses. Sawgrass usually grows along the slough borders. The islands are mainly of the bay-head type." (Gallatin *et al.* 1958).

It is noteworthy that the soil surveyors record two important pre-drainage Ridge and Slough characteristics still present in the 1950s in this western portion of Miami-Dade County. Wet prairies are not mentioned and sloughs are bordered directly by sawgrass. Drainage does appear to have lowered water depths; sloughs were reported as being filled with water only "much of the year."

34. Ecologist Charles Loveless worked extensively in Water Conservation Areas 2 and 3 during the 1950s. His classification of Everglades plant communities is similar to that of Andrews (1957). Loveless differs somewhat in which communities he considered representative of the pre-drainage Everglades. We quote from his study in detail, as it includes many aspects of the pre-drainage plant communities, as well as clear indications of changes brought about by drainage and altered fire regimes:

> 1. Sawgrass Communities
>
> A. *Mariscus-Sagittaria-Panicum hemitomon* -- "the most extensive association of the Everglades" "[sawgrass] in association with flag (*Sagittaria lancifolia*), maidencane (*Panicum hemitomon*), pickerel weed (*Pontederia lanceolata*) and cattails (*Typha* sp.); buttonbush (*Cephalanthus occidentalis*) and willow (*Salix amphiba*);... sufficient open water areas exist to permit the growth of such plants as *Utricularia* spp. white water lily (*Nymphaea odorata*), floating heart (*Nymphoides aquaticum*), arrow-arum (*Peltandra virginica*), swamp-lily (*Crinum americanum*), ..."
>
> B. *Mariscus-Myrica-Ilex* -- Sawgrass and the shrubs, myrtle (*Myrica cerifera*), and dahoon holly (*Ilex cassine*). -- "hell nests" -- "probably uncommon in the Everglades prior to the initiation of drainage, has become increasingly important as a result of the general lowering of water levels and perhaps fire."
>
> C. *Mariscus-Panicum hemitomon* -- "occurs irregularly over much of the region and is similar to the sawgrass-flag-maidencane type in its species components but normally occupies drier areas. It is predominantly an association of sparse to medium dense sawgrass and maidencane."
>
> 2. Wet-prairies

A. *Rhynchospora flats* -- *Rhynchospora tracyi*, *Eleocharis elongata*, *E. cellulosa*, *Panicum hemitomum*; "In the wetter portions of these flats white water lily, floating heart, swamp-lily, and spider-lily (*Hymenocallis tridentata*) are abundant." -- "one of the more typical representatives of the pre-drainage Everglades vegetation;"

"most abundant in the central and east-central portions of WCA 2 and in the western and southern sections of WCA 3. They frequently form transition zones between the sawgrass communities and the sloughs and generally occur as elongated strands paralleling the north-south oriented tree islands. Originally these flats were probably more widespread than at present because it seems that many of them have been replaced by sawgrass. On the other hand, some of the former slough areas are now *Rhynchospora* flats and it may be that the present total area covered by them approaches the original extent, the difference being a shift in the site location of the communities as a result of the general lowering of water tables."

B. *Panicum hemitomon* flats -- "Maidencane has apparently only recently become a dominant part of the Everglades flora. Although this species was undoubtedly present in the area prior to drainage, it was probably restricted to the drier sites. It is now widespread as a result of ability to withstand both widely fluctuating water levels and repeated burning."

C. *Eleocharis* flats -- "in many instances almost pure, dense stands of *Eleocharis cellulosa*. ... can tolerate high water conditions due to its rapid growth and for this reason during such periods exerts dominance in the *Rhynchospora* flats. ...most conspicuously represented in the western edge of the Everglades in the ecotone between the open marsh and the Big Cypress Swamp."

3. *Willow communities* -- "much more prevalent in the Everglades today than formerly, according to local persons familiar with the history of the area. ... As a result of repeated fires willows have replaced much of the original vegetation on some tree islands in the Everglades. The ecotone between the wet prairie and tree island communities is often dominated by this shrub and it frequently forms pure, dense stands in the burned-out depressions in the interior of many islands."

4. *Tree islands* -- "circular to ovoid or strand-like in general outline. Circular tree islands, in which redbay (*Tamala [Persea] Borbonia*) is the most dominant tree species, are normally quite small in size, ranging from only about one-quarter acre to five or six acres ... usually two to three feet higher in elevation than the surrounding marsh. Tree island strands, normally dominated by the tree shrubs wax myrtle and holly, are much larger, sometimes even exceeding 300 acres. ... they are frequently oriented in a generally north-south direction, and are somewhat 'tear-drop' in shape, with their blunt ends directed northward toward the flow of water and the southern ends tapering to a distinct point. ... the northern ends of the tree island strands are three to four feet higher in elevation than adjacent marsh elevations... These elevated sites, on the northern portion of the strands, comprise about 5% of the total island's area. The remaining 95% is also higher in elevation than the adjacent marsh, rising from two to four inches on the edges to slightly over a foot in the approximate center. The tree island strand vegetation, excluding that occurring on the higher elevated sites of the northern ends, is structurally layered, with dahoon holly and myrtle the dominant woody species of the canopy. ... The ground cover in both the burned and unburned islands is composed principally of ferns... Many of these burned islands were originally true bayheads as evidenced from relics of burned-out bay tree stumps and logs occurring on some of them, and also the fact that in unburned areas the true bayhead type vegetation still predominates. In most sections, however, fire has resulted in a reversion of the apparent climax bay tree community to a holly-myrtle-elderberry fire subclimax associes. ... On the higher elevated sites of many tree island strands grow large strangler fig trees (*Ficus aurea*) and often some elderberry, southern hackberry (*Celtis missisippiensis*), Florida trema (*Trema florida*), castor bean (*Ricinus communis*), cabbage palmetto (*Sabal palmetto*), *Hibiscus tiliaceus*, wild-coffee (*Psychotria nervosa*), coffee-weed (*Ditremexa ligustrina*), and myrsine (*Rapanea guianensis*). Very infrequently such species as slash pine (*Pinus caribea*), royal-palm (*Roystonea regia*) and cypress (*Taxodium distichum*) occur on these sites." "...during the early summer of 1956, fire swept much of the northern Everglades marsh. These fires completely destroyed many tree island communities by burning the peat substrate out from under the tree growth. Some of the areas are now open water

ponds devoid of any emergent vegetation while others support sparse strands of sawgrass, water lily, floating heart and other aquatic species."

5. *Sloughs* -- "Sloughs are the narrow, drainage channels that are usually water-filled, or at least wet, most of the year. The 'valleys' of these channels average only a few inches to one or two feet below the elevation of the adjacent marsh areas. They are probably not so extensive as they once were as some of them have apparently been replaced by the wet prairie communities and by sawgrass and myrtle in some cases. This reduction in slough areas has been mainly due to artifical drainage. ... Sloughs are easily recognized by their drainage patterns and by the characteristic plant species that compose them. White water lily and floating heart are the dominant plants, with spatterdock present in the deeper portions. *Hydrotrida caroliniana* [synonym for *Bacopa caroliniana*, (blue hyssop, lemon bacopa)] is also a common component. ... Sparse, stunted sawgrass also grows in this zone. *Utricularia* spp. are abundant and probably play a major role in the formation of organic soils (Loxahatchee type of peat) in the slough communities. ... Another type of open water area related to slough drainage patterns is the alligator hole. ... These water retention units [that is, the alligator holes] are of considerable ecological significance to the Everglades fauna during dry years."

Loveless concentrated on characterizing the vegetation present at the time (1950s), rather than on estimation of the pre-drainage vegetation. He was acutely aware that the Everglades had been substantially altered, and indicated the plant communities he considered to be the result of drainage. Loveless considered the original components of the pre-drainage Ridge and Slough landscape to be: the sawgrass-flag-maidencane community; the *Rhynchospora* flats portion of the wet prairies; the bayhead and strand tree islands; and the sloughs. Curiously, although not citing any supporting pre-drainage evidence, Loveless was most explicit regarding the *Rhynchospora* flats. He referred to them as "one of the more typical representatives of the pre-drainage Everglades vegetation."

The two types of tree islands and the sloughs Loveless describes closely resemble pre-drainage descriptions of Ridge and Slough landscape elements. In contrast, the descriptions of the sawgrass-flag-maidencane community and the wet prairies flats do not. The sawgrass-flag-maidencane community seen by Loveless in the 1950s appears to be derived from pre-drainage sloughs (perhaps relatively shallow ones) invaded by sawgrass after drainage. Alternatively, the sawgrass-flag-maidencane community may be a remnant of the sawgrass ridges, thinned and invaded by slough species, although this seems less likely. (We hypothesize that the pre-drainage ridges of sawgrass corresponds most closely to Loveless' "*Mariscus-Myrica-Ilex*" ("Hell's nest") community. Under this hypothesis the pre-drainage sawgrass ridges, possibly diminished in elevation after drainage, were invaded by shrubs as water depths lowered.)

Loveless found the wet prairies to be the second most extensive plant community of the Water Conservation Areas. There is no counterpart in the pre-drainage accounts. Wet prairie plants were present, scattered throughout the shallower sloughs, but not as extensive communities. Other than Harshberger (1914), Loveless does not cite pre-drainage sources. His assumption that wet prairies were part of the pre-drainage landscape must have been based primarily on the extensive presence of wet prairies in the Everglades of the 1950s, rather than on any resemblances to observations found in pre-drainage accounts.

Conceptually, Loveless placed the slough, wet prairie, and sawgrass plant communities on a successional continuum, from wetter to drier. Thus with the lowering of water depths by drainage after 1906, Loveless notes the following: 1) a decrease in the area of sloughs, 2) little net change in the area of wet prairies, 3) a shift in location as sloughs were replaced by wet prairies, 4) wet prairies were replaced by sawgrass, and 5) an increase in sawgrass. The pre-drainage accounts support the ordering proposed by Loveless, as well as a decrease in sloughs and increase in sawgrass. In the 1950s, the wet prairies represent a dramatic expansion of a very minor part of the pre-drainage landscape.

35. Water depths increased in the Water Conservation Areas during the 1960s due to a combination of seepage reduced by the new L-35B and L-67A levees, high rainfall, and water management decisions. The area, covered by wet prairies, decreased significantly and was replaced by sloughs. A report by a committee of experienced Everglades scientists gathered to evaluate the "high water" situation included the following description of vegetation changes. The changes were apparently compared against what the authors had seen during the 1950s and 1940s, rather than against pre-drainage accounts:

> "Dramatic changes in the original vegetative matrix have occurred in the Conservation Areas, particularly Areas 1 and 2. Although intense, widespread fire during drought periods has undoubtedly contributed to these changes, the overriding cause has been alteration of the historic hydroperiod.
>
> Such alterations in the hydroperiod have essentially eliminated the tree island communities and the once extensive whitegrass (*Rhynchospora* spp.) flats in Conservation Area 2. Also, the willow-myrtle 'thickets,' once widespread in the northern portion of Area 2, now no longer exist. A few other formerly abundant species that are either now uncommon or rare include primrose willow, groundsel bush, wax myrtle, red bay, red maple, and two species of beak rushes. These changes have been accompanied by an increase in the slough aquatic communities and their component species (white waterlily, spike rushes, flag, and submerged aquatics), and an apparent increase in the density of sawgrass in some areas, extensive invasions of cattail in certain locations, and the reversion of areas formerly dominated by emergent vegetation to essentially open water with abundant submerged plants." (Loveless *et al.* 1970).

This passage, and information presented elsewhere in the report, suggest that Loveless *et al.* were concerned about the changes associated with the relatively high water. They strongly recommend restoration of "the original natural hydroperiod." However, neither the time period meant by "original," nor the length of the "natural hydroperiod" were specified. Paradoxically, the water depths present in Water Conservation Area 2A during the 1960s were probably closer to pre-drainage water depths than the 1950s depths that were apparently regarded more favorably by the authors.

All the vegetation changes described by Loveless *et al.* (with the important exception of cattail invasions and tree island elimination) were changes which actually brought the area closer to pre-drainage conditions. Elimination of the wet prairie *Rhynchospora* flats, elimination of the willow-myrtle thickets, increases in sawgrass density, and increases in slough aquatic communities all augmented the resemblance to the original Ridge and Slough landscape. Of the two exceptions, subsequent research has shown that the cattail invasion can be ascribed only in part to changing hydrology; phosphorus loading also played an important role (Jensen et al. 1995, Rutchey and Vilchek 1994; Newman et al. 1996).

The second exception, the elimination of tree islands by flooding, continues to be a serious ecological concern. It has been a perplexing aspect of pre- and post-drainage hydrology, but can be understood in light of post-drainage tree island history. Theoretically, if sloughs were the original aquatic community in this landscape, then the return in the 1960s to water depths that favor sloughs over wet prairies should not have posed any problems for tree islands. However, this is only true if the tree islands had been able to maintain pre-drainage elevations throughout the dry periods and extensive fires of the 1920s through 1950s. All observers suggest this was not the case; instead, many tree islands were reported to have lost peat to oxidation and especially to destructive peat fires. As a result, the return of water depths to something closer to pre-drainage levels caused destructive inundation of the lowered ground surface of the tree islands. Until the difference between tree island and slough bottom surface elevations again increases, restoring pre-drainage water regimes will require a gradual process to achieve a balance between promoting slough vegetation and avoiding irreversible damage to tree island vegetation.

36. In discussing tree island fires in the southern portion of the Ridge and Slough landscape, Craighead (1971) noted that under pre-drainage water depths, the higher water table and the moisture-retaining organic soils of the islands would have prevented serious injury by fire and peat elevations would have been maintained. When water tables were lowered by drought or water management practices, the soil dried out, allowing destructive burns of all plants as well as the soil:

> "Fire plays a major role in the evolution of these [tree island] communities. Normally none of the tree islands are seriously injured by fire, as the organic soil is quite moisture-retentive. In drought periods, however, when the moisture content of the peat or mucky soil beneath them dries to below 25 percent, it is possible for them to be completely burned out. All plants may be destroyed, leaving a rocky mesa in the case of a hammock or rocky basins of various depths." (Craighead 1971).

37. Dineen, who was familiar with the hydrological and vegetative history of the Everglades during the 1950s and 1960s, further emphasizes the dynamic relation between sloughs and wet prairies:

> "Loveless (1959), who worked in the Conservation Areas for several years, felt that the Everglades he was seeing and recording was a dried out version of the Everglades 'as a result of the general lowering of water tables.' He felt that some of the *Rhynchospora* flats he observed had formerly been slough areas. It should be noted that present water management, in some areas, is replacing wet prairies with sloughs, in places where sloughs were probably present in the first place." (Dineen 1972).

38. Dineen's description of tree island water levels in the late 1960s and early 1970s partially resembles pre-drainage accounts of the frequently wet camping sites provided by the smaller tree islands, but his description is in fact wetter:

> "Most of the bay-heads and smaller islands and strands contain dry ground only during low water periods and are flooded during most rainy seasons. Some of the larger tree islands have as much as a half-acre of dry ground during the wet season. Many of the longer tree strands have a high ridge running down the center line of the strand which remains dry in all but the wettest of years." (Dineen 1972).

39. Early accounts indicate that--prior to the drainage-induced decrease in tree island elevation--the dry area on the strand tree islands was more on the order of several acres, and that this area remained sufficiently high above surrounding water levels to permit cultivation. In Dineen's description of tree island decline it may be more accurate to ascribe the damage to the post-drainage loss of elevation, rather than to "high water:"

> "Tree islands in some parts of the Conservation Areas have taken a beating from prolonged high water. Islands in the lower third of Conservation Area 3, and particularly those nearest L-67A, show a high degree of water damage. Willow and red bay are the trees that have been most seriously set back by higher water levels." (Dineen 1972).

40. In a paper on wet prairies, the field biologist Goodrick notes the close relationship between wet prairies and sloughs, and the apparent ease of transitions back and forth between the two communities. Goodrick suggests that hydroperiod and water depth determined which community is present at any given time, much as did Andrews in Corps of Engineers (1957):

> "Where both sloughs and wet prairies are present, these communities are often adjacent to one another. But, the sloughs occupy the deeper water areas. The major difference between the vegetation of the sloughs and the flats is that floating leaf aquatics and submergent species are the dominant plants in the sloughs and the prairies abound in emergent plants. However, most plant species common to one of these communities will usually occur in the other under certain water conditions. ... Wet prairies are one of the more sensitive marsh communities. . . species composition and vegetation biomass are definitely influenced by hydroperiod." (Goodrick 1974).

Specifically, Goodrick observes that,

> "The best developed wet prairie communities are found in areas that frequently dry during the spring of the year."

This suggests an explanation for the absence of wet prairies in the pre-drainage Ridge and Slough landscape. Except for the sawgrass ridges and the tree islands, in most years this landscape was covered with water throughout the year, favoring aquatic slough species over wet prairie ones. It also explains the temporal variation in wet prairies in the Water Conservation Areas: absent prior to drainage, present during low water in the 1950s, absent during "high" water of the mid and late 1960s, and present to varying degrees at the time of writing (**Figure 5.3**). Goodrick's analysis indicates that wet prairies occur where the water level recedes below ground 60% of the time during April-May, and never exceeds 2.5 feet in October. In contrast, he found that sloughs exist where water levels receded below ground only 10% of the time, and exceeded 2.5 feet during October 60% of the time. One of the locations where Goodrick found wet prairies further marks this plant community as a post-drainage phenomenon:

> "The sawgrass communities and the more aquatic sloughs are often separated by this ecotone."

This ecotone or transitional area does not appear to have been present prior to drainage; pre-drainage accounts of the Ridge and Slough landscape describe sloughs as being bordered directly by an abrupt edge of tall sawgrass, without an intermediate zone. The following comment at the end of Goodrick's paper suggests that

Goodrick himself did not consider wet prairies to have been an original part of the pre-drainage Ridge and Slough landscape:

> "While attempting to modify the environment of South Florida man has inadvertently destroyed these important ecotones both by drainage and water impoundment. Paradoxically, in some cases, the wet prairies that he has destroyed were created by his efforts originally. The wet prairies of the northern Everglades are valuable ecological entities. Any attempt to defend them on other grounds becomes a philosophical problem." (Goodrick 1974).

41. In a summary of their extensive and detailed studies of southern Florida vegetation, Alexander and Crook (1974) described changes they had observed over the preceding 16 to 30 years. Their observations help explain differences between pre- and post-drainage descriptions of two elements of the Ridge and Slough landscape, the sawgrass ridges and the tree islands:

> "For some reason(s) not clearly understood, large and small areas dominated by thick and previously vigorous sawgrass have been failing. Sawgrass in this condition is referred to as decadent. This is widespread around some tree islands and in sawgrass strands, especially in ENP (Q 58) [Quadrat 58 in Everglades National Park]. The accumulation of dead leaves becomes massive, living culms are covered and suppressed, and die-off of clones occurs. This may be a reaction to extended fire-free periods. Shrub invasion into decadent sawgrass is common and may lead to a tree island community. . . . Sawgrass is being replaced by shrubs such as *Myrica cerifera* (wax myrtle), *Ilex cassine* (dahoon holly) and *Baccharis* sp. (saltbush)." (Alexander and Crook 1974).

This sawgrass decline and shrub invasion may be the explanation for the post-drainage transformation of some sawgrass ridges into the 'Hell's nest' areas mentioned by Davis (1943), Andrews in Corps of Engineers (1957), and Loveless (1959). The phenomenon of sawgrass thinning and decline may also explain the unexpected presence of aquatic and wet prairie species in Loveless' (1959) primary sawgrass category, the "sawgrass-flag-maidencane" community. Post-drainage changes in the sawgrass ridges observed during the 1950s--decline in density, invasion by shrubs, and intermingling of aquatic slough species--all suggest a "blurring" of the different landscape elements. This contrasts with pre-drainage descriptions, which suggest a landscape of more clearly differentiated elements: well-defined ridges of dense sawgrass bordered directly by aquatic sloughs, without intervening transition zones or ecotones.

42. Tree islands also changed substantially, primarily as a result of elevation lost relative to the surrounding sloughs. This elevation loss occurred because of burning and oxidation of tree island peat exposed during over-drained periods between the 1920s and 1950s. When water levels were later raised closer to pre-drainage levels, the islands were subjected to unnatural flooding:

> "Tree islands within the basin have changed in many ways. Some have been completely lost through flooding and/or fire. Others still exist as slightly elevated islands containing only a few small shrubs and trees. *Ilex cassine* (dahoon holly) and *Magnolia virginiana* (sweet bay) are the common survivors (Q 4). *Chrysobalanus icaco* (cocoplum), *Persea borbonia* (red bay) and wax myrtle have disappeared from many of the islands, especially in the southern parts of Area 3. Ferns and herbaceous annual plants are common ground cover in burned hammocks that are not flooded. Flooded islands are developing a hydrophytic flora. Willow invasion is also common in burned tree islands. Many of the tree islands originally had a good representation of red bay in their canopies. This is judged from the common occurrence of stumps and standing trunks of this species (Q 84)." (Alexander and Crook 1974).

Loss of cocoplum and increase in willow are especially informative, as pre-drainage accounts, particularly township surveys in 1845 and the 1870s, often mention cocoplum islands, but rarely mention willow. King remarked on an unusual sighting of a willow during an expedition south of Tamiami Trail (Larned 1917).

43. Gleason and Stone (1994) note that although wet prairies are presently common in areas of the former Ridge and Slough landscape, evidence for their presence prior to drainage is absent from the soil record:

> "Microscopic examination of peat profiles from numerous Everglades sites (Cohen 1968; Cohen and Spackman, 1970; Spackman *et al.* 1976; Gleason 1972; Gleason *et al.*, 1974, 1975a) has not revealed wet prairie peats." Gleason and Stone (1994).

Gleason and Stone offer three hypotheses in explanation: that the prevalence of wet prairies is a recent phenomenon related to lowered water depths, that wet prairies do not generate sufficient biomass to accumulate peat, and that stems and roots of wet prairie plants may not persist in recognizable form. The history of wet prairies, waxing and waning with variations in water depths, strongly favors the first hypothesis, that wet prairies are an artifact of post-drainage reductions in average water depths. Preliminary analysis of pollen from soil cores suggests an increase in wet prairie pollen at about 1900, further supporting the first hypothesis (D. Willard, pers. comm., 1998).

Tree Island Endnotes

1. **Plate 40** shows a time series of maps and images of a Peat Transverse Glade. This glade included a tree island, the western (check) half of which was described as follows by U.S. Surveyor George MacKay in 1845:

   "[W side Sec 30, course South]:
   16.00 x Pine to saw grass
   6.50 x saw-grass to Bay thicket
   5.50 x thicket to saw grass open to the Everglades
   6.00 x sawgrass + water to pine
   6.00 Pine + palmetto Set 1/2 m post
   40.00 Pine + palmetto"." (MacKay 1845-T51 R42).

2. Williams, John Lee. (1847) Appears to be describing both sand-based non-tree islands, and directional, peat-based, Everglades tree islands:

   "Many of the islands are but little above the level of the water; but some of them are from 2 to 3 feet high, with a soil as rich as any that can be formed. Others are more sandy. The principal timber on most of the rich islands is livevoak, wild fig, papaya, and cabbage palmetto, thickly festooned with a great variety of vines. All the islands are surrounded with dense grass circles, from 100 to 500 yards wide. Boats can only approach the outward edge of this circle. A circle of mangroves is often formed inside of the grass. The Indians cultivate the inside of the islands only, leaving a border of liveoak and wild fig, which are very ornamental trees. ... In their fields they plant corn, pumpkins, tobacco, squashes, melons, and lima beans in abundance. Coconuts, plantains, bananas, and sweet potatoes are found on some of the islands." (Williams 1847, p.).

3. Williams, John Lee. (1847**)**. Tree island of known location. Sand-based; not a peat-based, directional, Everglades tree island:

   "Chitto-tus-te-nug-gee, or Snake-warrior, ... took possession of an island about 20 miles west of Little River; had procured to be cleared about 20 acres of first-rate land; built upon it two small towns, and drew to it, from Sam Jones's men, near 60 inhabitants. About 3 miles west of Chittos Island is situated Tuscones. It is inhabitated by an Indian family, who have erected a few houses and cultivated some small fields of corn and cane. The island cultivated and usually inhabitated by Sam Jones is about 20 miles west of Tuscones. It is about half a mile long, but not quite so wide. It had three villages and as many hunting grounds. Attached to this are many smaller islands, all cultivated for provisions, but no houses. Narrow channels of water separate them from each other. The old chief [Sam Jones?] is said to have here 70 warriors, many of them with families. Most of these islands swarm with fleas, cockroaches, and mosquitoes. A great many islands were found near there highly cultivated; but it is probable that one-tenth part of the islands have ever been visited by whites." (Williams 1847, p.)

4. Williams, John Lee. (1847). Based on their location, these very likely were directional, peat or peat and rock-based tree islands:

   "On the southern route from the Miami River, and about 40 miles from that stream, there is a beautiful island called Hocomothlacco. Around this island there is a circle of grass, or mud, 400 yards wide. It is highly cultivated with provisions. Seven miles north and northwest of this lies Efanoc-co-qu-chee. This is not cultivated, but has some cleared land on it. It is used as a kind of caravansary or stopping place for boats on their route across [to] the Big Cypress. Six miles northwest is Co-chok-o-ne-ha-jo. This island is cleared and cultivated. It is near the center of the Glades. Six miles further is In-tas-kee, a large island inhabited and richly cultivated. From this island the current passes to the east; after passing it the current sets to the southwest." (Williams 1847, p.)

5. The Ives (1856) map indicates Cabbage Island, Prophets Island, Alligators Island. Separately: Pine Island, Sam Jones Island, Council Island. Pine Island and Sam Jones [Seven] Islands were sand-based islands. Not clear on the others.

6. Ives (1856). Some idea of the varying water levels and their relation to pre-drainage hammock (tree island) elevations:

   "The country being considered being, for the greater part, a flat expanse, where the prairie of one day may at another be converted into a lake, and where the lakes, rivers, swamps and hammocks are subjected to such changes as can be produced by an additional layer of water of a depth sometimes as great as three feet, all statements relating to its surface are liable at times to considerable modifications."

7. Ives (1856) **check ref to "mud islands**" The reference to pine, cabbage palm and live oak suggest that Ives may be referring to the non-Everglades sand-based islands – Pine Island, Sam Jones Seven Islands, and Snake Warrior's Island:

   "Besides the mud islands, small keys are here and there met with which are dry at all seasons. Upon these the soil is very rich. There are many such, undoubtedly, that are often made the sites of Indian gardens. In some places, they will be grown up with bushes, appearing in the distance like a continuous wood, and occasionally there are clumps of pine, cabbage palmetto, cypress, and live oak."

8. Ives (1856) Captain Dawson's first expedition west in March 1855. "Long mud banks" probably refers either to sawgrass ridges or two exposed, partially compacted organic floc in sloughs. Note that the tree islands ("clumps of trees and bushes") are referred to as "boggy and wet," even in March:

   "During the latter part of the second day, long mud banks were encountered in which the men sank to their middles while dragging their boats. The course through the intervening ponds was greatly obstructed by fungi, clumps of trees and bushes, and innumerable keys could be seen in all directions; the ground everywhere, however, being boggy and wet."

9. Ives (1856) Captain Dawson's first expedition west in March 1855

   "On the fourth day all of the difficulties increased; breaks occurring two or three hundred yards in length, grown up with old sawgrass, and without water. The ponds were but a few yards across and filled with fungi [periphyton??]. The keys were smaller, lower, and fewer in number. At the end of the day the command had reached a point…twenty-seven and a half miles in a direct line, from Adams' landing [on the south fork of the Miami River]…" (Ives 1856, p. 21-22).

10. Ives (1856) Possible changes over time in tree islands under pre-drainage conditions:

    "The Indian Guide who accompanied Capt. Dawson [in 1855] stated that the country was greatly changed since he had crossed it sixteen years before [in 1841 with Major Childs], and that the keys were larger and more numerous. Settlers, who have resided upon the Miami River for ten or twelve years, assert that the gradual filling up of the Everglades has been very perceptible." (Ives 1856, p. 22-23).

11. Dodge (1894) This likely refers to some of the same islands mentioned by Williams (1847):

    "The keys or islands, which always form the distance to a picture taken in almost any part of the glades, vary in size from a mere mound to a few feet across, to areas of many acres. Many of them are cultivated by the Seminoles, ... raising of corn and pumpkins. Many of the keys are heavily wooded, and all are interesting. What gives them a particular interest is the fact that they form the abiding-places of these Seminoles…

    ... and as if to add insult to injury, some of their most fertile keys have recently been homesteaded by white men, after the Indians had tilled the soil for years (Dodge 1894, p. 361-362).

12. Dodge (1894) Clearing of canopy causing a change in internal humidity, and, indirectly, a change in soil decomposition rate (?):

"On those [Florida] keys that are more or less covered with "hammock" growth (hard-wood trees), there is quite a surface layer of decomposed vegetation, but in a comparitively short time after being cleared and "cultivated," the white, honey-combed rock comes to the surface and predominates." (Dodge 1894, p. 354)

13. Griswold (1896) Despite low water levels during his trip "The water in the Everglades was lower than I had supposed from previous reports." (p. 57), Griswold found islands to be wet:

    Scattered about in this sea of grass are islands of bushes and trees, called Keys [i.e., tree islands]. These Keys seem to owe their origin to an accumulation of vegetable matter which may appear some inches above water level, during the dry season becoming partially dry (Plate XXIII. Fig. 2). During a night's sleep upon them one's bed is liable to settle to water level, and it is a common experience to break through to the knee in walking over them without feeling a firm foundation; it is probable that the mat of grass roots or peat is what stops one's downward progress." (p.54)

14. MacGonigle (1896):

    "For 8 or 10 miles on either edge of the glades the conditions change materially. Thousands of islands, varying in size from one-eighth of an acre to several acres, greet the eye. On these islands the soil is phenomenally rich, and giant ferns, the fronds of which measure 12 feet in length, grow upon their edges. The virgin forest is composed of the wild lemon, wild cucumber, and wild orange, the dogwood, the custard-apple, the prickly ash, and hundreds of other varieties. Overhead the myrtle and the morning-glory mingle in tangled masses with countless varieties of tropical vines." (p. 390)

15. Dix and MacGonigle (1905). Writing about Buckingham Smith's trip:

    Mr. Smith explored numerous islands, large and small, with a view to obtaining datat as to their early occupants, if any, the character of the geological formation, and the nature of the soil. 'Most of the islands,' says his report, 'give evidence of having been inhabited. On some, large quantities of bones of animals and broken pottery were found, but nothing to indicate that the early inhabitants were other than Indians. (p. 517-518).

16. Dix and MacGonigle (1905). These descriptions refer to the sand-based island near the Atlantic Coastal Ridge, not directional tree islands:

    "Scattered along the eastern and western edges of the lake are uncounted islands. Some of these have been formed by alluvial deposits and decaying vegetation, but the majority of them are really outcrops of the rock of the basin, covered by a rich, waxy mold. They vary in size, in some cases the dry and cultivable area being hundreds of acres in extent. The alluvial lands are wet, but the outcrop islands are habitable, and respond generously to the somewhat fitful culture of the Seminoles, producing all the vegetable products of the temperate and subtropical zones in great abundance and with little labor."

    "The islands of the Everglades are covered with luxuriant virgin forests. The live-oaks and the bays are present in large numbers, interspersed with wild cucumber, wild lemon, and wild orange. The papaya, the custard-apple, and the prinkly-ash are of very frequent occurrence, and here and there, governed by the size and elevation of the islands, are the cabbage-palmetto and the pine. Wild rubber-trees are also found in some localities, growing to enormous size. Throughout the region there is a phenomenal growth of vines. The morning-glory and honeysuckle attain great size and are almost everywhere. The wild fig, which fastens itself about a massive trunk of live-oak or bay, lives its cannibal life until the supporting tree-trunk has been destroyed. Wherever the land is dry enough, the coontie-plant flourishes [this most likely refers only to the high elevation, sand-based islands: Pine Island, Sam Jones Seven Islands, Snake Warrior Island]." (p. 522)

17. Dimock (1907) Had trouble finding dry ground during their trip along route similar to Willoughby's 1896 trip:

    "We lunched on a key of cocoa-plums, myrtle, and sweet-bay, where we found about a square foot of earth for a camp-fire. I sat on a log, with my feet in the water... That night we found no key with land enough for a camp-fire, ... and we slept in our boats." (p.247)

18. Baldwin and Hawker (1915) Tree islands with myrtle and cypress that they considered to be generally dry:

> "In the 'lower glades' [probably here means Ridge and Slough landscape as opposed to Sawgrass Plains further 'up'], the eastern portion of the Everglade section, there are numerous small islands covered with a growth of cypress and myrtle which are sufficiently high to be free from standing water at most times. These areas, however, because of their small size, are not indicated on the accompanying water table map. No attempt is made to indicate the water conditions east of the Everglades." (p.753)

19. Baldwin and Hawker (1915) This appears to be a classification into tree islands, sawgrass ridges, and sloughs:

> "The native vegetation shows three well-defined groups. The higher, better drained ridges support a heavy growth of myrtle and cypress, with a scattering of wild fig and sweet bay, and an entanglement of bamboo briars. [These appear to be tree islands.] In the moderately wet areas, where the water is very near the surface or 1 to 3 inches deep over the surface, the vegetation is chiefly sawgrass and hydrophytic grasses. [These appear to be sawgrass ridges.] The deeper sloughs are characterized by water lilies and bonnets [yellow water lilies]. This phase is not used for agriculture." (p. 787)

20. Simpson (1920) Formerly wet tree islands becoming dry due to drainage, and then destroyed by fire:

> "Although only the preliminary work of drainage has been done yet it has had a marked effect on the vegetation. Along the banks of the canals and on all slightly elevated spots a variety of trees and shrubs are springing up, so that where formerly the eye swept over a monotonous even expanse of saw grass, the view now presents patches of incipient forests. This new element in the flora is especially noticeable around the eastern border which is somewhat drier than the main body of the swamp. Here groves of young timber are claiming titles on every hand.
>
> One of the results of partial drainage is that along this same east border numerous low, timbered "islands," which were formerly quite wet, have now been changed to dry land. A considerable part of the foundation of these groves is peat and in dry times it is very liable to fire, and once begun it is well-nigh impossible to extinguish it. These groves, despoiled of their only defense against fire, are often wholly destroyed. So it happens that while the draining of the Everglades makes it possible for forests to spring up and flourish in some places it is the cause of their destruction in others." (p.126-127)

Rockland Marl Marsh

General Description

The Rockland Marl Marsh was an intermediate landscape positioned between the pines of the Everglades Keys (Miami Rock Ridge) and the ridges and sloughs of Shark Slough. By the 1930s, after several decades of Everglades drainage, this marl marsh and the associated Ochopee Marl Marsh further west became referred to as "marl prairies". However, descriptions of the original, pre-drainage vegetation, soils, hydrology, and navigation all suggest the wetter conditions of a marsh. An experienced General Land Office surveyor described the Rockland Marl Marsh area in the 1840s:

> "I was forcibly impressed with the pecularity of the southern Glades–a vast rock of interstices and partitions, something in the form of a honeycomb–the interstices or cells, filled with soil, saw grass or water, are barren, with islands of trees, traversable with canoes in high water, and upon horseback in low water, the whole presenting

> the most romantic view of grass, prairie, and water, with gems of islands of rare timber and shrubbery." (George MacKay, 1847, in Senate Doc. 89, 1911).

On its upslope border, Rockland Marl Marsh resembled the Everglades Keys in having exposed pinnacle rock and shallow soils. The two landscapes were distinguished by elevation, hydrology, and vegetation, with the slightly lower marsh having sufficient water in the wet season to prevent encroachment of pines (see also **Figure 2.1**):

> "At the border of the Everglades the rough surface of the oölite [bedrock] becomes concealed for the most part beneath a mat of grass, and pines grow no further west (Plate XXIV. Fig. 1). In the zone of oscillation of water the grasses change in character from a small wiry variety near the pines to saw-grass six feet or more tall, and flags and cane growing in water." (Griswold 1896, p.53)

On its downslope, western border with Shark Slough, the Rockland Marl Marsh resembled the Slough in having sawgrass and peat, but differed by the presence of slightly drier hydrology and exposed pinnacle rock. It is likely that the transition from ridge and slough landscape to marl marsh was gradual and indistinct (**Figure 4.20**).

Bedrock contours (**Plate 3** and **Plate 4**), elevation profiles (**Figure 4.3**) and satellite imagery confirm the relation of the Rockland and Ochopee Marl Marshes as floodplains of Shark Slough. Even under post-drainage conditions, this relationship can be seen in a set of dry and wet season water depths measured along a transect perpendicular to the Slough and extending up into the Rockland Marl Marsh (**Plate 15**). A related remote sensing study used Landsat Thematic Mapper satellite imagery to delineate the expansion and contraction of the inundated area onto the bordering marl marshes (Rose and Rosendahl 1983).

Under pre-drainage conditions, water depths in Shark Slough were deeper than at present, and the durations of surface water were longer. In addition, peat elevations in Shark Slough appear to have been slightly higher (**Figure 3.15**). Taking these changes into account, the floodplain relationship that was still visible in the 1980s would originally have been wider, with wet season water levels rising and extending outward to meet the edge of the pinelands. This edge of the pinelands (i.e., the Everglades Keys) is at about elevation 9 feet above mean sea level. **Figure 2.1** suggests that the Marl Transverse Glades—low swales within the pinelands—were connections between the Rockland and Perrine Marl marshes. The annual wetting of the Marl Transverse Glades, which were also at about elevation 9 feet, suggests that under pre-drainage conditions, the whole cross section of the southern Everglades (e.g., **Figure 4.3**) filled to the point of overflowing during the wet season.

The pre-drainage vegetation and navigability of the Rockland Marl Marsh suggests annual periods of significant water depths–1 to 2 feet. At the same time, the relatively short drainage distances to Shark Slough, the additional southward drainage through Taylor Slough, as well as the extreme porosity of the underlying oolitic limestone, together appear to have contributed to decreasing these high water depths more quickly than in other parts of the Everglades. Although no pre-drainage descriptions were found of water tables declining below ground during each dry season, post-drainage descriptions suggest this may have happened. The landscape's position as a floodplain, its significant natural drainage, and the effect of local rainfall suggest a unique hydropattern: high in the wet season, low in the dry, and with a shorter hydroperiod than that of the Ridge and Slough landscape.

Unlike the Sawgrass Plains and Ridge and Slough landscapes, where the peat soil thoroughly covered the bedrock, in the Rockland Marl Marsh the bedrock was a visible and influential element in the ground surface topography. The soil layer was thin, such that the regional surface topography closely mimicked the bedrock topography. Locally, uneven dissolution of the limestone bedrock formed a highly irregular surface, known as honeycombed or "pinnacle rock," with 1 to 2 foot differences between the average lower surface and the tops of the uneroded "pinnacles." Soil--organic peat, freshwater marl (calcitic mud), or a combination of peat and marl--accumulated in the depressions.

Where the bedrock is not bare, marl is presently the dominant soil of the Rockland Marl Marsh. However, both pre-drainage and post-drainage observations suggest that prior to drainage, and prior to extensive fires, peat was more prevalent. The pre-drainage presence of peat would be consistent with the reported vegetation--sawgrass as well as flags, with reported navigability, and with reported concerns about flooding to the east.

Rates of peat accumulation in the Rockland Marl Marsh likely differed from those in the Upper Glades (Sawgrass Plains, Ridge and Slough landscapes). Sparser plant growth would produce less plant remains each year; in addition, more of the accumulated peat would oxidize each year as water levels declined during the dry season. Both effects would result in a lower net accumulation rate, and could also result in mixed areas of peat and marl.

The accumulation of peat in this landscape suggests significantly higher pre-drainage water levels than those observed in the 1940s and later. In the southern Everglades, marl formation is thought to occur under shallower water depths and shorter hydroperiods; whereas peat formation under deeper water conditions (Browder *et al.* (1994). However, several pieces of evidence suggest that, throughout the Lower Glades (south of Tamiami Trail), both marl and peat formation have occurred either sequentially at the same location, or simultaneously at adjacent locations. This evidence includes the Hialeah mucky marl soil mapped by Jones *et al.* (1948), the King (1917) soil profiles (**Figure 2.9**), a comment in Davis (1943, p. 29) regarding interbedding of marl and peat, and the soil types recorded in Southern Drainage & Engineering (1918-T 54 R 37).

Early and apparently substantial drainage-induced changes make it difficult to definitively determine the vegetation that was present in the pre-drainage Rockland Marl Marsh. Early reports refer to thick and tall sawgrass, along with more open areas with emergent aquatic species. Post drainage descriptions refer to sparser sawgrass, to other graminoid species, and to other aquatic species that are not usually found with denser sawgrass stands.

Both pre- and post-drainage reports are consistent in reporting substantial tree islands with what seem likely to be tropical hardwoods. Smaller islands of more shrubby vegetation (e.g., cocoplum, myrtle, or bay trees) were also reported. Two early post-drainage maps (Figure 2-8; Newman 1908) show a directional, southwest orientation for tree islands within or directly adjacent to the Rockland Marl Marsh, which reinforces the impression of a southwest flowing floodplain. Several accounts suggest that the landscape was originally bimodal in appearance; either treeless, shrubless marsh or forested tree island. The documented post-drainage increase in shrubby species, especially willow (*Salix*) "changed the whole aspect" of the landscape. Robertson's (1953) suggestion that the increase in woody vegetation was an effect of drainage, not fire, would be consistent with many other observations suggesting strong post-drainage lowering of water levels in this landscape.

<u>Hydrology</u>

Estimation of water depths for this landscape is complicated by its sloping surface, east to west, and by the irregularity of the pinnacle rock. The slope means that water depths within the Rockland Marl Marsh were likely somewhat deeper toward Shark Slough and shallower toward the Everglades Keys. An exception to this appears to be a narrow strip that runs just west of the pineland (Everglades Keys) and appears to have been somewhat deeper. This deeper area was a standard navigation route between north and south. The irregularity of the bedrock, the thinness of the soil layer, and the scattered presence of bedrock at the ground surface make it difficult to identify a clear reference elevation for water depths. The estimates given here are based on a location midway between the east and west borders of the landscape, and are referenced to the average pre-drainage soil surface, which we assume to be 6 inches below the tops of the pinnacle rock and 6-12 inches above the median, non-pinnacle bedrock surface.

Based on navigability, the presence of six foot tall, thick sawgrass, and the high likelihood that some peat soil was been present, we estimate a typical end of dry season low water level of 6 inches below soil surface, and an end of wet season high water level of 2 feet above. We estimate a hydroperiod—water above the average soil surface—of 8-9 months.

Hindcasting

Chapter 3 suggests that there has been 1, possibly up to 2 feet of peat subsidence within areas of the Shark Slough due to the effects of drainage. A number of sources suggest that peat was also lost from the Rockland Marl Marsh. Such peat subsidence within Shark Slough, the Rockland Marl Marsh, and presumably also in the Ochopee Marl Marsh, suggests that the southern Everglades was formerly wider and flatter in cross-section than at present. Peat subsidence in the center of the Slough also suggests that the pre-drainage width of the peat area would have been greater than what was mapped in the 1940s. A greater width of peat indicates a greater width of the source of the peat: substantial sawgrass growth. This would be consistent with the 1840s observations of the township surveyors MacKay and Jackson, who both found dense sawgrass as far east as the 5th mile of the northern boundary of Township 56 Range 38 (**Table 4.6**). Similarly, the combination of greater width and depth of peat would be consistent with the observation by Willoughby in 1897 that an impenetrable strip of sawgrass was present along the western edge of Shark Slough (**Appendix G**). Taken together, all of this suggests that, prior to drainage, the Shark Slough portion of the Ridge and Slough landscape was likely wider, and as a result, the Rockland Marl Marsh was likely narrower.

Table 4.6. Township surveys within the Rockland Marl Marsh area.

Twp	Rge	Comments	Citation
54	39	Strand tree islands oriented NE-SW	King (1917h)
54	39	Hammocks (tree islands) oriented NE-SW	Southern Eng. & Const. Co. (1918)
54	40	Water current and tree island orientation is SW-NE	Newman (1908)-T54 R40
54	40	Strand tree islands oriented NE-SW	King (1917h)
55	38	Never surveyed, per letter Nathan Mayo, 4/9/59	--
55	39	Border of Everglades; In Transverse Glades: "Sawgrass Prairie"	Jackson (1847)-T55 R39
55	39	Border of Everglades; Rockland: "Rocky Ridgey Country", NE-SW orientation	King (1917h)
56	38	Border of Everglades; See **Appendix A**	MacKay (1845)-T56 R38
56	38	Border of Everglades; See **Appendix A**	Jackson (1847)-T56 R38
57	38	Border of Everglades; "Everglades very wet and rocky covered with high sawgrass"	Jackson (1847)-T57 R38

Limited spatial information was available to estimate how far drainage and subsidence might have expanded the 1940s western edge of the Rockland Marl Marsh into Shark Slough. We moved the edge approximately one mile eastward. This was based on the locations of the dense, tall sawgrass mentioned in township surveys (MacKay 1845-T56 R38; Jackson 1847-T56 R38) and in Willoughby (1897; Appendix G), on the sawgrass mapped in the 1940s (Plate 5), on the changes in peat depth within Shark Slough (Chapter 3), and on the bedrock contours. It is more likely that we have underestimated, rather than overestimated, the pre-drainage width of Shark Slough. The hindcast western boundary of the Rockland Marl Marsh corresponds very closely to the edge between the more porous geological stratum of the Miami limestone mapped by Hoffmeister (1974), although the significance (if any) of this is unclear.

Overall, hindcasting changes made to the extent of the Rockland Marl Marsh after drainage were small. An area at the northern end that changed to Rockdale complex (Everglades Keys) decreased the extent, while the above-mentioned contraction of the peat-covered area of Shark Slough was estimated to increase the Rockland extent. Additionally, the tongue of shallow phase perrine marl recorded on the 1940s soil map (**Plate 3**) north of Taylor Slough was incorporated in the Rockland Marl Marsh landscape. The location of the eastern border with the Everglades Keys remained very stable, confirmed by an almost identical match between the "Edge of the Everglades" line indicated on township survey plats and the Rockland to Rockdale complex line drawn a century later on the (Jones *et al.* 1948) soil map.

Hindcasting of the northern area, which was enclosed and (over)drained by the Tamiami and Snapper Creek canals, was based on photos of peat burns (Parker 1940), a township survey (Newman 1908-T54 R40), and a map of the Southern Drainage District (King 1917h; see **Figure 2.8**). Early drainage caused this area to resemble, and be mapped in the 1940s as a piece of the drier Everglades Keys.

Rockland Marl Marsh Endnotes

1. In a letter written in 1851 (Knetsch 1989), William Cooley describes pinnacle rock of the Miami Rock Ridge, noting that the pinnacle rock continued westward into the Everglades, specifically, into the Rockland Marl Marsh. The hammocks that Cooley describes appear to be within the Rockland area; it is less clear whether the foot or more of soil he described was only on the Miami Rock Ridge or also present in the Rockland area.

   "...at Loyd's Lake [According to Knetsch, "Loyd's Lake appears on maps from the Seminole War period at the extreme southeastern corner of the Florida Mainland, opposite Key Largo."] you strike the porous or honeycomb rock which reaches from that point to Rio Ratones [Snake Creek] -- most of this distance this rock appears above ground but in some places it is covered with soil a foot or more -- this rock on this route extends some distance into the everglades but I have not seen it anywhere else in any body -- There are several large Hammocks whose base is this porous rock -- the land or soil is rich but if fired in a dry time it will burn up--..." Cooley, 1851, in Knetsch 1989.

2. While surveying Township 56 Range 38 in 1845, the U.S. Deputy Surveyor George MacKay recorded the following notes during his course west along the northern boundary of the township, beginning with the transition from the pinelands of the Miami Rock Ridge to the open Everglades, just east of the present L-31N canal (**Plate 9** and **Plate 3:**

   "2nd Mile: 60.00 chains: exit to open level rock prairie.
   3rd Mile: Open level rock becoming broken, with large holes - with saw grass"
   4th Mile: Rock broken up like honey comb, and gradually disappearing–saw grass more general, with islands of cocoaplum myrtle and other timber not known – To the Eye the country descends West and ascends East – Saw grass to[o] high & thick to proceed." (MacKay 1845-T56 R38).

3. Two years later, MacKay had completed a number of township surveys along the Everglades, the Miami Coastal Ridge, and the Atlantic Coastal Ridge. In an 1847 letter to Buckingham Smith, MacKay gives a good overview of the Rockland Marl Marsh, as well as an idea of the water depths in the wet and dry season:

   "I was forcibly impressed with the pecularity of the southern Glades–a vast rock of interstices and partitions, something in the form of a honeycomb–the interstices or cells, filled with soil, saw grass or water, are barren, [it seems likely that "barren" here refers to an absence of trees--not to an absence of sawgrass or other marsh growth--on the soil filling the interstices of the pinacle rock] with islands of trees, traversable with canoes in high water, and upon horseback in low water, the whole presenting the most romantic view of grass, prairie, and water, with gems of islands of rare timber and shrubbery." (George MacKay, 1847, in Senate Doc. 89, 1911).

4. Elsewhere in the same letter, MacKay gives a vivid impression of the porosity of the unusual limestone- location he describes is likely Township 54 Range 40 (**Plate 9** and **Plate 3**):

   "In the region southwest of the head currents of the Miami River, when the rainy season had made the water superabundant, I observed that there were currents and counter currents running in every direction, frequently quite rapid, and in the dry season I found that that the course of these currents was, owing to numerous rock basins, in many instances perforated with holes in the bottom like a colander, into which these currents poured and disappeared; and in the pine woods, between the Glades and the Bay of Biscayne [i.e., on the Everglades Keys], may often be heard the rippling sound of running water, and frequently, in the fissures of the rock, it may be seen at from 6 to 8 feet below the general surface of the ground; and there are springs in the midst of the bay, where, by very indifferent means to shut out the salt water, pure fresh water has been raised 3 or 4 feet above the surface of the ocean, ...” (George MacKay, 1847, in Senate Doc. 89, 1911).

5. Another U.S. Deputy Surveyor, John Jackson, also surveyed the north boundary of Township 56 Range 38 along a westward course in 1847, two years after Mackay:

   “2nd Mile: 58.00 chains: Came to Everglades.
   3rd Mile: Everglades very Rocky and about 2 inches deep of soil.
   4th Mile: rough honey comb rocks with about 18 inches of water on Part of it.
   5th Mile: Honey comb rocks Covered with about 2 ft of water and thick Saw grass.” (Jackson 1847-T56 R38).

   Like MacKay, Jackson also found pinnacle (“honey comb”) rock, increasing water depths, and increasing thickness of sawgrass as he progressed westward. He was unable to survey the 6th mile. The thick sawgrass seen by both surveyors suggests significant peat deposits; at least 1 to 2 feet.

6. Col. George F. Thompson inspected Dade County in January-February 1866 for the Freedmen’s Bureau (Bentley 1950). According to Bentley, Col. Thompson mentions the “honey-combed, rotten limerock surface” of the pine barrens [i.e., the Miami Rock Ridge], and low prairies of great fertility. (Bentley’s quotations from Thompson’s original serialized account in the Tallahassee Sentinel, April-May, 1867, are limited. We did not obtain the originals, but they seem likely to include further information on the Rockland Marl Marsh area.)

7. The U.S. Deputy surveyor Marcellus Williams found indications of deep water in the Rockland area while searching for a boat route through the Everglades. Because of the difficulty of walking through the pinnacle rock of the Miami Rock Ridge, he sought to bring provisions by boat to his survey party based at the southern tip of the Miami Rock Ridge. A boat route from the headwaters of the Miami River (SW corner of T 53 R41) to Taylor Slough, passing southwestward along the western edge of the Miami Rock Ridge seems to have been well-known to the Indians. (Willoughby and his assistant Ed Brewer refer to this route in 1898. From their description (Willoughby 1898), it seems likely that they visited the same island described by Williams.) Unfortunately, the year 1874 was too dry for Williams to reach Taylor Slough:

   “I ... found it utterly impossible to supply my party [by overland route along the Miami Rock Ridge] with provisions, unless I could reach this point [Townships 57 and 58] by way of the Everglades in my boat.

   “I therefore proceeded to the Miami River and hired two Canoes and with them passed out of the Miami river into the Everglades. I was however told by the Indians that the water in the Everglades was unusually low and that I would find it impossible to pass through it – I however concluded to try it but soon found that this information was correct. I spent three days in this endeavour and returned – I will here say that there are portions of the Everglades that can be surveyed with water high enough to pass through the very many channels in there – Upon this trip I spent a night upon an Island about 4 miles South West of the outlet to the Miami, which is planted by the Indians and is one of the richest pieces of land that I ever saw. There is probably 7 acres in cultivation in Corn, Potatoes and Banana. – The soil is very black [the black color of the soil of this larger tree island is not a reflection of man-made drainage, but more likely of the woody origin of the peat in combination with oxidation due to the island’s natural elevation], about 1 foot deep and lying upon lime rock.” (Williams (1874)-T 57 R39).

8. The geologist Griswold (1896) explored westward from the Everglades Keys into the Everglades. His description of the border between these Keys and the Rockland Marl Marsh suggests that a substantial amount of water covered the Marl Marsh, at least in the wet season; enough to prevent growth of pines, and a little further west, to support sawgrass. Six foot high sawgrass would be consistent with the surveyor’s descriptions 50 years earlier, and also with later suggestions that peat soil was originally present:

   “At the border of the Everglades the rough surface of the oölite becomes concealed for the most part beneath a mat of grass, and pines grow no further west (Plate XXIV. Fig. 1). In the zone of oscillation of water the grasses change in character from a small wiry variety near the pines to saw-grass six feet or more tall, and flags and cane growing in water.” (Griswold 1896, p.53)

9. MacKay’s and William’s descriptions of the Rockland Marl Marsh was passable for canoes in the wet season are consistent with Willoughby (1898), who in January 1897, covered the most distance between his Station

No. 12 and 13, an area of Rockland Marl Marsh (see **Figure 2.5**; and **Appendix G**). However, Willoughby's passage from Stations No. 10 to 12, over a short section of the Rockland Marl Marsh closer to Shark Slough, was painfully slow, with insufficient water to float canoes over the exposed pinnacle rock. It appears that there was a deeper water portion of the Rockland area that was closer to the Miami Rock Ridge:

> "At last we cleared the ridge, and the face of the rock began to get smoother, and more of the round grass [probably a reference to *Eleocharis* sp.: Harper (1927) lists *Eleocharis* as present in the marl prairies with limestone or marl substratum, and gives "round grass" as the common name] and deeper water could be seen ahead. ... Brewer thought that we would not have many more miles to travel before reaching a district that he had hunted over when going in from the east coast. He had followed down the pine-timber of the main land at a sufficient distance from it to find it insured deep enough water for the canoes. Finding better leads, we were now able to take the much-desired northeasterly direction." (Willoughby 1898).

10. John Stewart (see Chapter 2) recorded several useful observations concerning the Rockland Marl Marsh area in 1907. The following passage suggests that both pinnacle rock and peat were present in the area before drainage. The peat did not necessarily form a continuous layer, but rather filled in the holes:

> "From what I can learn the country in the vicinity of and south of Miami is rocky. Rock is full of pot holes in places in other places in sheets. The pot hole formation also occurs in the southern part of the Glades where the rock sticks out of the water, the holes being filled with muck. The muck is stringy and more of a peat and if thoroughly dry will burn. Several companies have been considering the advisability of pressing it into bricks for fuel." (Stewart 1907, p.45)

11. Early settlers around Miami were aware of and concerned about high water in what was most probably the Rockland area:

> "The Glades below Miami are rocky and are not of much value. The water should be held down to about the present low level to prevent overflow of east coast." (Mr. S. M. Richmond, of Miami, Florida, March 1907, quoted in Stewart 1907).

12. The following description of the southern Glades likely applies to the Rockland Marl Marsh as well as to the Ochopee Marl Marsh:

> "The sawgrass growth in the southern Glades is very light. There is much open water with a light growth of marsh grass." (W.A. Roberts, timber estimator and land locator, Ft. Myers, Florida, 1907, in Stewart 1907).

The reference to "marsh grass" may be to *Eleocharis* spp. Another possibility, maidencane (*Panicum hemitomon*) seems less likely as that species seems to have been generally recognized and referred to by name.

13. Typical water depths in the Rockland Marl Marsh were still high enough in 1917 (after opening of the Miami canal, but before much work on the Tamiami Trail and canal; see Chapter 3) to raise the same concern mentioned above in Stewart (1907)--that water from the Rockland Marl Marsh could flood other areas. Based on field studies for a project to drain and develop lands in the Southern Drainage District (see **Figure 2.8**; also King 1917d; 1917g; 1917h), the civil engineer John King felt that protection would be needed from the water in Township 55, Ranges 37 and 38:

> "... as well as on the Southern boundary, provision must be made to prevent the over flowing of the lands within the drainage district from the waters accumulating on the undrained lands adjacent thereto." (King 1917g).

14. King's concern about flooding from Rockland waters is particularly significant given his observation elsewhere (see Chapter 3) that

> "...the drying up of the 'Glades, due to the various canals, is playing havoc with the birds here. ... five years has made a marked change." (Larned 1918).

This suggests two important points. First, that southern Everglades water levels had declined noticeably by 1917 and second, that, in spite of this decline, there was still enough water on the Rockland Marl Marsh to be of concern for flooding.

15. **Figure 4.20** shows a map of peat ("muck") and marl soil depths recorded in March 1918 at each of the section corners in Township 54 Range 39 (Southern Drainage and Engineering Co. 1918-T54 R39), and plotted over

the (Jones et al. 1948a) soil map. The 1918 soil type indications and depth measurements are very consistent with the 1940 soil mapping. Deep peats, 4.5 to 6 feet, are found in the area mapped as Loxahatchee Peat; somewhat less deep, 2 to 5 feet, in the two subcategories of Everglades Peats. The area of Hialeah Mucky Marl, a soil type that by definition includes layers of peat as well as marl, lists shallow marl depths and several feet of peat.

The 1918 measurements for the Rockland Marl Marsh portion of the township, approximately the southern one third, include sixteen measurements. Of these, only one, located near the Everglades Peat area, indicates a depth of peat soil. Five section corners indicate no soil at all--zero feet of either marl or peat. The remaining ten non-zero corners indicate marl only, averaging 1 feet in depth.

These measurements are certainly consistent with earlier observations of exposed pinnacle rock in the Rockland landscape. It is less clear what these measurements imply about pre-drainage peat presence or absence. It is conceivable that drainage had been sufficiently rapid and effective to permit peat fires to remove any shallow peat originally present (See Parker 1940 below). It is also conceivable that the township surveyors chose only to record agriculturally useful peat, i.e., when its occurrence was in continuous layers with a thickness greater than a minimum of perhaps 1 or 1.5 feet. Finally, it is possible that **Figure 4.20** does accurately represent pre-drainage conditions.

16. Like King, the naturalist Charles Simpson observed effects of drainage on vegetation, shortly after canal completion in 1920. Simpson does not specify an exact location for his observation, but the location of his home near the Little River and the descriptions of travels around Paradise Key (T58 R37) suggest that it would apply to the area west of Miami, both north and south of Tamiami Trail:

> "Although only the preliminary work of drainage has been done yet it has had a marked effect on the vegetation. Along the banks of the canals and on all slightly elevated spots a variety of trees and shrubs are springing up, so that where formerly the eye swept over a monotonous even expanse of saw grass, the view now presents patches of incipient forests. This new element in the flora is especially noticeable around the eastern border which is somewhat drier than the main body of the swamp. Here groves of young timber are claiming titles on every hand.
>
> One of the results of partial drainage is that along this same east border numerous low, timbered 'islands,' which were formerly quite wet, have now been changed to dry land. A considerable part of the foundation of these groves is peat and in dry times it is very liable to fire, and once begun it is well-nigh impossible to extinguish it. These groves, despoiled of their only defense against fire, are often wholly destroyed. So it happens that while the draining of the Everglades makes it possible for forests to spring up and flourish in some places it is the cause of their destruction in others." (Simpson 1920).

17. In a different description, Simpson suggests that muck (organic soil) was present in the southern Everglades, but only in a layer thin enough to leave visible pinnacle rock:

> "...there has not been sufficient time ... to form any great depth of vegetable deposits. In fact the rock appears on the surface over extensive areas in the newer part of the great swamp. [Earlier Simpson indicates that he is referring to the "southern part of the Glades." Simpson's reference to ""not sufficient time .. in the newer part..." reflects his hypothesis that the Lower Glades were younger in geological age than the Upper Glades.] In this connection the settlers make a distinction founded on the depth of muck, and speak of the "Upper Glades" and "Lower Glades." In the upper (northern) part of the swamp the saw grass is much more dense ..." (Simpson 1920)

18. Harper (1927) describes "Marl Prairies," which correspond to the Rockland Marl Marsh. His impressions of water depths and hydroperiod most likely reflect partially drained conditions caused by the main four canals and by the almost complete Tamiami Trail and canal (Chapter 3):

> "The south end of the Everglades has a limestone or marl substrate instead of sand, and the same is true of the numerous narrow glades that intersect the Miami pine land, and the coast prairie south of it. The vegetation of these places is similiar in aspect to that of the northern part of the Everglades, and other saw-grass marshes, but differs in composition, on account of the calcareous soil, and also because the water is shallower, and absent about half the time. Besides the regular marsh vegetation there are clumps of small trees and bushes in drier spots, and some aquatics in small pools, commonly known as 'gator-holes."

19. The full list of species can be seen in Harper (1927); we reproduce here only his comment on differences between the marl marsh and other sawgrass marshes:

    "Among the plants which are commoner in the marl prairies than in the typical saw-grass marshes, presumably on account of the more calcareous soil, are *Spartina bakeri*, *Phragmites*, *Crinum, Aletris, Hyptis, Potamogeton*, *Polygala baldwinii, Aeschynomene, Dichromena, Lippia, Sisyrinchium, Ludwigia, Thalia, Samolus*, and *Flaveria*."

20. A portion of the Rockland Marl Marsh area merits special mention. This portion was isolated by canals on all sides beginning in the 1910s, and therefore was subject to severe drainage during a number of years. The portion, which comprises most of Township 54 Range 40, was bounded by the Tamiami, the Coral Gables, and the Snapper Creek canals, all of which were completed by approximately 1930. The effect of this drainage on the peats ("mucks") of this portion of the Rockland Marl Marsh can be seen clearly in several photographs (**Figure 3.18**) and the accompanying captions by Mrs. Garald Parker:

    (A-90): "Annual fires have burned off muck to reveal solution pitted top of Miami oolite. Fire in background has recently burned this area again."

    (A-91): "Oolite revealed by annual fires that have finally burned muck off." (A-91)

    (A-92): "Muck fires have burned down to and into the Miami oolite where muck used to be." (Parker 1940).

    By the time of the 1940s soil survey, no portion of Township 54 Range 40 was mapped as Rockland Marl Marsh; it was at that time classified as the material making up the Miami Rock Ridge, Rockdale-limestone complex (**Plate 11**).

21. The remaining area of Rockland Marl Marsh to the south was described as follows by the 1940s soil survey of the Everglades Drainage District. They noted particularly that it was too wet for agricultural use:

    "Surface soil: Light gray honeycombed limestone. Water at or near the surface. Peaty material or marl in some of the cavities. Native vegetation: Sparse sawgrass."

    "The low-lying rock land is different from the Rockdale rock land [the Miami Rock Ridge] previously described. It is low, wet, and not suitable for any cultivation." (Jones et al. 1948a)

22. Davis (1943) considered the Rockland Marl Marsh and the Ochopee Marl Marsh as two parts of the same vegetation community. The following describes them as seen in the 1940s:

    "[The fifth main vegetation type of the Everglades is] the southern mixed marshes and wet-prairies on marl soil or rockland areas, and covering two areas mostly south of the Tamiami Trail that lie to the east and west sides of the funnel-like southern part of Tamiami slough and tree-island area. The vegetation is a growth of low and sparse marsh plants with patches of saw-grass common, or of switch-grass and other grasses and some marsh plants that form wet-prairies, so that it is difficult to designate them as either marshes or prairies. Over these low-lying marshes and prairies are scattered many sub-tropical hammocks on the higher usually rockier parts and some groups of bay trees, and wax-myrtle, at lower elevations. Some parts are not at all covered by marl, or so thinly covered by marl, that the areas are very rocky and rough with solution holes and other erosional features. These rockland prairie-like areas are common on the southwest side adjoining the Miami Rock Ridge pinelands. Parts of these plains that are prairie-like with cabbage-palm and tropical hardwood trees in the hammocks are among the most beautiful scenic parts of the Everglades." (Davis 1943).

23. The presence or absence of peat soil would provide further information on the likely pre-drainage water regime of the Rockland Marl Marsh. Davis felt that before drainage, the Rockland area was formerly covered by peat (see Chapter 3; **Figure 3.10**):

    "Excessive artificial drainage has recently created drier conditions promoting these fires and also causing the shallow organic soils to become oxidized and subside until now some areas once soil covered are returning to rockland conditions." (Davis 1943).

    "Figure 21.--Rockland resulting from fires that have destroyed the shallow organic soils." (Davis 1943).

24. In a later study specifically focussed on peat, Davis again emphasizes the loss of peat that occurred in areas likely corresponding to the Rockland Marl Marsh:

    "Moreover, large, shallow peat ["shallow peat" here is in comparison with the 6 to 9 or more feet of peat that Davis encountered in the northern Everglades] areas of the southern part of the Everglades that have neither been drained nor cultivated have lost their peat cover completely or nearly completely due to dry season fires, of which those during April and May 1945 were some of the most destructive, frontispiece. In many places only bare rock now remains in some of these areas." (Davis 1946).

25. The following water depths, described in the 1950s by the Dade county soil surveyors, pertain to an unspecified combination of the Rockland Marl Marsh, Shark Slough and part of the Ochopee Marl Marsh. Nevertheless, the description gives an accurate impression of how wet this part of the Everglades could be, even with all the drainage mechanisms already present in the 1950s. Pre-drainage water levels would have been even higher:

    "Much of the county may be covered by water 2 to 60 inches deep for many days." (Gallatin et al. 1958).

26. The depths of water and length of hydroperiod still observed as late as the 1950's, suggest that pre-drainage water depths must have been substantial in this landscape:

    "Owing to the low and nearly level relief, many of the soils in the county are naturally poorly or very poorly drained. Only those soils on the [Miami Rock] ridge in the eastern part of the county are well drained to excessively drained. During the rainy seasons most of the soils, except those on the ridge, are covered with water that may be several feet deep. During dry seasons, most of the marl glades in the southeastern part of the county and some of the low-lying sandy soils in the eastern part become dry enough to permit cultivation of crops. Even after lengthy dry periods, much of the area of soils in the Everglades basin is still covered or saturated with water." (Gallatin et al. 1958).

27. Robertson describes a change in the landscape that took place before the 1950s. He suggests that the change is a result of lowered water tables:

    "Local residents most familiar with the Everglades area agree that within the period of their observations (roughly 25 years) there has been a marked expansion of woody vegetation at the expense of the sawgrass area. It is also agreed that, in spite of fires which have destroyed many tree islands, this invasion has been sufficient to change the whole aspect of large areas particularly south of the Tamiami Trail. The species most involved in this thicket expansion is willow (Egler, 1952: 240; Poppenhager, Redding, Winte, pers. comm.). Some of the present willow areas mark sites of burned-out bayheads, but there seem to be many sites where willow scrub is independently invading sawgrass. It appears a reasonable hypothesis to attribute this development to the drying of the lower glades. It has, at least, occurred under conditions of lowered water levels, and cannot be interpreted as a fire effect because, as Egler points out (ibid), fire acts to limit this thicket extension." (Robertson 1953).

28. An unpublished map (Flood Control District 1960) from the predecessor to the South Florida Water Management District reinforces the impression that, prior to drainage, the Rockland Marl Marsh must have been quite wet. Even as late as 1960, with fires and willow expansion indicating that water levels were lower than pre-drainage levels, water levels were still sufficiently high for this map to label the great majority of the Rockland Marl Marsh--up to approximately the 9 foot elevation contour, or 1 to 2 miles from the Miami Rock Ridge--as subject to "long-duration flooding." The 1 to 2 mile band surrounding the Miami Rock Ridge together with the Marl Transverse Glades were labeled as "Intermittent flooding without [Central and South Florida] Project influence." Only the individual high areas making up the Ridge--the rock islands known as the "Everglades Keys" and which lie above the 10 foot contour--were shown as free from flooding on this map.

29. Craighead (1971) stresses the role of fires, presumably made possible or more frequent by drainage, in altering the distribution of saw grass and in causing the loss of peat soils:

    "Many great fires have been recorded (Davis, 1943, 1946; Robertson, 1954). Early botanists frequently commented on fires in the 1920s (Small, 1929). ... Again, in 1945 to 1947, in 1951 and 1952, and in 1962 and 1965 fires destroyed tremendous expanses of saw grass. The top layers of

> peat containing the mat of rhizomes were burned to ashes. In some places the peat burned to bedrock or to marl soil. Much roughly eroded limestone formerly covered with peat was exposed in these great fires of the past fifty years." (Craighead 1971, p.141-142)

Ochopee Marl Marsh

General Description

This marl forming landscape occurs to the west of Shark Slough and is defined as the area of Ochopee Marls mapped by Jones et al. (1948b; **Plate 3**), excluding the area covered by cypress forest (Jones et al. 1948b; **Plate 5**). It also corresponds closely to the westernmost of the two areas of "Marsh Prairies, Southern Everglades," mapped by Davis (1943b; **Plate 4**), but excluding most of the portion north of the Tamiami Canal. Harper (1927) as well as Davis (1943a,b) consider the Ochopee Marl Marsh to be paired with the Rockland Marl Marsh.

A transect of surface water stage and flow measurements that extended east and west from Shark Slough into both of these marl marshes also supports the concept that these two landscapes formed a hydrological and ecological pair (**Plate 15**; Rosendahl and Rose 1981). Early aerial photographs (USDA-SCS 1940) suggest water movement through the landscape, but the pattern is quite different from the Ridge and Slough landscape. Instead of a long, parallel pattern, the apparently wetter areas wind through the landscape in short S-shaped paths. This may correspond to King's (1917) description of "sloughs breaking up" (**Plate 26).**

Soils and Geology

In spite of the hydrologic pairing suggested above, we distinguished the Ochopee Marl Marsh and Rockland Marl Marsh landscapes because of differences in their soils and geology. In addition, the Ochopee Marls contained more sand than the Perrine Marls (which occur within the Rockland landscape). The soils distinctions are probably less important than the differences in the geology. The Rockland landscape occurs on highly porous Miami oolite (Parker et al. 1955; Fish and Stewart 1991). This limestone surface is rough, with jagged "pinnacle rock" extending upward and solution holes extending downward. Surface water and groundwater were likely to have been directly connected in many places.

In contrast, the Ochopee Marl Marsh Landscape is underlain by the Fort Thompson Formation (Fish and Stewart 1991), a limestone which is smoother, harder and less porous. This suggests that natural drainage in the Ochopee landscape was therefore more likely to have been dominated by surface rather than ground water movement (compared to Rockland Marl Marsh).

Hydrology

The predominant direction of surface water flow in the Ochopee Marl Marsh landscape may provide useful information concerning the nature of rainy season water depths across the Ochopee - Shark Slough - Rockland assemblage of landscapes. Surface water in the Ochopee landscape might be expected to have sheet flowed either southwestward toward the Lostman's River drainage basin or southeastward into Shark Slough. Bedrock contours (**Plate 3)** would suggest a southeastward drainage into Shark Slough. However, the directional markings visible in aerial and satellite images **(Plate 2)** clearly are southwestward .

A map from 1917 showing the same NE-SW directionality (King 1917b) suggests that the pattern has existed for eighty years or more. A possible explanation for this directionality running perpendicular to the bedrock and ground surface contours might be that at times of high water with sufficient flow to form the landscape scale markings, water would have filled the entire basin, that is, the Ochopee Marl Marsh, Shark Slough, and the Rockland Marl Marsh up to its border with the Everglades Keys. If, at such times, the upper surface of the water across the full basin was all at one level, then flow would have been southwestward throughout, consistent with the landscape markings.

Based on its topographic symmetry with Rockland Marl Marsh, we estimate a long term average hydroperiod—water above the average soil surface—of 8-9 months for this landscape, with a typical end of dry season low water level that was 0.5 feet below soil surface, and an end of wet season high water level that was 2 feet above the soil.

Hindcasting

No adjustments were made to the extent of either the Ochopee Marls or to the extent of the Ochopee Marl Landscape. It is possible that Shark Slough, as defined by the area of Loxahatchee Peats, may have been wider prior to canal drainage, but we found no means for estimating this. The observations of Willoughby (1898), although not definitive, seemed to be consistent with the boundaries mapped by Jones et al. (1948b). The map by King (1917b) also appears to be consistent with the western boundary of the Ochopee Marl landscape. For observations of pre-drainage and early post drainage water depths and associated vegetation in the Ochopee Marl Marsh Landscape, see **Appendix A, Table A-5.**

Perrine Marl Marsh

General Description

The Perrine Marl Marsh landscape is bounded on the north by the pinelands of the Everglades Keys, on the east and south by mangrove fringe lining the shores of Biscayne and Florida Bays, on the southwest by the terminus of Shark Slough, and is bisected longitudinally by Taylor Slough (**Figure 4.21**). Land surface elevation is low -ranging from below sea level at the seaward edge to approximately 3 meters at the western and northern boundaries with adjacent uplands. A distinct rise in topography (generally about 1 foot) occurs over a very short distance at the boundary with the pine uplands.

This low, flat, seasonally inundated region of calcareous marl soil presented a challenge to early Government Land Office surveyors who attempted to layout townships in the late 1800s (**Appendix A, Table A-6**) and early 1900s . The range and intensity of conditions in this “boggy” landscape are reflected in an excerpt from the U.S. Survey field notes recorded in March 1874.

> "Today I tried to reach the Survey from a point farther west and found the post on the Range line dividing Ranges 38 & 39 E … Post to comer Townships 57 & 58 S R38 & 39 E / The whole of the above is through Marsh & Savannah and could only be followed except by re Survey. The last two Miles of the above Survey is of the same character (it being however rather more boggy with more water) as the last two Miles on the West Boundary T 57 S R 40 E - March 21,1874"
>
> "Upon my return [approx. March 28] having been baffled in every effort, I concluded to again try the Survey of T 58 S R 40 E. - The weather having continued without rain, and the sun quite hot. My hope was that the soft Mud had somewhat dried. In this I was not disappointed. I found a very great improvement. In many places the surface was parched and cracked and would bear the weight of a man, but in other places it was still boggy." (Williams, 1874 - T57 R39).

The Perrine Marl Marsh region has previously been referred to as the Coast(al) Prairie, (Harshberger, 1917;Harper, 1927), Southern Coast Marsh Prairie (Davis, 1943), Southeast Saline Everglades (Egler, 1952), and Southern Marl-forming marsh (Davis et al., 1994), with some debate as to whether it was part of the Everglades system. This study, as did Davis et al. (1994), considers this landscape a distinct component of the Everglades ecosystem.

Historically as well as currently, calcareous blue green algae communities (periphyton) in this region contributed to surface accumulation of algal marl (Dachowski-Stokes, 1928, Browder et al., 1994) throughout this landscape. Sub-surface Perrine Marl sediments consist primarily of calcareous material that was deposited from water that flowed seaward through the Transverse Glades before the Everglades was formed. This water contained large amounts of calcium that were deposited as calcium carbonate. Being developmentally younger, the eastern part of this landscape contained thicker deposits of marl than the western areas. Post-drainage estimates of marl depth range from 2-3 feet in the deeper areas to shallow deposits (1 foot or less) in the west (Meeder *et al*, 1996)

The pre-drainage Perrine Marl Marsh landscape can be characterized as a short-stature sawgrass, marl-forming marsh, interspersed with tropical hammock tree islands and dotted with stunted pond cypress and red mangrove (**Figure 4.22** to **Figure 4.25**).

> "For the distance of twenty-odd miles southwest of Royal Palm Hammock and Long Key there is almost flat prairie. Its principal herbaceous growth is saw-grass (*Mariscus*) [*Cladium*]. There is often a scattered growth of pond-cypress (*Taxodium*) and of red-mangrove (*Rhizophora*) and scattered dense hammocks of a mixture of temperate and tropical trees. Several of these hammocks, which are flooded part of each year, harbor a kind of *Zamia* that occurs nowhere else in Florida." (Small 1923, p.237)

Most of the plants in the upper reaches of the Perrine Marl Marsh were considered freshwater marsh and swamp species. However, this area was periodically inundated with saltwater during extreme tide and storm events making it subject to exposure to wind-driven salt spray. Thus, most of the species also exhibited considerable salt tolerance. The nature of the interface between freshwater and saltwater plant communities was variable within different parts of the Perrine Marl Marsh:

> "To the south the boundary [of the Everglades] is less definite, as the 'Glades change character more or less approaching the Gulf, although in places the saw grass marsh reaches to the mangrove swamps bordering the coast." (Sellards 1912, p. 76).

Tree islands were sometimes, but not always, associated with either rises or depressions in topography, with distinctive shape consisting of a taller "head" of larger trees at the upstream edge and an elongated "tail of low-lying shrubby vegetation extending downstream with an orientation in the general direction of water flow (Egler, 1954). This feature is captured in aerial photography as early as 1938 (**Figure 4.26**).

Although drainage and an altered fire regime have impacted the vegetation of this landscape, unlike the peat portions of the Everglades, there has probably been little change in topography of this area during the past century with the exception that a general increase in sea level throughout the region has been accompanied by deposition of increased depths of marl along the eastern boundary and formation of mangrove peat at the southern seaward margin. These rates of deposition are, however, very slow.

Hydrology

Water flowed from the Everglades (Rockland Marl Marsh) to the Perrine Marl Marsh as sheet flow through Taylor Slough and, when levels were adequate, through the Marl Transverse Glades that provided openings through the rock ridge between the Everglades Keys (see Everglades Keys and Marl Transverse Glades sections in this chapter). Flows were augmented by local rainfall and runoff from the Everglades Keys. Water levels in this flat "prairie" like landscape remained above ground level in most places well into the dry season (**Appendix A6**). Water may have been impounded in this area due to a naturally occurring coastal levee referred to as the buttonwood embankment (Craighead, 1964). Formed by processes associated with a fluctuating sea-level over the last 2000 years, the Buttonwood Embankment averages 1.5 ft in height and "appears to form a barrier between the terrestrial environment (Everglades) to north and the marine environment (Florida Bay) to the south. (Holmes et al., 1999).

As recorded by early observers of this area, water levels fluctuated widely corresponding to seasonal and interannual rainfall cycles. We estimate the long term average annual hydroperiod would be 8–9 months in this landscape. Average annual water levels would have ranged from 1 foot below ground at the end of the dry season to a high of 1.5 feet above ground at the end of the wet season, and would have supported predominantly (short stature) sawgrass and marl-forming marsh (periphyton) communities. Indications that diatom-rich periphyton existed in this region before drainage suggests that water levels were deeper and hydroperiods were longer than those supporting calcite-encrusting blue-green taxa found in the shorter-hydroperiod (6-7 months), shallow-water marshes that occur in this area today (Browder et al. 1994).

Hindcasting

The southern extent of the Perrine Marl Marsh landscape is defined by the transition from "Glade Land with Scattered Hammocks" (U.S. Coast and Geodetic Survey 1937c) to mangrove forest. Coastal maps (U.S. Coast and Geodetic Survey 1928; 1937a; 1937b; 1937c) were used to locate this boundary seaward of the current mangrove-marsh interface.

The retreating marsh is a result of saltwater intrusion landward. Recently, studies were conducted to determine the point at which saltwater meets freshwater along various transects located in the area between Turkey Point and Taylor Slough (Meeder *et al*, 1996). Measurements of salinity, vegetation and elevation were combined with estimates of accretion rates and sea level rise to estimate how much the location of this line had changed during the past century. These estimates indicate that since 1900, seawater has penetrated distances that ranged from a minimum of approximately 500 meters (0.3 miles) further inland at Taylor Slough to 2400 meters (1.5 miles) at Turkey Point and nearly 4500 meters (2.8 miles) at Highway Creek, just west of U.S. Highway 1, South of Homestead (Meeder et al. 1996). Studies of soil cores collected along these transects indicate that as one approaches the coast, recent soils contain increasing amounts of mangrove peat near the surface, underlain by freshwater peats containing species such as bladderwort, sawgrass, and spikerush. These peat profiles are consistent with a pattern of increasing penetration of salt water into this landscape, and associated changes from freshwater to saline communities.

The effects of sea level rise have been partially offset by soil formation processes. Recent estimates of soil accretion rates in this area suggetst that along the coast, mangrove peat is accumulating at a rate of about 3 mm/yr or 30 cm/century . Rates of marl accumulation are much less, on the order of 1 mm/yr or 10 cm/century (Meeder *et al*. 1996). Local measurements of the combined effects of sea level rise and local coastal subsidence in South Florida indicate that sea level has increased by about 30 cm during the past 100 years (Parkinson and Wanless, 1992). Thus, whereas the elevation (and by inference, the location) of the mangrove fringe may have remained fairly constant for the past 100 years, areas behind the mangroves have experienced a decline of about 20 cm relative to sea level, which has contributed to the observed changes in species composition over large areas of the landscape.

The hindcasted extent of the Perrine Marl Marsh is consistent with the spatial extent of Perrine Marl as delineated on the baseline soil map (Jones et al. 1948) with adjustment for the mangrove interface. The northern tongue of shallow phase Perrine marls, which extends north of the Everglades Keys, was incorporated into the Rockland Marl Marsh landscape.

Perrine Marl Marsh Endnotes

1. In 1902, William J. Krome led a survey team into the Everglades from Miami to investigate potential routes for the extension of the F.E.C. railway south from Miami to Key West. This effort included two phases -- the Cutler Extension and the Cape Sable Survey Expedition -- both of which are well documented in a collection of letters (Krome, 1902-1904). Krome and his team searched for a supply route into the Everglades south of the Miami River headwaters in November of 1902. Their plan involved finding a waterway sufficient to transport supplies from the coast as far west as possible, and then building a "cart road" to a permanent camp to be established on the "edge of the Everglades." This idea was abandoned following a reconnaissance of the area.

   > "Dusenbury, E.S. Frederick and myself… set out in a sail boat for Chi's Cut. We spent three days down there and thoroughly explored not only the cut but every other stream of any size at all that comes into the bay between Black Creek and the head of Card Sound. Chi's Cut is the only waterway that amounts to anything at all. It could be made navigable for a good sized dinghy for about six miles but then spreads out and winds up in a number of hammocks. The course of the stream instead of being very nearly west as shown on the maps is south west. It heads up nearly seven or eight miles from the pine land and the intervening prairie is so boggy that hauling or even packing across is out of the question." ...This knocks out the hope that I had of making the major portion of the supply haul by water. The only thing remaining is the overland haul from Cutler.

2. The following are excerpted from Krome's letters to Mr. E. Ben Carter, Chief Engineer of the F.E.C. Railway regarding the Cape Sable Survey expedition. Krome's team set out from Long Key (now Long Pine Key) and ran a survey line from Long Key SW to Cape Sable. They first set up a supply camp (Longview) on the Everglades Keys located in the NE ¼ Sec 29 Twp 57 Range 38 (approx. 3 miles WSW of Florida City's current location).

   Miami- Nov. 23, 1902

   > Dusenbury returned Friday night with the men whom he had down the country picking out a trail to our supply camp. He reports a very high stage of water in the 'Glades but not much in the way of open leads in the direction of Long Key. He saw Jenkins who made the trip some months ago with Sheehan [or Sheen] of whom you spoke. Jenkins says that they struck Long [Pine]Key about 12 miles from the main land after having abandoned the search once. They found it not so much a chain of islands as one long ridge broken by prairies.

   Miami- Dec.[illegible], 1902

   > Dusenbury informs me it will require the remainder of the week to complete a passable trail to the supply camp. The water in the prairies is very high and as there is no road at all, it requires considerable work to get across them.

   Camp Longview- Dec. 30, 1902

   > I have just returned from a trip to Long Key where Jenkins and I have been during the past week. …The main land breaks up into a series of big hammock islands extending far to the South.

   Field Camp- Jan. 28, 1903

   > I have just returned from a two week's trip through the Big Mangrove Swamp… We took with us two of the steel boats and two weeks supply of food…. My objective point was the source of Taylor river but I wished to cover a strip from 10 to 15 miles wide lying to the South of the pine land. I expected to find open leads of water through the Glades which would finally take me into

Taylor River but in this I was disappointed. [next sentence missing from original copy] …to find water enough to float our light-draught boats and had to drag them like sleds. In many places the muck is almost bottomless and progress was very slow, 3 miles a day being all we could make at times. I zig-zagged across the belt which I wished to examine… I found a most God-forsaken region in its present state but one which with proper drainage might yield thousands of acres of prairie with the same marl soil of those used for vegetables elsewhere in Dade Co. Much that is shown on maps as Big Mangrove Swamp is not a mangrove swamp at all but a dense cypress land. The timber however is all small and of no commercial value.

East Cape Sable, May 18, 1903

I found the country south of Long Key and east of Whitewater Bay to consist of wet prairies, buttonwood and mangrove swamps and countless lagoons and salt water creeks.

From all maps and other information available I expected to find a solid mangrove swamp lying between the Bay of Florida and Whitewater Bay but such is not at all the case. The mangrove is dense along the waterways but it seldom extends over a mile back and is more often much narrower. The whole interior of the peninsula is prairie. To the north it is black muck but along the Bay of Florida is a marl. It is all more or less subject to overflow in times of high tides and southwest gales but along the southern shore is ordinarily above high water. The last hurricane, 6 years ago, flooded the whole country between the coast and Whitewater Bay except a small territory between East and Middle Capes.

Some of my men who have worked along the East Coast say that if all the mosquitos at Jensen, F. Pierce, New Smyrna and Jupiter were collected in one locality they would feel ashamed in comparison with this Cape Sable multitude. If there was any way of escape I don't believe I would have more than three men left by tomorrow night.

3. Excerpt from "Field Methods in the Florida Everglades" (Krome, 1902-1904)

That portion of the State of Florida lying South of Latitude 25^{o} 30' has, up to very recent times, remained as completely unexplored as the interior of Thibet. It embraces the southern end of the Biscayne pine reef, the lower part of the Everglades, Whitewater Bay and the Great Mangrove Swamp….The few existing maps were entirely unreliable and the reports as to the character of the country by the occasional trapper or inquisitive naturalist who had penetrated for some distance into the region, were far from encouraging.

Therefore, when the officials of the Florida East Coast Railway decided upon an exploratory survey through this territory, with the object of determining its possibilities from a commercial viewpoint, various problems rather out of the ordinary, were presented to the engineering department.

The weight that could be carried by a packer varied of course with the length of the journey and with the character of the country to be traversed. Under favorable circumstances packs as heavy as ninety pounds were brought in over a trail five miles long, at other times, through pot-holes of deep muck twenty five pounds was a wearying load.

Boats were a necessity in transporting supplies although the water in the southern portion of the Everglades is usually very shallow during the dry season of the year during which the work was carried on. The dugout of the Seminole Indians is too heavy for carrying… So 14 foot steel duck boats were used and served the purpose admirably. They were light enough to be readily carried by two men across portages and three men could drag one loaded where only a few inches of water covered the muck. By using a couple of these boats as sleds, with two men harnessed in front and one pushing with a pole from behind, the six packers could bring in twelve full sized packs through muck and water where 40 pounds would have been a killing back load.

4. Observations from reconnaissance conducted in April, 1912 by F. J. Pepper, an agent of the Model Land Co.

"Following is memoranda of trip taken by Mr. Goodson and myself on the 24th, 25th, and 26th . . . to obtain samples of marl from and inspect quality of land embraced in Township 59 South of Range 37 East:

We left Miami morning of 24th by automobile and followed rock road out from Detroit [the old name for Florida City] until we came to the old Camp Jackson trail where we left the auto and walked to Camp Jackson…

On the morning of the 25th … left Camp Jackson at 5:30 with a pocket lunch and a machete: the distance from the camp to the NE corner of the township is about 4-3/4 miles along the range line. After going over very rough pine land and arms of shallow rocky prairies for a distance of about one-half mile we struck the large Everglade prairie which continued to the corner of the township unbroken except for an occasional cypress key; all of this prairie along the range line was covered with from four to fifteen inches of water with several deep sloughs running through; for a mile and half the walking was very difficult the water and mud being above our knees and in many places up to our waists. Most of this prairie over which we passed before coming to the township corner appeared to be of a good quality of marl running from six inches to two feet in depth; the lowest parts of this prairie is covered with a growth of saw-grass and the higher ridges with scattering mangrove bushes, with small cypress keys dotted here and there.

… about a quarter of a mile north of the township corner we found the soil beginning to get shallow, being about six inches deep at the corner. For a mile southeast of the corner we passed through scattering mangrove and a thin growth of a kind of wire grass; Mr. Goodson clim[b]ed a pine tree and from a height of about twenty feet as far as he could see with the naked eye west and south over the township it all looked the same, being covered with numerous small cypress keys and the stunted growth of scattering cypress. A great many of the keys near the northern line of the township contained scattering pine trees, and at a pint about four or five miles west of the NE corner there appeared to be a pine island of considerable size penetrating down into the township.

As far as we went out into the township it was hard to find over four inches of soil except in an occasional hole which appeared to be filled mostly with partly decayed vegetation. On a great deal of it there was not over two inches of light marl underlaid with flat surfaced rock.

…The soil was so shallow that we did not consider it necessary to take a separate sample of the top and one of the bottom…

5. J.W. Harshberger's monograph, *The Vegetation of South Florida*, (1914) provides a system-wide description of the Everglades landscapes based on field surveys conducted by the author beginning in 1911. His "coastal prairie" landscape closely corresponds to the spatial extent of this study's Perrine Marl Marsh.

Along the shores of Biscayne Bay and the Bay of Florida, inside of the mangrove swamps, which fringe them part of the way, is a flat prairie, so slightly elevated above the sea that it is in part inundated with salt water in times of hurricanes and when the tides are exceptionally high This prairie touches the pineland on the west and stretches as far north as Cutler, where the pineland approaches salt water. …

Physiognomically*, it resembles the Everglades. It is a vast saw-grass marsh in wet weather or plain with open lagoons of water and intersected by numerous drainage channels. The tension line between the extreme southern pineland and the Great Coastal Prairie is not drawn sharply. The two formations sometimes blend imperceptibly.

*Small believes that the distinction between the Everglades back of the Everglade keys and the "Front Prairie" east and south of the Everglade keys if fictitious. He has walked over the "Front Prairie" from Cutler south and west to Monroe County with the exception of about 3 miles, and did not find a single plant species that he did not find on the other side of the pineland. There are large areas not influenced by salt water and where mangroves are not in sight, according to Small.

The prairie is dotted with islands of bushes and low trees and Small considers it to be a part of the Everglades. There are differences, however, which lead one to consider the coastal prairie a distinct phytogeographic formation. The coastal prairie is influenced by salt water. Several miles south of the pineland, the surface of the prairie is sprinkled with low mangrove bushes, *Rhizophora mangle* L., raised on stilt-like roots and with round-headed tops of light-green foliage, and the presence of this tree phytogeographically makes the coastal prairie a formation distinct from the Everglades proper….

As the botanist approaches the coast of the Bay of Florida, where the railroad leaves the mainland for the Florida keys, the red-mangrove trees become larger and more closely set together until when the shore is reached they form a continuous fringe along the coast.

…Here [in the coastal prairie] it [mangrove] is surrounded with the saw-grass and other grasses that form a close sod or compact root system, the mangrove is finally suppressed, when the prairie vegetation becomes absolutely dominant.

…Some of the hammocks scattered over the prairie have such component species as tall palmettos, *Sabal palmetto* (Walt.) R. & S., waxberry, *Cerothamnus (Myrica) ceriferus* (L.) Small. At the southern end of the prairie, the surface is intersected by channels of water and the prairie islands are replaced by mangrove-covered islands

….the coast prairies occupy the marl soil, the pineland and the saw-palmetto [occupy] the drier rough oolitic limestone, and the hammock is developed in a soil rich in organic matter.

6. The following quote is from an offering to investors and developers for lands located in Township 5?S and Range 35E designated as "Paradise Prairie". This area was not developed but was eventually included in Everglades National Park.

The poor, sandy soil of Florida ends about latitude 26^{o}; the limerock lands end at the south line of Township 58. From there to the end of the peninsula the soil is a loamy marl, or a rich black muck [mangrove peat]. Paradise Prairie has a large body of both marl and muck land. The depth of marl on the prairie varies from six inches to two feet: the depth of muck is often as much as ten feet. The muck land is not much above mean high tide in the Gulf, and requires drainage before it can be cultivated. (Dewhurst, 1927)

7. Botanist adventurer J. K. Small conducted several surveys of the vegetation of the Everglades Keys in addition to venturing into the surrounding marsh on occasion. Below is a collection of his observations regarding the Perrine Marl landscape.

After leaving the Everglade Keys near Royal Palm Hammock, Dade County, and traveling a few miles toward the southwest, isolated, scrawny cypress trees appear in the landscape. The dwarf cypress trees and the white or pale-gray bark of their trunks and branches attract the attention of everyone passing along the trail toward Cape Sable, which lies about fifty miles further to the southwest…

These pygmy cypress forests have the aspect of great age. The trees evidently have a very slow growth. After nearly thirty years of observations in various parts of this swamp no changes in the gross aspect or size of trees anywhere have been noticed. (Small, 1934)

The area occupied by the cypress growth in question is an immense limestone reef so gently undulating that the differences in elevation can be noticed by the layman only when the surface is partly flooded or by the botanist when he observes the types of vegetation.

The rock foundation is covered primarily by a thin layer of marl. A little field experience will enable one to judge the thickness of the marl-stratum by the growth of the cypress trees. However, the growth is not wholly regulated by the mere thickness of the marl. There is a certain system of relativity operating through the amount of organic plant-food that has become incorporated in the marl. (Small, 1934)

Where the marl is very thin there are forests of thousands of trees of this peculiar form of the pond-cypress varying from a foot to six or eight feet tall. The trees may be scattered or closely set together. They form a second story of vegetation, but the first story is a scanty growth mainly of grasses and sedges. Where the marl is slightly deeper, the first story of vegetation is more vigorous. Here it is augmented by and made more conspicuous by additional flowering herbaceous plants ... This part of the Everglades, like most of the southern half of this vast savannah, is dotted with thousands of hammock islands. These islands represent the only spots in the Everglades that have not been seriously fireswept in prehistoric and historic times. Contrary to the popular opinion, they are not necessarily low spots. Theses are more frequently circular or irregular elevations of deeply eroded rock, often with a kind of moat which, together with the usually wet or moist accumulated humus in erosion holes and a consequent vigorous growth of broad-leaved shrubs and trees, served to stop the prairie fires that swept the Everglades through the ages. The fires as a result of lightning and aboriginal methods of civilization were evidently not so frequent as those resulting from careless use of fire and vandal incendiarisms following the white-man's occupation, for many hundreds of these picturesque hammocks have been rapidly and completely wiped off the fade of the Everglades within the past score of years. (Small, 1934)

Here is a hammock island of broad-leaved trees- pigeon-plums (*Coccolobis*), mastic (*Sideroxylon*), coco-plum (*Chrysobalanus*), dahoon-holly (*Ilex*), myrsine (*Rapanea*), marl-berry (*Icacorea*), etc. There may be a cordon of saw-palmetto (*Serenoa*) around the edge of the hammock-growth, always tending to grow outward, thus making the entrance of fire more difficult. Then comes a cordon of cypress, the tallest coniferous growth in the cypress swamp, taller than the rest of the cypress growth because it has the moisture from the hammock and the moat around it to draw on. As the moisture away from the moat fails during dry spells, the cypress trees rapidly shrink to the lower growths ….

The prairie landscape of the Everglades embellished with the unique cypress growth of the hammock islands or with both, especially with the rising or the setting sun, is both unique and enchanting. A few more years of the white-man's incendiary mania and the landscape will be absolutely without relief. (Small, 1934)

8. Ecologist Roland Harper investigated the southern Everglades for the Florida State Geological Survey beginning in March of 1909. Conditions at this time were dry- reflecting several years of below average rainfall (**Figure 2.10**). Subsequent field investigations yielded a characterization of south Florida's resources documented in the Eighteenth Annual Report of the Florida State Geological Survey (Harper 1927).

After dinner we took a Sunday afternoon stroll into the coast prairie south of Paradise Key, to see how that compared with the Everglades to the north of us. The ground, as far as we went was so smooth and dry that there seemed to be nothing but lack of time to hinder us from walking all the way to the coast of Barnes Sound, about twelve miles away.

On passing around Paradise Key we came upon something which seemed rather unusual at that distance from the coast, namely, mangroves. The mangrove is sometimes a large tree, but these were bushes no higher than our heads. (Harper, 1910)

This has been confused with the Everglades by some writers, and its inland edge does not differ much from the southern edge of the Everglades; but the Everglades are never touched by salt water, and the mangrove and two species of cypress, which are common in the coast prairie, seem to be wanting in the Everglades, except at the extreme southern end, and there are various other differences. … The soil is everywhere a gray marl, mostly calcium carbonate, with rock near the surface at the inland edge, and some muck over it southward. (Harper, 1927)

The vegetation is quite diversified… At the inland edge it is mostly prairie with scattered clumps of trees, much like the transverse glades of the Miami pine land, and the southern edge of the Everglades. Going south or east from Florida City (formerly called Detroit) to where the influence of salt water becomes apparent, one soon comes to multitudes of red mangrove bushes, a few feet tall. These look vigorous and not at all stunted, and at first sight one might think they were young trees which would soon grow taller; but they and their ancestors have probably been there hundreds if not thousands of years, without ever growing any larger than they are now. A plant cannot live long without growing; so there must be something (perhaps fire?) that kills these mangrove bushes every few years and makes them start all over again. Nearer the coast the mangroves are larger, and where their roots are in salt water all the time they are medium-sized trees, as usual. (Harper, 1927)

Going southwestward from Royal Palm Hammock toward Cape Sable there is first a great deal of stunted pond cypress (*Taxodium imbricarium*) scattered through the prairie, and dense clumps of trees with large river cypresses (*Taxodium distichum*) can be seen offto the south, probably mostly along the course taken by the water discharged from the Everglades in the rainy season. (Harper, 1927)

.. here it [pond cypress] is in a soil of nearly pure calcium carbonate. It extends southward only a few miles from the pine land, and then for a similar distance there are no woody plants in the prairie except an occasional clump of shrubs and small trees, some of them containing among other things the rare palm *Paurotis Wrightii*. Then bushes of red mangrove and buttonwood and other salt-loving species appear, partly replacing the saw-grass. (Harper, 1927)

9. Although the following are from a more recent source, and consequently reflect a drainage impacted landscape, they are included to provide context for hindcasting, and in appreciation of the author's comprehensive knowledge of this landscape's character and driving forces.

> …it follows that more often than not the fires would get started at the inception of the dry season in fall. In this manner, the fires would skim over the surface, not damaging the water-covered roots. The fires would smack against a sense hammock, and stop, pronto. The hammock itself may be under water; the foliage would be turgid and fire-resistant. Then, at the end of the dry season, when the peat soil and the hammock trees actually could burn, then there was no sawgrass debris on the surface with which a fire could get started. It is only by this hypothesis that I can logically account for the wall-like abruptness of the S.E.S.E. hammocks, existing quite paradoxically as dryseason-burnable islands in a sea of burned vegetation which sea, without the burning, would quickly be invaded by those same hammock trees. (Egler, 1954. p. 227)

> With the inferred change from frequent early-dry-season light fires to infrequent late-dry-season severe fires, a new fire-equilibrium is coming into existence. The situation is markedly aggravated by the wholesale lowering of the water tables, brought about by well- pumping at Miami and by canal-draining elsewhere. …The lowered water table directly affects the vegetation. Such lowering is related in part to the canal-building in the northern Everglades which removes the water that used to sweep southward. It is related mainly to the canals in the immediate vicinity, which tend to drain off the surface water soon after it appears. Numerous wells affect the situation, as well as the construction of tide gates on some canals which prevent the inflow of high tidal waters. In general, the duration of summer flooding is much lessened, and the dry season is longer and more critical. The change toward xericism is apparent in some high inland parts of the Saline Glades, where during the eight years of observation, the quantity of upland grasses among the sawgrass has markedly increased, even though locally the trend may be reversed. (Egler, 1954. p.228)

> Belt 3 in general is a region of absolutely flat sawgrass swamp, dotted with impenetrable evergreen round hammocks that rise like cliffs from a sea. Each hammock has its tail, sometimes fragmented and appearing like isolated rocks from out of the waters. (Egler, 1954. p.233)

> Circular depressions and rises [in the level plain of Miami oolite] of approximately only 30 cms., and up to 150 m. or more in diameter, occur sporadically. On these depressions and rises are developed the hammocks. (Egler, 1954. p.234)

> The sawgrass swamp here described is on first glance a flat featureless plain, dominated completely by sawgrass itself, growing only one meter high. At a distance it appears to be very dense. On walking into such areas, it always turns out to be a thin stand with the living stalks occupying not more than ten percent of the surface at a height of 1 cm. It is in the interstices that one finds a large number of constantly occurring species, almost all small, and of no dominance in the community. (Egler, 1954. p.237)

> The entire area is seasonally flooded, usually from May or June, to November. During these times the marl is soft enough for one to sink in 10-20 cm. with each step. In winter, the marl is firm, and the bare interstices between the plants are usually covered with a dried algal crust. [periphyton]. (Egler, 1954. p.238)

Related Landscapes

Eastern Flatwoods

<u>General Description</u>

This landscape bordered the eastern side of the Everglades, from Lake Okeechobee south to approximately the New River (**Plate 13**). The Eastern Flatwoods occupied a sandy shelf, from

5 to 25 miles wide, between the Everglades and the narrow, slightly elevated Atlantic Coastal Ridge. Particularly in Broward County, the separation between the Eastern Flatwoods and the At1antic Coastal Ridge was indistinct.

Although now often referred to as "pine flatwoods," pines (primarily the slash pine, *pinus elliotii*) were originally only one of the many components of this varied landscape. Before drainage, the Eastern Flatwoods was a mosaic of upland plants such as palmettoes (*sabal palmetto*), mixed grasses and hardwood hammocks, as well as water-loving and water-tolerant plant communities such as wet prairies, marshes, ponds, open pinelands, and cypress domes or strands. Slight local elevated areas and depressions, combined with plentiful surface water, created the diversity within this otherwise generally flat landscape (**Figure 4.27**).

The wet prairies scattered throughout the Eastern Flatwoods (and analogous Western Flatwoods) were abundant. In contrast with the wet prairies reported within the post-drainage Everglades after about 1940, open areas within the Flatwoods supported wet prairies that were originally present in predrainage South Florida. They were sand-based, seasonal wetlands with characteristic plant species, often including a shrub, sand cypress, *Hypericum fasciculatum*, along with some combination of maiden cane, *Panicum hemitomon*, spike rush, *Eleocharis* spp., and beak-rush, *Rhynchospora* spp. Austin (1976) notes that sand cypress (also called Marsh St. John's Wort), not cypress trees, *Taxodium* spp., gave wet prairies the historical common name of "cypress bottoms."

The confusing application of the same term, wet prairie, to the peat-based areas of maidencane, spikerush, and beakrush found growing in former sloughs of the Everglades began only after drainage. Although some of the species overlap, the substrates are very different. The so-called wet prairies within the Everglades are an artifact of canal drainage, reflecting Everglades conditions that were sufficiently dry to resemble the shorter hydroperiods of the Flatwood wet prairies. (See also the hindcasting section of the Ridge and Slough landscape, this chapter.)

In addition to being a mosaic at the local scale, the Eastern Flatwoods varied regionally, differing somewhat between Palm Beach and Broward Counties (i.e., north and south of the Hillsboro Canal). In Palm Beach County, the landscape was wider, flatter, and dominated more by pines than by cypress. Cypress was present mostly in numerous, scattered cypress domes. A peripheral cypress swamp, running north to south, formed the western border with the Everglades in Palm Beach County (**Figure 2.6** and **Figure 2.7**). The following description from 1907 is from the southern portion of this strand, on the Township 47-48 border, Range 41:

> "Apr. 3. ... Where this line was run out from the pine timber, the pine is bordered by open scrub cypress, and small cypress heads; then there are strands of cypress and sawgrass which run out to the Glades, these strands being very thick and hard to get through. The cypress at one time has been continuous, but for some reason, probably fire, a great deal of it has died. The cypress island where we set the bench mark is in the edge of open Glades. The open Glades are flags, lillies, water grass and water." (Stewart 1907, p. 58).

On the eastern side, a 35-mile long, 1 to 2 mile wide fresh water marsh formed the border of the Eastern Flatwoods with the Atlantic Coastal Ridge. No name was found in the historic literature for this marsh. The label "freshwater ponds" (**Plate 13**) was adapted from a late 19th century map of Florida (N. America XIV Florida 1834).

Early accounts of the Eastern Flatwoods report plentiful game, including deer, bear, panther, and wading birds (Pierce 1970; Henshall 1884 [19911; Dupuis 1954a). The Corbett Wildlife Management Area is a remnant of this landscape, though this area is now almost certainly drier than under pre-drainage conditions. Lamar Johnson, who began observing the Everglades in the 1920s, suggests that the Eastern Flatwoods, rather than the Everglades, may have been the primary habitat for deer:

> "The recurring emotional problem of the deer herd in the Everglades is a case in point. Few remember that the slough and sawgrass Everglades is not the natural habitat of the deer. A half century ago [i.e., the 1920s] a deer track could not be found beyond the cypress and wet prairie margins of the Everglades. The deer only went into the deep Everglades as a result of the press of civilization and increased hunting. I know from personal observation that there were no deer deep in the Everglades forty-five or fifty years ago [1920s]." (Johnson 1974, p. 183).

South of Cypress Creek in Broward County, the Eastern Flatwoods and the Atlantic Coastal Ridge intergraded as the ridge became wider and lower. Further south, combined upland areas of the flatwoods and ridge became sufficiently dissected by the Peat Transverse Glades to form an archipelago of isolated, high-ground islands (**Plate 37, Plate 35,** and **Plate 38**).

Hydrology

The Eastern Flatwoods were only slightly elevated above the Everglades (**Figure 4.1**). When water levels rose, there were times when the Everglades and the Flatwoods were connected continuously by water. According to George W. Potter, president of the Dade County Bank, even as late as 1907 it was sometimes possible to canoe directly from the Everglades into and across the Eastern Flatwoods:

> "West of Palm Beach, there is a ridge near edge of Glades, but at high water Glades water comes over into Clear Lake and the Indians bring their canoes into Clear Lake." (Stewart 1907, p. 44).

Fifty years earlier, Ives (1856) also described a navigable trail across the Flatwoods, most likely south of the Clear Lake trail:

> Westward, a trail runs from the village [Chachi's Village, which is thought to have been located near Dreher Park, between Southern Boulevard and Summit Boulevard in West Palm Beach] to the swamp bordering the Everglades, the eastern boundary of the former being about seven miles distant. ... There were indications that it had been frequently traversed in boats during high water.

The proximity of pre-drainage Everglades water levels to the Eastern Flatwoods land surface was recognized by early settlers as a drainage issue. Stewart (1907) notes that some of those opposed to large scale drainage of the Everglades did however favor lowering of the water sufficiently "to prevent the flooding of the coast." (Stewart 1907, p. 51, 56).

Natural surface water drainage of the Palm Beach County portion of the Eastern Flatwoods was poor. The Loxahatchee Slough, draining into the Everglades as well as into the North Fork of the Jupiter (now Loxahatchee) River, may have provided some local drainage. The coastal freshwater ponds, possibly draining into the north prong of the Hillsboro River (Williams 1870-T47 R43), functioned as a collector along the eastern edge of the Palm Beach County portion of the landscape. Other than the Jupiter River, no coastal rivers were present. Groundwater flow would have had a major contribution to the water budget in this area.

In contrast, natural surface water drainage in the southern portion of the Eastern Flatwoods (i.e., Broward County) was very evident, extending eastward from the Everglades through to the Atlantic Coast. (See also the Atlantic Coastal Ridge landscape.) Pines were less prevalent than in Palm Beach County. The landscape in Broward County was instead dominated by directional cypress strands following the eastward drainage from the Everglades (**Plate 36**).

Patches of wet prairie and pineland were scattered throughout the cypress strands. These strands drained water from the Everglades into the numerous rivers piercing the coastal ridge: Hillsboro Creek, Hillsboro River, Cypress Creek, the north and south forks of the Middle River, and the north and south forks of the New River (**Figure 2.6** and **Figure 2.7**). The eastward drainage through these bordering uplands is reflected in the eastward and southeastward flow arrows visible in **Figure 5.1 and Figure 5.2** in the adjacent areas of the Everglades (Townships 48-49, Range 40-41). Together with the Peat Transverse Glades further south, the cypress strands and associated coastal rivers discharging into the Atlantic Ocean formed an important part of the natural eastern outflow of waters from the Everglades.

The topographic variability formerly present in this landscape makes it difficult to specify average water depths and hydroperiods that could apply to the whole landscape. We used two soil groups associated with the Eastward Flatwoods, the Wet Sands and Upland Sands (**Appendix K**), to partially capture the variations that were formerly present. Long-term average water depths for the Wet Sands typically ranged from 1 to 2 feet above ground (average annual high) to 1 to 2 feet below ground (average annual low), with a hydroperiod of 5 to 6 months. Analogous values for the Upland Sands found within the Eastern Flatwoods area were 0 to 1 foot above ground to 2 to 3 feet below ground, with a hydroperiod of 0 to 2 months.

Much of the Eastern Flatwoods landscape has been converted to housing developments or agricultural fields. The landscape has been strongly influenced by the man-made drainage associated with these activities. Extensive drainage, beginning in 1915, has lowered water tables about six feet (Thomas 1974; Mock, Roos & Associates 1990). In its present drained state, it is hard to imagine that this landscape was once so wet that it was navigable from the Jupiter Inlet to the Hillsboro Inlet and that, in the rainy season, canoes could regularly pass from the Atlantic coast west to the Everglades (Ives 1856, Pierce 1970).

Hindcasting

The pre-drainage extent of the Eastern Flatwoods was determined primarily by the pre-drainage extent of the bordering Sawgrass Plains and Ridge and Slough landscapes. The eastern border with the Atlantic Coastal Ridge was not delineated precisely for this study, but this could easily be drawn from the Township survey plat maps. The southern border of the landscape, where it intergrades with the Atlantic Coastal Ridge landscape, is somewhat indeterminate. Based on Sanford (1913), we included the area southward to the New River.

Eastern Flatwoods Endnotes

1. In a chapter entitled, “Observations on the soil and its natural growth,” Vignoles (1823) included an insightful classification of Florida into 12 “qualities of land” (plant communities). Four of Vignoles’ categories--flat pine lands, cypress swamps, cypress galls, and bay galls--reflect the wet mosaic of ponds, streams, and swamps formerly present in the Eastern Flatwoods:

   > “The *flat pine lands* are of themselves of two kinds: ... the [second] kind has little or no undergrowth: being thickly covered with savannas and cypress ponds and galls, it is overflown from them and on the least fall of rain becomes drowned; the herbage however is generally plentiful. ... a great number of branches and runs of water take their rise among these low grounds; and wherever these low pine lands are found they may be considered as the head of some river or creek. ...
   >
   > *Cypress swamps* are mostly near the head of rivers, and in a continued state of inundation; little or no underbrush, but only crowds of the cypress shoots or knees, which point up like small pyramids. ...
   >
   > While we are on the subject of wooded low lands, it may be observed that, in the pinelands, the early courses of the creeks and streams are through two sorts of channels, bay galls and cypress galls. The bay galls are spongy, boggy, and treacherous to the foot, with a coat of matted vegetable fibres: the loblolly bays spread their roots, and the saw palmetto crawls on the ground, making them altogether unpleasant and even dangerous to cross: the water in these bay galls is strongly impregnated with pyroligneous acid. The cypress galls have firm sandy bottoms, and are only troublesome from the multitude of the sprouting knees.” (Vignoles 1823 [1977], p.87-91).

   Loblolly bay, *Gordonia lasianthus*, though frequent in bayheads and swamps further north in Florida (Wunderlin 1982), did not occur in south Florida. Bay galls as a wetland type, however, were present in the pine flatwoods of south Florida; MacKay (1845)-T47 R42 and MacKay (1845)-T50 R42 each indicate several. The bay was likely red bay, *Persea borbonia*, and/or swamp bay, *Persea palustris*.

2. While surveying the Eastern Flatwoods near the head of the north fork of the New River (T 50 R 42, Section 6) in the beginning of April, 1845, U.S. Surveyor George Mackay included an unusually detailed description of the landscape as it appeared at the end of the dry season. At this western location close to the edge of the Everglades, pines were mostly replaced by a mixture of cypress, thickets, streams, and sawgrass prairies:

   > “Cypress clumps scattered in every direction to the North and West with dry grass prairie intervening far as the Eye can reach-- ...
   >
   > Started North to extend West Boundary of Township 49 S. R. 42 E.-- one mile of cocoa plum Willow + cypress+bay hammock to cypress and dry sawgrass mixed, which continued for two miles when it became so boggy as to render it almost impassable for one mile. We wound [?] through and came to a thick Cypress hammock for a few chains--which opened upon an old Indian field surrounded with a dry willow + cypress hammock in the midst of which a deep narrow stream of water hard bottom 4 feet deep-- followed down bank of stream 8 or 10 chains when it spread out and became lost in the hammock-- Returned I followed bank of stream West--until it spread out and became lost in a dry saw grass-- the water cool and sweet + current considerable-- considered ourselves within 1/2 mile of where line would x [cross] and turned North to the thickest cypress-briar[?]-palmetto-gum bay cocoa plum thicket ever man undertook to penetrate-- The further we progressed the worse it became-- Could not cover it-- had to back out-- when it began to rain and in torrents --covering the whole country with rain water-- ...
   >
   > Undertook to extend line South [from NW corner of T 50 R 42] but found it impassable from bay gall, cypress, + sawgrass being filled + softened [?] with rain-- might have off seted [?] thro' Ever Glades-- but having no provisions and being compelled to swim mules X [across] both branches of New River we were obliged to return East ... April 6” (Mackay 1845 - T50 R42).

3. MacKay makes an important observation regarding the connection between the Everglades and the headwaters of the New River. During the dry season, water flow out of the Everglades continued as during the wet season, but below, rather than above the ground surface. MacKay's comment (above) of "being compelled to swim mules X [across] both branches of New River" suggests that this below ground flow at the headwaters was sufficient to maintain considerable flow downstream:

   > "... The head of this branch [i.e., North Fork of the New River] can be passed dry shod-- The water that passes is filtered-- ...
   >
   > It would appear from observation, in dry season that there is no direct communication with the streams that flow to the sea-- Their waters are filtered thro' the edge or rim of the Ever Glades-- and here by following the several courses of this rim, I have no doubt but that a road may be constructed--"(Mackay 1845 - T50 R42).

4. In 1847, S. R. Mallory, who explored southeast Florida for many years, wrote the following to Buckingham Smith regarding the Eastern Flatwoods area in the vicinity of the New River. Along with saw palmetto and coontie, Mallory, like Vignoles in 1823, found a mosaic of pine woods, seasonal ponds, streams, and cypress swamps:

   > "The woods and streams abound with game and fish, frost is rarely seen, the coomty grows profusely, and its preparation is a bagatelle. ... The pine woods are covered with the saw palmetto, and contain many ponds, low grounds, in which the water during the wet season collects. ... The land in the cypress swamps here appears to be neither rich nor deep, being apparently but pure silex with an admixture of [organic] sediment." (Mallory, 1847, in Senate Doc. 89, 1911, p.63).

   The reference to "pure silex" (i.e., to a clean sand bottom) in the cypress swamps is noteworthy. Ordinarily, the water levels and hydroperiods associated with cypress growth would have led to the accumulation of organic soil on top of the sand. We hypothesize that the observed absence of organic soil reflects a scouring effect of eastward flow through the cypress swamps. Most of the time, flow rates would have been too low for such transport, but occasional high flow events could have periodically flushed out any accumulated organic material.

5. William Cooley, long-time resident along the New River, gives a description of the dry season connection between the Everglades and the headwaters of the New River almost identical to that of MacKay (1845)-T50 R42. Downstream, the river continued flowing, but the upper reaches apparently disappeared below ground:

   > "... all the branches [of the New River] communicate with the Everglades; but during a dry time they are all dry except the south prong ([Footnote] 1).
   >
   > ([Footnote] 1):That is dry at the heads where they come out of the Everglades." (Cooley, 1851, in Knetsch 1989).

6. In 1856, topographic engineer J. C. Ives published a detailed map and memoir describing South Florida. Based on field notes from military expeditions, particularly that of Captain Wade in December 1841, Ives described two inland navigation routes from Fort Jupiter to Fort Lauderdale. Through comparison with landscape features shown on Township plat maps made a few years later, Ives' account of this portion of the Eastern Flatwoods was found to be very accurate. The better known of the two boat routes passed through Lake Worth (on earlier maps, e.g., Vignoles 1823; Williams 1837), Lake Worth was known as "Fresh Water Lake") and in the 1890s was expanded into the present Intracoastal Waterway (Griswold 1898, p. 56).

   The second route, several miles further inland, passed west of the Atlantic Coastal Ridge (**Figure 2.6**), following a long, narrow marsh that extended continuously north to south for 35 miles, from Township 41 to Township 47. This marsh ("Long Marsh") occupied a 1 to 2 mile wide shallow depression between two long, narrow pine barrens: the Atlantic Coastal Ridge to the east and a second, lesser ridge to the west. The Atlantic Coastal Ridge was vegetated primarily with sand pine (formerly called spruce pine), *Pinus clausa*; the western ridge primarily with slash pine, *Pinus elliottii*:

   > "An extensive sawgrass pond or marsh extends from this place [headwaters of Lake Worth Creek, about three miles south of the Jupiter [now the Loxahatchee River], twelve and a-half miles south, to Chachi's Village, which is a mile and a-half west of Lake Worth. Lagoons of deep water, covered with spatterdocks, are here and there to be met with. In many places, canoes have to be pushed and hauled, but at others the water expands into grassy lakes, a quarter of a mile in extent,

> and generally from one to two miles apart. To the east can be seen a growth of spruce [pine] with some [slash] pines, and to the west, a line of cypress bordering the pine barren back of it.
>
> ... Leaving Chachi's Village, and travelling six miles a little east of south through the grassy lake, where the water continues about two feet in depth, the pine barren to the west is again encountered at a point where the lake makes into it for a short distance" (Ives 1856, p. 16-17).

Long Marsh is clearly recognizable as an area of "Freshwater Marsh" on the Davis (1943) vegetation map of South Florida, and as a low area of Everglades peats, Davie mucky fine sands and Arzell fine sands on the Jones et al. (1943) soil map. Township plat maps label this area as "Marsh" (Reyes 1858-T4 R43); "Inundated Marsh" (Williams 1872-T45 R43); and "Open Grass Pond" (Williams 1870-T46 R43). The present-day Congress Avenue runs through the middle of the former marsh in Townships 43 to 46. Township plat maps show a number of lakes within the marsh, most of which still remain, although altered by drainage and/or dredging: Lake Mangonia, Clear Lake (originally much smaller than Lake Mangonia), Lake Clarke, Lake Osborne, and Lake Webster (now drained.

7. At times water depths in the Long Marsh were high enough to consider it a lake, as indicated in the following reference to the southern end, in Township 46:

> "...patches of hammock are occasionally to be found on the main side [of the "Rio Seco," or Boca Raton Lagoon], but the chief growth [of this portion of the Atlantic Coastal Ridge] is pine; a mile or two west in the woods is the large lake which gives rise to Jupiter creek." (Vignoles 1823 [1977], p.48-49).

8. The wagon-road following the higher ground of the western pine barren formed the basis for the present-day road known as "Military Trail:"

> "A dry pine barren, more than a mile across, through which runs the wagon-road from Fort Jupiter to Fort Lauderdale, forms the boundary of the [grassy] lake. ... the wagon-road ... was opened many years ago. It follows the pine barren, which extends almost uninterruptedly, a few miles from the coast, from Fort Jupiter to Key Biscayne Bay." (Ives 1856, p. 17-18).

9. This wagon-road was likely passable only in the dry season, as even the ridge was inundated frequently enough in the wet season to be crossed regularly by an east to west boat trail to the Everglades:

> "Westward, a trail runs from [Cachi's Village] to the swamp bordering the Everglades, the eastern boundary of the former being about seven miles distant. Capt. Wade's command examined this trail [over the western pine barren ridge] at a time when the water was rather low [December 1841], and did not attempt to take the canoes over, as it would have been necessary to haul them a mile and a-half over perfectly dry and rather rough ground. There were indications that it had been frequently traversed in boats during high water." (Ives 1856, p. 17).

The exact location of Chachi's [Indian] Village was not determined, but it appears most likely to have been in Township 44, on the western edge of Lake Clarke. Less likely is a site near Lake Mangonia.

10. Another route explored by Capt. Wade's party in December 1841 extended northwest from Chachi's Village, crossing the western pine barren ridge into the flatwoods. Despite Ives' comment that "the water was rather low," the flatwoods still included numerous ponds deep enough for paddling large canoes. Like almost all military expeditions of the 1840s, Capt. Wade's expedition employed large dugout cypress canoes. The party of eighty men travelled in 17 canoes, thus 4 to 5 men per canoe, plus gear for several weeks:

> "Beyond this [pine barren] is a small pond, and an eighth of a mile further a string of them, deep enough to paddle in, and generally not more than forty feet apart. At the end of half a mile the water again overspreads the surface of the ground to the depth of two feet; dotted with small islands of cypress and pine." (Ives 1856, p. 17).

The area of small islands may be a portion of the Loxahatchee Slough.

11. The following paragraph from Capt. Wade's expedition describes an east to west transect through the Eastern Pine Flatwoods, likely near the middle of Township 45. The description suggests a region with a water table close enough to the surface that during the rainy season canoes could cross all the way west to the Everglades:

> Turning to the west [from a point 6 miles south of Chachi's Village], at the end of a mile of alternate water and dry land, a series of ponds is arrived at. When the water is high, canoes can

cross to the Everglades at this place without difficulty. At ordinary stages of the water, some of the haulovers between the ponds are three hundred feet across; others not more than forty or fifty, and the ponds themselves, at such times, too short to admit of canoes being paddled in them. The labor of hauling is excessive. Five miles beyond, there is a belt of cypress marsh, three hundred yards wide, with plenty of water, but requiring the constant use of an axe to clear a passage for canoes. An open space of a hundred yards then leads to a broad boat-trail through a thin cypress growth. This continues, four miles, to a kind of haulover, where the cypress trees are of large size, and there is no water at most seasons of the year. ... A mile beyond the haulover the Everglades commence." (Ives 1856, p. 17-18).

12. The plat map for Township 45, Range 42 gives a similar impression, showing numerous ponds. The map is labelled "Low open glades with ponds and scattering pine timber" (Williams 1872-T45 R42).

13. Six miles further west and south, the plat map for Township 46, Range 41 (Williams 1872-T46 R41) shows a north to south line marking the edge of the flatwoods with the "Cypress Swamp," and west of the cypress, a north to south label indicating "Everglades" (see also **Appendix B, Table B.1**). An "Indian Camp" labelled in Section 36, on the western edge of the flatwoods, marked the last area of drier ground before entering the Everglades basin.

14. The parents of Charles William Pierce were among the first settlers of the banks and islands of Lake Worth, arriving in 1872. Charles grew up exploring and hunting in what was then the "back country" west of Lake Worth and west of the freshwater ponds. References to ponds, islands, and the need for a boat in this account from approximately January 1879, all suggest plentiful surface water in this landscape:

"When Louie Bradley and I learned of the building of this boat for use on Lake Osborne, we at once commenced to plan hunting and exploring trips into the vast swamp surrounding the lake and to the unknown woods to the east.

Up to this time no one from the settlements on Lake Worth had crossed this swamp to the woods beyond, nor had anyone explored any part of this great morass since no one had a boat in those waters and its exploration was quite impossible without one. ...

... we found a creek near the south end of the lake [Lake Osborne] that led off in a westerly direction into the open marsh to the west. We could see that the way to the distant woods farther west was open to us by this creek route...

...it became evident that more time [than one-day trips] was absolutely necessary if we were ever to reach those very mysterious woods. ...we obtained Merkel's consent to use his boat for two days...

It was the first of spring and herons were in full plume so we loaded our guns... At the edge of the woods our boat was stopped by thick grass so we started wading towards the pines a short distance beyond. As we passed near a very small island, a deer jumped out and ran for the timber. ... At the edge of the woods we looked to the northward and saw three large bucks feeding in a shallow pond... we sneaked along until we had a large island between us and the deer... (Pierce 1970, p. 100-101).

15. Part of the appeal of the following campsite likely reflects the scarcity of dry sites in much of the Eastern Flatwoods:

I had noticed a high piece of ground on an island [most probably in Lake Osborne (SE 1/4 of Sec 5, T 45, R 43; Richards 1918-T45 R43), or in a pond on the western half of the border between Secs 18 and 19, T 45, R 43; Williams 1872-T45 R43)] on our way across the lake, and we decided to investigate it. ... The top of the hill was quite open with only a few scattered small scrub oaks. The ground was covered with a nice carpet of pine straw. Some very large spruce [pines (= sand pines, *Pinus clausa*)] were growing over the top of the hill, and nearby to the north we found plenty of good lightwood ["Lightwood, or lighter wood, was the very heavy heartwood of the yellow pine. It was rich in oils and would light instantly, wet or dry, when cut into kindling. It was this ability that gave it its name..." (Gilbert L. Voss in Pierce 1970)] for the campfire. This spot was so much better than any other found later that we made it our regular camp for many years." (Pierce 1970, p. 102).

16. Samuel Sanford, a geologist and experienced observer of South Florida before and around 1910, noted the sands and rock of the Flatwoods, and their role in defining the eastern boundary of the Everglades:

> "... inconspicuous outcrops of [Palm Beach] limestone [are] sparsely scattered through the pineland, cypress swamp, and prairie along the eastern side of the Everglades, from Delray northward. ...the exposures are all low, consisting of mere heads of rock projecting a few inches to a foot above the surrounding sands... From the low relief of the pinelands and the monotonous flatness of the ground, it can not be said of the Palm Beach limestone that it contributes to the physiography of the country. It helps, however, to define the eastern boundary of the Everglades for possibly 30 miles." (Sanford in Matson and Sanford 1913, p. 175-177).

17. In a chapter on the geography of South Florida, Sanford divided the Eastern Flatwoods into "Rolling sand plains" and "Flatlands," but also noted that they merged imperceptibly. This division is somewhat different than ours, as Sanford's Rolling Sand Plains included the pine barren forming the Atlantic Coastal Ridge, as well as two elements which we include in the Eastern Flatwoods: Freshwater ponds and the slight ridge just west of the marsh:

> "ROLLING SAND PLAINS
>
> By rolling sand plains is here meant sandy stretches of the mainland undulating in broad swales and low ridges. In the swales are shallow lakes or lagoons, wet prairies, or cypress swamps ...these sand plains form a belt that extends, with a maximum width of 6 miles, from the north side of Palm Beach County nearly to the Miami River. Out of this belt rise most of the dune mounds and ridges [i.e., the Atlantic Coastal Ridge]. Inland the rolling sand plains merge imperceptibly into the monotonous level of the flatlands and the prairies bordering the Everglades...
>
> Near the shore on the east coast the higher ground and the ridges of the sand plains are in many places covered with a straggling growth of spruce pine [i.e., the Atlantic Coastal Ridge].

18. Sanford describes the coastal freshwater ponds as follows:

> In the hollows [of the Rolling Sand Plains] are many fresh-water lakes, some several miles long [Lake Mangonia, Lake Clarke, Lake Osborne, etc.]. Most of these are less than 10 feet deep, and some are so shallow that they disappear entirely for months during a period of deficient rainfall such as prevailed from November, 1906, to May, 1908. ...the lakes, as a rule, are so shallow and the slopes of their banks so gentle that a survey of the rolling sand-plain country made in or shortly after a summer of normal rainfall would show vastly different relations of land and water from one made in early spring following a year of deficient precipitation. ... (Sanford in Matson and Sanford 1913, p. 49-50).

19. In Palm Beach County, the ridges apparently generated enough flow to support small springs:

> "There are a few springs of no particular importance along the shores of lagoons [in Palm Beach County]. Most are of small flow." (Sanford in Matson and Sanford 1913, p. 382).

Much of the drainage of the Eastern Flatwoods must have been groundwater seepage into the Everglades to the west and into Freshwater ponds to the east.

20. The Flatlands category of Sanford form the bulk of the Eastern Flatwoods landscape. Here variations of a foot in elevation were sufficient to create a mosaic of open pine woods, wet prairies, ponds, and cypress:

> "FLATLANDS
>
> The term 'flatlands' is applied to the imperfectly drained pinelands lying between the rolling sand plains and the Everglades or their bordering prairies and forming a discontinuous strip of country which ... extends from the north side of Palm Beach County to the vicinity of New River, in Dade County [Broward County had not yet been created].
>
> The flatlands have a soil of light-gray sand, resembling that of the rolling sand plains, and bear a thin growth of pine trees separated by expanses of prairie a mile or more wide, a difference of a foot in elevation determining the character of the vegetation. In the rainy season these prairies are shallow lakes. In the flatlands lie also exceptional sloughs or pond holes, some of which are a fourth of a mile or more across, and which, being 3 to 5 feet below the general level of the country, are never entirely dry. In places these deeper hollows support good growths of cypress, and as the region of relatively permanent standing water, the Everglades, is approached the pine and cypress

> growths intermingle in most irregular fashion. In some places pines grow up to the edge of the prairie bordering the Everglades; in others a fringe of dwarf cypress separates pineland and swamp; and in still others considerable areas support good growths of cypress." (Sanford in Matson and Sanford 1913, p.50).

The "exceptional sloughs ... 3 to 5 feet below the general [ground] level ... supporting good growths of cypress" probably correspond to the directional cypress strands draining water from the Everglades to the upper reaches of coastal rivers: Hillsboro Creek, Hillsboro River, Cypress Creek, the north and south forks of the Middle River, and the north and south forks of the New River. The "considerable areas of good growths of cypress" bordering the Everglades are the north to south bands of cypress shown on Harshberger (1913) (**Figure 2.7**).

21. The Lake Worth Drainage District was created in 1915 to drain the majority of the Eastern Flatwoods in Palm Beach County: Ranges 42 and 43, from Township 43 south through Township 47. The drainage canals were laid out on a regular grid, with north to south equalizing canals every three miles and east to west lateral canals every half mile. The notable exception to this regular grid is the easternmost equalizing canal, which follows an irregular route corresponding to the former course of a string of freshwater ponds (Lake Worth Drainage District 1939). The system of 50 lateral canals and 4 equalizing canals rapidly lowered the water table about six feet in a large portion of the Eastern Flatwoods. This drastic lowering of the water table initiated the secondary succession which has replaced wet prairies with pine flatwoods.

22. Harper (1927), in his characterization of the Natural Resources of Southern Florida, described the wet prairies as seasonal, sand-bottomed ponds, with plant species that vary, depending on distance from the center of the pond (i.e., on hydropattern):

> "Scattered throughout the flatwoods and prairies, ... are innumerable shallow approximately circular depressions, varying in extent from one to many acres, which may hold a foot or two of water in wet weather, and become entirely dry in spring. Occasionally they are full of cypress trees, constituting the cypress ponds (described farther on); but more frequently they have a few other trees, scattered shrubs, or nothing but herbs. When treeless they are sometimes called 'sand soaks.'
>
> The soil is nearly always sandy, but there may be limestone or marl not far from the surface, and a little muck in the deeper portions.
>
> The vegetation of the treeless depressions varies considerably with the depth and permanence of the water, and tends to be arranged in concentric zones, so that it is difficult to make a satisfactory quantitative study of it. ...
>
> ...*Hypericum fasciculatum*, sometimes known as 'sand myrtle,' or 'guinea cypress,' is especially characteristic of this habitat, and is more abundant than all the other woody plants combined." (Harper 1927, p.114-115).

23. Two soil scientists studying the vegetation and the genesis of the organic soils of the northern Everglades in the 1930s felt that lowered water levels had promoted the spread of dwarf cypress from the Eastern Flatwoods into the Everglades:

> "Large bodies of bald cypress are found dominant along the eastern and western border and sandy ridge sections of the Everglades. Usually these are not continuous but alternate with deciduous, broadleaved, tree hammocks and together they are encroaching upon the sawgrass vegetation. The early cypress trees that have invaded the fibrous peat of the outer borders are low, spreading and dwarfed." (Allison and Dachnowski-Stokes 1932, p.229).

Allison and Dachnowski-Stokes were probably mistaken in their interpretation of the dwarf cypress as a drainage-induced effect.

24. Township surveys conducted well before and just after initiation of major drainage both indicate the presence of dwarf, or "scrub cypress" along the border between the Everglades and the Eastern Flatwoods:

> "First Mile West, Between Secs [T49 R41] 36 and [T50 R41] 1: The line lays in open prairie land - flat and boggy - water generally over it - Cypress heads on either hand which are sometimes dense + thick - and often scrub cypress flats - The line is boggy..." (Ensey 1911-T50 R41).

See also **Appendix B, Table B.1** and **Appendix C, Tables C.1** and **Appendix C, Table C.3** for similar references to scrub cypress in Townships 46, 48 and 49 in Range 41.

25. The "Arzell complex" of soils mentioned below occurred along the border with the Everglades and in the large areas of directional cypress swamp in Broward County. The following comment by two soil scientists emphasizes the role of the Eastern Flatwoods as a slightly elevated border of the Everglades basin:

    "The Arzell complex is a mixture of Arzell, Plummer, Broward, and Portsmouth fine sands. [Note that all of these soil names are intermediate between those found in Baldwin and Hawker (1915) and those in Jones et al. (1948).] These soils are located in a slightly higher position than the Everglades and originally supported a growth of cypress trees." (Evans and Allison 1942, p.45).

26. Despite the confounding influences of drainage, cultivation, and urbanization, aerial photos taken in 1940 (USDA-SCS 1940**),** the Jones et al. (1948) soil map (**Plate 3),** and the Jones et al. (1948) vegetation map (**Plate 5**) all provide extremely useful information regarding the Eastern Flatwoods. At that time, there remained sufficient areas of native vegetation and organic soils, particularly in the lower-lying areas, to recognize regional patterns.

    North of the Hillsboro Canal, in Palm Beach County, the flatwoods appear to have been similar to the present-day Corbett Wildlife Area; a non-directional, random mosaic of wetter and drier areas. Cypress was present as circular cypress domes, irregular patches, and as extensives stands along the edge of the Everglades. The line of cypress once bordering the western edge of appears to have been harvested by the 1940s, likely by the nearby coastal communities.

    South of the Hillsboro Canal, in Broward County, the nature of the flatwoods was different: less pine and considerably more cypress was present, oriented in long, directional, east to west swamps or strands. These cypress strands narrowed to the east, terminating in coastal rivers: Hillsboro Creek, Hillsboro River, Cypress Creek, the north and south forks of the Middle River, and the north and south forks of the New River. The appearance, particularly visible on USDA-SCS (1940), is one of water from the Everglades flowing eastward into the cypress swamps, then concentrating into the coastal rivers.

    This eastward funnelling of water from a wide collection area along the border of the Everglades to narrower outlets into the coastal river--can be seen at several scales. At the regional scale, a hindcast map of pre-drainage vegetation communities (Steinberg 1980**; Plate 36**) shows the pattern clearly. At finer resolution, historical analysis of a number of 10 to 100 acre sites of protected vegetation in Broward County also suggest a pre-drainage pattern of east to west directional cypress swamps (Pennington et al. in preparation). Aerial photographs, Township survey field notes, soils maps, vegetation maps, on-site studies, and oral histories were used in these historical analyses.

27. Daniel Beard, in his reconnaissance study of the proposed Everglades National Park, also noted the eastward flow of a substantial portion of Everglades water. Beard described the presence of an eastern as well as a western watershed--before either the aerial photos (USDA-SCS 1940) or the Jones et al. (1948) soil maps were available to him-- which suggests that the combined outflow through the cypress swamps, coastal rivers and the Peat Transverse Glades must have once been considerable:

    "...Also, during the rainy season the Everglades were well wetted down and the water moved in a southerly direction. There were two main flows of this water through the Everglades - one to the southeast and the other to the southwest. The eastern flow broke through the slight ridge along the Atlantic in places such as the New River at Fort Lauderdale and Miami River at Miami. It also went through between the Everglades Keys and emptied into Biscayne Bay or Florida Bay.

    We see, then, that all the water in the Everglades drainage basin did not come through the proposed park, but the park got the bulk of the western flow and some of the eastern flow that went through the Everglades Keys (Taylor River from Paradise Key to Madeira Bay Section). Probably the flow through the park was not quite half of the total water in the basin, although this is just a guess." (Beard 1938, p. 46).

28. In a detailed botanical history of a portion of the Eastern Flatlands--the Pine Jog Environmental Sciences Center (SE 1/4 Sec 3, T44S, R42E)--Austin (1976) notes the drainage of the freshwater ponds, in the early 1920s, by the West Palm Beach Canal:

    "Before the Palm Beach Canal was opened water was high enough in Lake Clarke east of Pine Jog that Seminoles came along the marsh edge to a trading post near what is now Dreher Park (T.

T. Sturrock, personal communication). Enough water was removed when the canal opened that the Indians could not use their canoes on the old lake route." (Austin 1976, p. 231).

29. Regarding the Pine Jog area itself, four miles west of the freshwater ponds, Austin's conclusions are very similar to those of the present study: the Eastern Flatwoods was a distinctly wet landscape that has been significantly altered by drainage:

> "Data indicate that the entire Pine Jog region is undergoing secondary succession. All analyses show that the original vegetation was wet prairie, marsh and low hammock. Due to lowering of the water table by drainage, many of the wet prairies have changed to pine flatwoods." (Austin 1976, p. 230).

Atlantic Coastal Ridge and the Coastal Rivers

General Description

The highest ground east of the Everglades was (and is currently) known as the Atlantic Coastal Ridge. The topographic high of the ridge and some of the rivers remain at present, but almost all of the original vegetation has been lost as well as the low areas between islands of the ridge and the Peat Transverse Glades (see same landscape). As suggested by the name, the east edge of the ridge sloped down to the coastal beaches (or to the shore of Lake Worth). The ridge extended from the Jupiter inlet south to the Miami River where it merges with the Everglades Keys landscape. Based on the presence of sand pine (formerly called spruce pine, *Pinus clausa*) vegetation, the Atlantic Coastal Ridge was sometimes referred to as the Spruce Pine Barren. As the only area not subject to flooding, it was the first area to be settled around the turn of the century. Austin (1977) includes a good plant ecological study of this landscape.

The ridge includes two parts; a northern and a southern portion. The northern portion, extending south to the Hillsboro River (now Hillsboro Canal), and continuing south to Cypress Creek, formed (and forms) a single, distinct ridge, varying between one-half and one and a half miles wide. The west side of this northern portion of the ridge merged with the Eastern Flatwoods landscape. With the exception of the Hillsboro River, no coastal rivers crossed through this northern portion of the ridge.

In Broward County, the southern portion of the Atlantic Coastal Ridge was pierced by a number of coastal rivers and by the Peat Transverse Glades, forming a series of islands of high ground (**Plate 35**, **Plate 36, Plate 37** and **Plate 38**). The collection of islands formed a band about five or six miles wide. In this portion, the strip of Eastern Flatwoods was absent; here the Everglades bordered directly on the islands of the Atlantic Coastal Ridge.

Hydrology

Historical information about this landscape is consistent and clear (**Table 4.7**). Three aspects of this landscape are particularly relevant to estimating the hydrology of the pre-drainage Everglades: (1) the numerous short coastal rivers all originated in the Everglades; (2) currents in these rivers were strong. At least four sets of rapids or falls were present; several rivers were strong enough to drive water wheels; (3) the coastal rivers flowed throughout the year.

Table 4.7 Pre-drainage measured dimensions of the coastal rivers.

River	Width (feet)	Depth (feet)	Comments	Location	Date	Citation
Miami R., So. Fork	83		"running rapid"	W bd Sec 34	Apr 1845	MacKay 1845-T53 R41
Miami R., No. Fork	39	—	"channelled 9 ft deep thro' solid rock"	W bd Sec 34	Apr 1845	MacKay 1845- I T53 R41
Miami R.	198	--	--	W bd Sec 35	Apr 1845	MacKay 1845- T53 R41
Big Snake Creek	66	5	"Rio Rattones"	N bnd Sec 4	Apr 1845	MacKay 1845- T52 R42
Big Snake Creek	66	--	--	N bnd Sec 4	May 5 1870	Williams 1870-T52 R42
Big Snake Creek	176	--	--	N bnd Sec 9	May 12 1870	Williams 1870- T52 R42
Big Snake Creek	264	--	--	N bnd Sec 16	May 11 1870	Williams 1870- T52 R42
Little Snake Cr.	132	--		W bnd S 5	May 9 1870	Williams 1870- T52 R42
Little R.	--	2 - 6	"full of fish and alligators leisurely swimming"	W bnd S 7 T53 R42	1898- 1908	Dupuis 1954a
Little R.	66	--	--	W bnd S 7 T53 R42	Mar 1874	Williams 1874- T53 R42
Little R.	66	2.5	"4.00 x [exit] to small canal N.E. & S.W. race way to Coonty Mill 5 chains East belonging to a Mr. Mood [Wood?] 3.00 x to Little River rapids -- said to be 8 feet [drop?] in 1/2 mile. Water 2 1/2 feet deep 1.00 x River to hammock"	W bnd S 7, Course So.; T 53 R 42	Apr 18 1845	MacKay 1845- T53 R42
Arch Cr., No. Fork	99	20	"Just below arch. Water 20 feet deep"	N bd Sec 28	May 11 1870	Williams 1870-T52 R42
Arch Cr., So. Fork	132	--	--	W bd Sec 28	May 9 1870	Williams 1870- T52 R42
New River	--	[85]	"generally deep, but very deep in places, one spot having a depth of eighty-five feet"	T 50 R 42	ca. 1909	Gifford 1909, in Gifford 1911
New River	150	3 - 20	"This branch of New River is much like other rivers in Southeast Florida. About an average width of fifty yards, with perpernicular [sic] banks, green to the water's edge with a profusion of wild grasses and shrubs, and with a varying depth of from three to twenty feet . ... As we progressed the water became deeper and the current stronger."	T 50 R 42	ca. Feb 22 1882	Henshall 1883 in Reiger (1971)
North Fork New River	66	—	"North Branch of New River perpendicular rocky banks and 16 feet deep / x creek to pine + palmetto"	W bnd Sec 4 T 50 R 42	Apr 7 1845	MacKay 1845-T50 R42
South Fork New River	20	5	"North line Sec 30 [Course] W: 66.00 running water 5 feet deep 30 links wide C[urrent] NE"	N bnd Sec 30 T 50 R 42	Jun 20 1870	Williams (1870)-T50 R42
South Fork New River	--	--	"Here [at the end of the river] the water was pouring from the Everglades through a narrow channel and running so swiftly it taxed our strength to the utmost to paddle the old canoe through. When we reached the still water of the Glades we paused to eat."	W bnd Sec 19 or Sec 30, T 50 R 42 [est'd]	1870- 1880	Pierce (1970)

Pre-drainage photos of two of the coastal rivers, Arch Creek and Little Creek, are provided in **Figure 4.28** and **Figure 4.29.** The three points note above, made by different observers over numerous years, provide strong evidence that water depths in the pre-drainage

Everglades were sufficiently high, even at the end of the dry season, to maintain substantial year-round flow in the coastal rivers. Water tables in the Atlantic Coastal Ridge uplands were always below ground.

Hindcasting

The pre-drainage vegetation of the Atlantic Coastal Ridge has been almost completely lost to urban development, so present vegetation is in most places not helpful for determining the spatial extent of the landscape. Township survey maps, mostly from the 1870s, however, clearly delineate this landscape.

Atlantic Coastal Ridge Endnotes

1. Hernando Fontaneda was shipwrecked on the coast of south Florida in about 1545. His brief account of the approximately 17 years he lived with Indians of this area includes a description of the Miami River as "fifteen leagues" (between 35 and 70 miles) long:

   > "Toward the north the Martires [the Florida Keys] end near a place the Indians called Tequesta, situate[d] on the bank of a river which extends into the country the distance of fifteen leagues, and issues from another lake of fresh water, which is said by some Indians who have traversed it more than I, to be an arm of the Lake of Mayaimi [Lake Okeechobee]." (Fontaneda 1575 [1944], p.27).

   The actual length of the Miami River, from coast to the rapids at the edge of the Everglades, measured only four miles. Fontaneda's much longer length and his mention of a connection to Lake Okeechobee together suggest that he considered the elongated, directional sloughs of the Ridge and Slough landscape as extensions of the river. Apparently the flow through the Ridge and Slough landscape at that time was sufficient for the sloughs to have been perceived as a natural continuation of the Miami River.

2. In Fontaneda's time the coastal rivers were apparently of substantial size and biologically productive:

   > "I will also mention, that in the rivers of fresh water are infinite quantities of eels, very savory, and enormous trout. The eels are nearly the size of a man, thick as the thigh, and some of them are smaller." (Fontaneda 1575 [1944], p.27).

3. Charles Vignoles navigated the southeast coast of Florida in the early 1800s, documenting his explorations in a book and a map. With the exception of name changes on certain rivers, the detailed township surveys conducted in the 1870s closely corroborate his information. The channels of these rivers cut through the pinelands of the Eastern Flatwoods and Atlantic Coastal Ridge. West of these, the headwaters either extended directly into the Everglades or drained cypress swamps which in turn drained water from the Everglades:

   > "The Potomac river [Hillsborough River], as the few occasional visitors here have named it, is merely the head of Middle river [Cypress Creek], its course is through a pine country of good quality, heading in swamps and savannas, and connected with the Great Glade which will be described. ...
   >
   > ... [The] New river and all the branches discharging though its bar [i.e., the North and South Forks of the Middle River, and part of Cypress Creek] originate in the Great Glade, running through pine lands and heading in cypress swamps; which have previously been inundated from the Glade... (Vignoles 1823, p. 49).

   (The name "Potomac River" was also used by Williams (1837) for the Hillsborough River; later the Potomac name disappeared. The Middle River Vignoles refers to is actually one river north of the present Middle River; i.e., the present Cypress Creek.)

4. Vignoles apparently considered the possibility that the coastal rivers might be fed by local drainage from the uplands they traversed. He rejected this, concluding instead that although the rivers passed through the uplands, they derived their water from the Everglades:

   > ...On looking back over the preceding pages the reader must be struck with the reflection, that the sources from whence the various water courses of the Eastern coast of Florida originate, are not the pure springs of a hilly region, but a series of connected reservoirs, from whence exude in languid streams their vast collections of waters...” (Vignoles 1823, p. 51).

5. Although there was very little slope in the south Florida landscape, Vignoles observed forceful flow out of one of the coastal rivers:

   > “...the rush of water through this narrow channel [between the Boca Raton Lagoon and the Hillsboro River] is very great, the current driving with a velocity capable of giving motion to the largest [water] wheels, and upon it several saw-mills might work with advantage, should the Florida pitch pine which is abundantly supplied by the adjacent woods, ever become in sufficient demand as lumber.” (Vignoles 1823, p. 49)

6. John Williams also explored, mapped, and wrote about the geography of Florida. He describes all of the coastal rivers, apparently after exploring them, from Hobe Sound to the Miami River with the exception of Cypress Creek and the Little River:

   > “From the eastern coast to the everglades, the distance is short; I entered the borders of these [everglades].” (Williams 1837, p. iv)

   From his explorations, Williams drew the same conclusion as Vignoles; that the coastal rivers were fed directly by the Everglades:

   > “Indeed, there is little doubt that all the streams on this coast, up to Indian River, are drains from the Glades...” (Williams 1837, p. 50-51)

7. Williams’ descriptions of each of the rivers notes that the headwaters extend through the ridge and into the Everglades:

   > “Miame River is a small stream that issues out of the Glades and enters Sandwich Gulf [Biscayne Bay], behind Cape Florida. It is about six feet deep where it enters the gulf. The tide rises about 4 miles up in a rocky channel. It there forks, and the north branch descends from the Glades in a rapid current over a limestone rock....if cut through [the Miami River] would drain a vast extent of grass meadow, that appears to the eye quite boundless. There may be lagoons of great depth, but they cannot be extensive, as the waters, to appearance, are not more than, from two to four feet deep.
   >
   > The River of Rats, or Rattones [Snake Creek], is extremely similar to the Miame in its course. The tide, however, scarcely affects it, and falls over a plane less inclined than the Miame. A prong of this stream is connected with a branch of New River. ...
   >
   > Arch Creek is a considerable stream that enters the bay between these two rivers [Miami and Rio Rattones/Snake Creek]. It waters a rich tract of land [one of the hammocks shown on Williams ____-T52 R42].
   >
   > New River has a longer course than the Miame and Rat Rivers. The Glade here recedes farther from the coast. It has six feet water on the bar, and it may be navigated several miles into the country [i.e., into the Everglades].
   >
   > The Potomac [Hillsborough River] leaves the Glades about fifteen miles from the coast and enters Hillsborough Inlet, where it is joined by the waters of Bocca Rattones. (Williams 1837, p.50-51)

8. Like Vignoles, other observers found rapids at the heads of several coastal rivers, at the point where the rivers left the Everglades. A “Map of the seat of war in Florida” (MacKay and Blake 1839) indicates “Rapids” at the headwaters of Arch Creek and of two branches of the Rio Ratones (Snake Creek), and “Falls” at the head of the Miami River.

9. Lieut. C. R. P. Rodgers, a member of the U.S. Navy involved in the Second Seminole Wars, traveled through the Everglades and the Atlantic Coastal Ridge from about 1840 to 1842. The rapid and year-round flow of

water that he observed in the coastal rivers indicates that water was present in the adjacent Everglades throughout the year:

> "During my three years' service in Florida, I traversed in canoes the greater part of the Everglades, and became familiar with their peculiarities and character...
>
> The freshness of these rivers, the rapidity of their currents at all seasons, ... abundantly prove that the bottom of these Glades is considerably above the level of the sea." (Rodgers, 1848, in Senate Doc. 89, 1911, p.60-61)

10. A map of the State of Florida (U. S. Bureau of Topographical Engineers 1846) indicates "Rapids" at the head of Arch Creek and "Falls" at the head of the Miami River.

11. A. H. Jones surveyed numerous townships in southeast Florida in the 1840's, several years after Lieutenant Rodgers' travels. Like Rodgers, Jones notes that the water leaving the Everglades through the coastal rivers flowed continuously throughout the year, and with a strong current:

> "In reply to your letter of inquiry ... I have to state that two years' professional labor as a Government surveyor in the country bordering the Everglades upon the Atlantic side have rendered me well acquainted with its peculiar characteristics.
>
> The numerous rivers that have their rise in the Everglades have a strong and permanent current until they meet tidewater." (Jones, 1847, in Senate Doc. 89, 1911, p.61).

12. Like Fontaneda three centuries earlier, S. R. Mallory, an explorer of the Atlantic Coastal Ridge and the Everglades, noted plentiful fish in the coastal rivers: "The woods and streams abound with game and fish..." (Mallory, 1847, in Senate Doc. 89, 1911, p.63).

13. William Cooley, a settler on the banks of the New River for many years, explored the Everglades, the coastal rivers, and the Atlantic Coastal Ridge:

> "It is about 9 miles from the head of Biscayne Bay to New River by land, which is high pine barren covered with a growth of Counta [coontie]--" (Cooley, 1851, in Knetsch 1989, p.42)

14. The Atlantic Coastal Ridge extended as far south as Cape Florida (present Miami Beach):

> "I think there is a ridge about one mile wide between Cape Florida & New River that does not overflow -- this ridge runs the whole distance about 19 miles -- I think that about 3/4 of the lands between Cape Florida and New River are subject to occasional overflow --" (Cooley, 1851, in Knetsch 1989, p.41).

Cooley's statement that only the narrow ridge was exempt from flooding is consistent with Township surveys (**Plate 8).** Prior to drainage, water in the Everglades was high enough to extend within six miles (in some places even less) of the coast between Fort Lauderdale and Miami.

15. Cooley also explored the New River. Water depths sufficient for steamboats, all the way to the edge of the Everglades, suggests substantial outflow:

> "...we there ascended New River about 8 miles to the Everglades this section is good steam navigation--" (Cooley 1851, in Knetsch 1989, p.41).

16. Cooley confirms Vignoles' assertion that the various branches of the New River originated in the Everglades:

> "In 1826 with Col. Fitzpatrick we explored [the] new River and its branches into the Everglades at different points. New River divides itself into four branches or prongs -- the south prong, North west prong, North prong, and Snook Creek [the name "Snook Creek" was applied alternately to Middle River and to the North Fork of the New River (Knetsch 1989)] -- The south prong is the main channel of New River -- all the branches communicate with the Everglades; but during a dry time they are all dry except the south prong ([Footnote] 1). ... on New River lie Rich Hammock, Pine and Prairie land, which never overflow except occasionally during the Equinoxial Gales but then not enough to do any great damage to crops -- Counta [coontie] grows here in large quantities, and the land generally must be good because counta does not grow on Wet land ...
>
> ([Footnote] 1): That is dry at the heads where they come out of the Everglades." (Cooley, 1851, in Knetsch 1989, p. 41).

As noted in the Eastern Flatwoods landscape, there appears to have been a slight ridge where the heads of the coastal rivers met the Everglades. Surface water flowed over this ridge in the wet season; and apparently under the ridge as groundwater during dry times, thus maintaining downstream river flow throughout the year (see also MacKay 1845-T50 R42).

17. Coontie (*Zamia integrifolia*) was common in the Eastern Flatwoods, Everglades Keys, and Atlantic Coastal Ridge landscapes. Native Americans taught the early settlers how to extract a starch from the root, eventually leading to important coontie starch mills. In this account by Mrs. Rose Wagner Richards, presented in Dieterich (1987), early settlers found sufficient flow in Arch Creek to attempt to build a waterwheel-driven starch mill:

> "It was in the fall of the year, 1858, that Mr. George Lewis returned to Miami ... desirous of finding a good location on which to build a factory and engage in the manufacture of starch. Such a place he and Mr. Robert Fletcher... found on Arch Creek... The factory was built immediately on top of the arch. On the south side where a ditch was cut through the rock, can yet be seen, and where the water was made to flow through after the main passage beneath the arch had been closed up sufficient to cause the water to rise and flow through the ditch with such force as to turn the water wheel attached to the machinery used in the factory. A year or more of time was consumed by them at this place and not succeeding as well as they could have wished, the place was abandoned by them altogether." (Richards, 1903, in Dieterich 1987, p. 55).

18. Township plat maps by Marcellus Williams for Townships 45 south to Township 49 all clearly delineate the Atlantic Coastal Ridge, referring to it as "Spruce Pine Scrub" (Williams 1872-T45 R43), or simply as "Scrub" (Williams 1870-T46 R43; Williams 1870-T47 R43; Williams 1870-T48 R42; Williams 1870-T49 R42). The ridge is distinct and continuous from Township 43 south through Township 48, varying between one half and one and one half miles wide. Continuing further south, in Townships 49 through 52, the Atlantic Coastal Ridge becomes discontinuous, breaking up into a series of high ground islands, separated by the coastal rivers or the Peat Transverse Glades (**Plate 36** and **Plate 38**). Here the vegetation varied more; some islands were still labelled "scrub," while others were labelled "Hammock" or referred to in the field notes as pine land (Williams 1870-T49 R42; Williams 1870-T50 R42; Williams 1870-T51 R42; Williams 1870-T52 R42).

> North Line Sec 30 [Course W] ...
> 66 00 [chains W] running water 5 feet deep ... Marsh Water from 2 to 3 feet deep." (Williams 1870-T50 R42).

19. Field notes from the U.S. survey of the area near the headwaters of the New River, conducted June-July, 1870, indicate that the marshes and Peat Transverse Glades separating the islands of the Atlantic Coastal Ridge were quite wet:

> "West Line Sec 29 [Course] N ...
> All Marsh Water from 2 to 3 feet deep.
>
> North Line Sec 30 [Course W] ...
> 66 00 [chains W] running water 5 feet deep ... Marsh Water from 2 to 3 feet deep." (Williams 1870-T50 R42).

20. Charles Pierce grew up in the 1870s between the fifth "House of Refuge" on Cape Florida (present Miami Beach) and a house on Lake Worth, frequently going up and down the coast, by sailboat, on foot on the beach, or by canoe through the Everglades, between the New River and Snake Creek (Pierce 1970). The following description is from one of his trips up the New River:

> "Just at sundown we arrived at the end of the river. Here the water was pouring from the Everglades through a narrow channel and running so swiftly it taxed our strength to the utmost to paddle the old canoe through. When we reached the still water of the Glades we paused to eat. The extra exertion of pushing up against the rapids had sharpened our appetites to a painful point." (Pierce 1970, p.158)

21. The current in the coastal rivers was always rapid, but the following unusual account describes an exceptional event, witnessed from the fifth House of Refuge:

"In October 1884 occurred the greatest and longest rainfall known on the east coast since its earliest settlement. It poured for eight days and nights without stopping. The whole southern part of the state, with the exception of the higher land, was inundated. All hollows on the beach ridge east of Indian Creek were full of water.

On the night of the eighth day the rain stopped, and the next day came in bright and clear and the sun shone on a rain-soaked Florida. In the afternoon of that day, when I was on the porch looking out to sea, I caught the glint of something white about four miles to the north. At first I thought it was a sea gull, but when I looked through our old spyglass the flickering white appeared to be whitecaps at the head of a dark body of water rushing down the coast. In less than an hour it was passing the station; in the meantime I had called everyone to come and see the strange sight. A dark mass of fresh water, some hundred feet in width, was rushing along to the south with breaking seas overrunning the blue water in front. It was a strange sight and at first we all wondered where it came from. Father solved the mystery when he said that it was fresh water from New River Inlet. New River was fourteen miles away, yet there was no other solution of the phenomenon. What a mighty volume of water must have been coming out of the inlet, with tremendous velocity, enough to overcome the resistance of wind and sea for so many miles. By night of that day the entire ocean in sight of the station was covered with dark coffee-colored fresh water from New River. There was not a bit of blue water to be seen in any direction; in fact, Biscayne Bay was fresh for nearly a month after the week of rain." (Pierce 1970, p.187).

22. The following descriptions, from one of Pierce's plume hunting expeditions, give an impression of two of the smaller coastal rivers, and of the intermingling of the Atlantic Coastal Ridge and Eastern Flatwoods landscapes in this area:

"... We started one morning making our way up Hillsborough Creek. We had never been up this creek before and made slow time finding our way through the crooks and turns and shallow water at its upper end. We were near Cypress Creek when we had to stop because of shallow water.

We made camp in the pinewoods on the west side of the marsh, then hunted back in the swamps to the west. We could see many plume birds flying far to the west but could not locate their nesting places. ...

... We determined on a cruise up Snook Creek [the Middle River], so hurriedly ate our breakfast and departed [from the Hillsborough Creek area]. Late in the afternoon we were far upriver where it became a shallow narrow creek with bushes growing high and thick on either side and meeting overhead, preventing us from seeing any birds flying over. As night was now coming we had to find a place to camp. The shore was low and swampy, but I cut a trail through the scrub to a patch of ground that was comparitively dry, and we prepared to spend the night by clearing a space large enough for our tent and campfire. ...

While eating breakfast the next morning we decided we had better go home and give up the plume hunting business for this season." (p. 164-165)

Pierce's description of obvious declines in large game and birds suggests that wading birds ranges once extended far to the east, into the Eastern Flatwood and Atlantic Coastal Ridge landscapes.

23. Pierce ascribes this decline to hunting; as settlement increased in later years, drainage and loss of wetlands likely also played a role:

"When the first settlers came to the lake [Lake Worth] they found the woods fairly alive with game. Bears were plentiful in the beach hammock and deer could be found everywhere, as well as wildcats, coon and possum, and an occasional panther. Wild turkeys were also fairly numerous, as were ducks in the winter time; while every known species of heron, crane, curlew, snipe, plover, or, in fact, any other aquatic bird found in Florida could be seen feeding along the lake's shores. ...

Three or four years after the coming of the first settlers, change in the wildlife was apparent to even the casual observer. Bears were the first to leave their haunts in the beach hammock, but by 1886 hardly any deer, herons, or curlews could be found east of the freshwater ponds [see Eastern Flatwoods landscape]." (Pierce 1970, p.210-211).

24. Dr. James Henshall, a physician, fisherman, writer, and eventually member of the U.S. Fish Commission, explored the southeast coast of Florida by sailboat, on foot, and by canoe. Here he provides quantitative details regarding the New River, as seen during the dry season--about February 22, 1882:

    "This [South] branch of New River is much like other rivers in Southeast Florida. About an average width of fifty yards, with perpernicular [sic] banks, green to the water's edge with a profusion of wild grasses and shrubs, and with a varying depth of from three to twenty feet. ... As we progressed the water became deeper and the current stronger. The banks were clothed, usually with pines, with an occasional hamak [hammock] of palmetto, water oak, swamp maple, bay, Spanish ash and other timber." (Henshall, 1883, in Reiger 1971, p. 52-53).

25. Henshall's description of the New River headwaters, in the cypress at the edge of the Everglades, gives some idea of the vast quantities of water that must have been present in the Everglades to maintain such an outflow well into the dry season:

    "We soon reached the great cypress belt, through which the amber-colored stream poured silently and swiftly, though so clear that great masses of white, coralline rocks, seamed, fissured and lying in endless confusion, could be plainly seen at the bottom..." (Henshall, 1883, in Reiger 1971, p. 52-53).

26. Despite the only very slight slope from Everglades to the coast, flow in the New River was sufficient to double the upstream travel time:

    "...for we were quite tired after paddling upstream some six hours..."

    "Three hours of sailing, paddling and the swift current of New River took us [downstream] to the station landing..." (Henshall, 1883, in Reiger 1971, pp. 53 and 57).

27. Henshall considered the currents in the coastal rivers a significant deterrant to most intrusions into the Everglades:

    "Such a life [of the Indians on Pine Island] is not without its charms, shut out, as they are, from all the world by impenetrable cypress swamps, the only avenues to civilization being by way of the streams which drain the Everglades, the currents of which are so swift during high water that few attempt to ascend them to the Everglades, and still fewer succeed." (Henshall, 1883, in Reiger 1971, p. 55).

28. Henshall's observations of fish in the New River are consistent with Mallory's description, forty years earlier, of abundant fish:

    "Rushing in and out with the tide, at New River, fishes can be seen by thousands, snapping at anything, even a bit of white rag tied to a hook and thrown to them by a strong hand line. We took crevalle from ten to thirty pounds, always large ones here, never less than ten pounds. By anchoring a boat in mid-stream they can be speared or grained as they swim rapidly by, often pursued by sharks and porpoises ... The largest alligator we killed was here ... twelve feet in length. Alligators seem to be as much at home in salt water as in fresh." (Henshall, 1883, in Reiger 1971, p.52).

29. Also like Mallory and Pierce, Henshall found plentiful game on the Atlantic Coastal Ridge:

    "Among the pines on the west shore [of Lake Worth], and on the savannahs bordering the Everglades, deer are quite plentiful, while bears, panthers, and wild cats are common in the thickets and brakes." (Henshall 1884 [1991], p.60).

30. Ralph Middleton Munroe was approximately contemporaneous with Pierce and Henshall, settling in Coconut Grove in 1889. His photographs provide an important record of vegetation and natural features present before drainage (Parks 1977). Photographs of the Miami and Little Rivers, and of Arch Creek all suggest substantial outflow and current. Regarding the north fork of Arch Creek, where the shore suddenly became high banks of rock, Munroe's uncle, Alfred Munroe wrote:

    "the rapid currents had in many places carved into most fantastic shapes, with numerous caves showing lights and shadows that were perfectly fascinating to the eye." (Parks 1977, p. 54).

31. Gifford, a forester, described the vegetation and soil of the Atlantic Coastal Ridge, and its early use for growing pineapples:

"All along the East Coast of Florida there are dunes of snow-white sand covered with scrub pines and palmettoes. This fine, white, silicious sand, although naturally sterile, is excellent for the growth of pineapples in regions where there is sufficient warmth. Mile after mile of this sand along the line of the railroad between the Everglades and the sea is used in the cultivation of pineapples..." (Gifford 1911).

32. Gifford also described the New River after a visit in about 1909:

"We visited the New River from Fort Lauderdale. It was after a long period of heavy rains, and the mosquitoes were bad in the pine woods. We ascended the New River, a beautiful, winding stream, generally deep, but very deep in places, one spot having a depth of eighty-five feet. [This depth may or may not be depth of water; c.f. a later geologist's description: "The New River valley cuts through the coastal ridge between Dania and Fort Lauderdale. It is the widest and deepest of all the sand-filled Pleistocene cuts in southeastern Florida. The maximum depth to hard rock is about 100 feet." (Parker et al. 1955, p.169)] The banks were quite low and sandy and lined with moss-draped cypress, oak, maple, magnolia, coco-plum, pond-apple, etc. After a short ride we reached the beginning of the drainage work--one long canal ran northwestward, with the dredge Everglades, another due westward, with the dredge Okeechobee, at work." (Gifford, 1909, in Gifford 1911, p.8).

33. Samuel Sanford, a geologist, explored much of the Atlantic Coastal Ridge before 1910 as a route for Flagler's Florida East Coast Railroad:

"...these [rolling] sand plains form a belt that extends, with a maximum width of 6 miles, from the north side of Palm Beach County nearly to the Miami River. Out of this belt rise most of the dune mounds and ridges." (Sanford, in Matson and Sanford 1913, p. 49).

34. Like Cooley in the early 1800s, Sanford notes the narrowness of the ridge south of Township 48, where the Everglades still extended almost to the ocean:

"In the southern part of [Palm Beach] county [at this time Broward County did not yet exist; Palm Beach County extended south to the middle of Township 49, three miles south of Pompano] the Everglades extend almost to the ocean shore; further north the expanse of relatively dry land is much wider, but there are few settlements more than 10 miles from the railway along the coast." (Sanford, in Matson and Sanford 1913, p.381).

35. Sanford had heard of subterranean springs off the coast of Dade County [at this time Broward County did not yet exist; Dade County extended north to the middle of Township 49, three miles south of Pompano], north of Biscayne Bay, but he apparently had not seen them himself:

"There are said to be springs in the ocean bottom off Fort Lauderdale and elsewhere, but the evidence needs confirmation. The writer doubts the existence of large offshore springs anywhere along the coast of [Dade] county." (Sanford, in Matson and Sanford 1913, p. 289).

Sanford, usually a very reliable observer of the South Florida landscape, in this case likely underestimated the presence of offshore springs.

36. Kohout, who studied several submarine springs still present in Biscayne Bay in the 1960s (Kohout and Kolipinski 1967), suggests that such springs can easily be present, yet pass unnoticed:

"The occurrence of submarine springs is quite common and anyone who has visited the seashore may well have observed the phenomenon without realizing it. There is good reason for missing them -- submarine springs in many cases are quite obscure and not easily recognized. Indeed some are so imperceptible that one must resort to chemical analyses to be certain that his eyes have not deceived him." (Kohout 1966, p. 392).

37. Dr. John Harshberger, a phytogeographer, or what would now be called a landscape ecologist, studied the plant communities of South Florida during 1912-1914. Like numerous observers before him, he found a narrow Atlantic Coastal Ridge, bordered directly by the Everglades:

"The high ground of the east coast of Florida is a narrow strip between the ocean and the Everglades." (Harshberger 1914, p.53).

38. Harshberger gives a detailed plant list for the scrub community of the Atlantic Coastal Ridge, of which the most characteristic species were sand pine, shrub oaks, and branching rosemary:

> "Sand-Pine Formation (Rosemary Scrub)"
>
> "...the dominant tree of this region is the sand-pine or spruce pine, *Pinus clausa* (Engelm.) Vasey, not over 6 to 9 meters tall and with its stem in some localities, as at Palm Beach, inclined to the west, because of the prevailing east winds. ... The [shade] tolerant species that form the second story are several evergreen oaks which remain as shrubs and small trees beneath the shade of the pines. ...open places [in the forest] are characterized by the candelabra-like, branching rosemary, *Ceratiola ericoides* Michx., ... which with the pines is a character plant of these barrens, known locally as rosemary scrub." (Harshberger 1914, p.83-84).

The distinctive westward leaning trunks of the sand pines can still be seen in the few patches of scrub vegetation remaining on the coastal ridge.

39. Like many earlier observers, Harshberger found rapids and swift currents in the coastal rivers, and linked them to the Everglades:

> "In all streams flowing from the 'Glades on the eastern side are rapids, as the streams leave the big saw-grass marsh [the Everglades]. From the rapidity of current and the number of these rivers, it is evident that they have their source not in a spring, but in a great reservoir." (Harshberger 1914).

40. During a 1912 trip down the North New River Canal, Harshberger recorded the vegetation of the South Fork of the New River:

> "New River.--Here the cypress swamps blend with the river hammock vegetation where the cypress is common together with custard-apple, *Annona glabra* L., red-maple, *Acer rubrum* L., cocoa-plum, *Chrysobalanus icaco* L., with such lianas as *Smilax laurifolia* L., bullace-grape, *Muscadinia (Vitis) Munsoniana* (Simps.) Small. The tall palmetto trees support two characteristic epiphytic ferns, *Phlebodium aureum* (L.) R. Br. and *Vittaria lineata* (L.) J. E. Smith." (Harshberger 1914, p. 172).

41. Botanist J. K. Small (1914) travelled up the New River, noting upland woods followed by cypress, and a rapid current, at this time probably supplemented by flow from the North New River Canal:

> "...we started up New River [from Ft. Lauderdale] for the Everglades. In saying up, I merely mean against the current for the New River passes through a tortuous channel which covers all points of the compass within short distances. Its banks are lined with a succession of pinelands, hammocks, and weird cypress-swamps. ...
>
> That the Everglades are considerably above the level of the sea is at once realized by the rapidity of the current that flows through each canal." (Small 1914, p.71).

42. The archeologists Robert Carr and William Steele have studied Native American settlements and their relation to the landscape throughout South Florida. In a study of Chitto-Tustenugge (Snake Warrior) Island (Sec 25, T 51 R 41; see **Plate 40**), they note that even as late as 1917, after drainage had begun, the Everglades extended east to the Atlantic Coastal Ridge; Chitto-Tustenugge Island, just west of the ridge, was still known then as the "old Cuban Boat landing." (Carr and Steele 1991, p. 15). The archeologists particularly note the presence of a clearly recognizable edge, or border, between the forested Atlantic Coastal Ridge and the open Everglades:

> "In fact, the Everglades border in present day southern Broward and northern Dade County was quite distinctive prior to drainage. The elevated Atlantic Coastal Ridge presented a sharp contrast of pinewoods against the Everglades prairies and sawgrass that provided a visual reference for all early travelers." (Carr and Steele 1991, p. 9).

This border of the Everglades, particularly its location only six miles from the ocean, is difficult for present observers to imagine because drainage has artificially pushed the present border of the Everglades another 15 miles westward.

43. Vegetation changes along the New River provide an important indication of the formerly greater pre-drainage flows of this river. Prior to drainage, outflow kept the New River sufficiently fresh that mangroves were present only along the lowest reaches of the New River, in the "New River Sound" (Williams 1870-T50 R42),

south of Port Everglades (Sec 12, T 50, R 42). As water levels in the Everglades were lowered by drainage, fresh water outflow has been reduced such that salt water and accompanying mangroves now extend more than ••seven miles upstream (Carol Morgenstern, pers. comm.).

Peat Transverse Glades

The Peat Transverse Glades seem to have extended at close to the same elevation as that of the adjoining Ridge and Slough landscape. This is consistent with Buckingham Smith's description in 1847:

> "Inside the basin, near the heads of the rivers of the eastern coast, there are covers or indentations in the shore of the Glades about 2 miles in depth. The nearest point touches the margin of the rim where the waters of the Glades approach the heads of the rivers, and where these waters are about a foot in depth. There are within the coves, channels, converging to such a point, and in which the waters are from 1 1/2 to 2 1/2 feet in depth. The shallow places between them are covered with mud and rank saw grass." (Senate Doc. 89, 1911; p. 49)

The network of Peat Transverse Glades (in combination with any groundwater outflow) appears to have provided sufficient outflow to prevent significant ponding west of the coastal ridge. No historical evidence was found of water depths deeper than those typical for the Ridge and Slough landscape. There is some evidence that water depths were at times slightly shallower than further west within the Ridge and Slough landscape. The portion of the landscape adjoining the coastal ridge differed from the portion further west mainly in that the presence of an underlying sand wedge (Figure 3.18) meant that the overlying peat thinned toward the coastal ridge.

General Description

Between Fort Lauderdale and Miami (Townships 51 to 53), a network of low, shallow valleys extends from the Everglades basin to the Atlantic shore (**Plate 38**); Townships 51 and 52, Range 42). These valleys are old drainage courses, cut through the limestone of the Atlantic Coastal Ridge before the Everglades were formed. In the 1800s, prior to drainage, peat elevations and water elevations in the Everglades were sufficient to allow water to flow out through these valleys. Pre-drainage Everglades water levels were in fact sufficient to promote sawgrass growth and the accumulation of 1/2 to several feet of peat within the valleys. As a result, a series of miniature Everglades were formed: long, flat marshes of dense sawgrass, 1/4 to 1 mile wide, and bordered by higher-lying areas of pineland or hammock. These "Peat

Transverse Glades" were narrow lateral arms, through which areas of sawgrass, peat soil, and water flow extended continuously from the main body of the Everglades, and out to the east coast. The presence of elongated tree islands in some of the Glades must have given them a resemblance to the Ridge and Slough landscape of the main Everglades. These features were recognized as islands of "Myrtle and bay" on the land use and land cover map of Jones et al. (1948). One such island is shown on **Plate 38**, in Township 51, straddling the border between Ranges 41 and 42 (Sections 25 and 30, respectively). At least until 1990, despite intensive residential development, the eastern portion of this island (Range 42, Section 30) was still visible on aerial photos as a stand of trees, likely bay trees.

Hydrology

Water flowed from the Everglades through the Transverse Glades marshes in a combination of sheet flow and deeper water channel flow. In some of the Transverse Glades, the channels coalesced to form the headwaters of short coastal rivers (**Figure 3.17**). The former presence of Indian settlements on the edge of the uplands bordering some of the Peat Transverse Glade suggests that water depths were high enough during much of the year to permit navigation by dugout canoe to and from the settlements. Some examples of such settlements include Big City Island in T 51 R41 (**Plate 38**), Aleck's Town and Tiger Tail's Town in T 51 R 41, Section 35 (see Williams 1870 -T52 R41, Section 2), and Little Tiger's Town (Williams 1870 -T52 R41, Section 23). See also Carr et al. (1992). Many of the coastal canals in part follow courses of the former Transverse Glades.

Pre-drainage soils of the Peat Transverse Glades would have been mapped as Everglades Peats over limestone or sand. The elevation of the upper surface of the peats (i.e., ground surface) in the Transverse Glades was likely similar to the peat elevations in the sawgrass ridges in the adjacent Ridge and Slough landscape . All of these peat elevations would have been controlled by long-term average water levels in the main Everglades. With drainage, the original 1/2 to several feet of peat was lost to oxidation such that by the 1940s, many parts of the Peat Transverse Glades were mapped as sandy rather than as organic soils. (**Figure 3.20**; see also Chapter 3).

The importance of the Peat Transverse Glades to this study lies in their function as outlets of water flow from the Everglades and in their indication, through the presence of peat soils, of water elevations in the main Everglades. The peat depths of several feet present in the pre-drainage Peat Transverse Glades could only have been maintained if pre-drainage water elevations in the main Everglades were sufficient to flood these lateral glades during a substantial portion of most years.

Hindcasting.

The Peat Transverse Glades were identified on the Jones *et al.* (1948b) soil map through synthesis of several sources of information: Township plat maps; bedrock topography; soil type; characteristic polygon shapes on the soil map; and adjacent upland soil types and vegetation. In some cases, the original Everglades Peats soils and sawgrass vegetation were still present in the 1940s and mapped as such by Jones *et al.* (1948). These Everglades Peats polygons were left unaltered in the hindcast vegetation map (**Plate 13**). In other cases, the soils had oxidized under drainage, exposing the underlying sands, and the areas were mapped as Davie fine sands, Davie mucky fine sands, or in a few cases, as sands of the Wet Sands group (**Table 2.2**). We hindcasted these oxidized soils to the Everglades Peats group.

Peat Tranverse Glades Endnotes

1. The U.S. surveyor George Mackay described and drew areas that can be recognized by their shape as Peat Transverse Glades. Along the western boundary of Section 6, Township 51 Range 42, he described one in April 1845 as:

   "Open boggy Saw grass. Set 1/2 mile post in bog. No trees + too wet for [corner marker] mounds." (MacKay 1845-T51 R42).

   The adjoining upland on the southern edge of this Transverse Glade was described as "pine & palmetto."

2. Twelve miles further south, Mackay described another Transverse Glade, this one forming the headwaters of the Little River and labelled simply as "Saw Grass" on the plat map:

   "Through Saw grass bog. Set 1 mile post in Bog - No trees - too boggy for mounds." (MacKay 1845-T53 R41).

   The adjacent eastern edge was described as "Open pine land + rocky -- plenty of coonty [*Zamia integrifolia*]."

3. Buckingham Smith, in his report of 1848, describes the Peat Transverse Glades as "coves or indentations" in the edge of the main expanse of the Everglades:

   "Inside the basin, near the heads of the rivers of the eastern coast, there are coves or indentations in the shore of the Glades about 2 miles in depth. The nearest point touches the margin of the rim where the waters of the Glades approach the head of the rivers, and where these waters are about a foot in depth. There are within the coves, channels, converging to such a point, and in which the waters are from 1 1/2 to 2 1/2 feet in depth. The shallow places between them are covered with mud and rank [tall] saw grass. There are also sinks or holes of water several feet deep. Near the head of Little River these sinks or holes have 6 feet or more water, and similar depressions near the head of the Miami have 11 feet. Immediately east of them, and on the line where the waters of the glades fall into the heads of the rivers, over rocky passages of not more

> than 15 or 20 yards wide, and from 50 to 150 yards in length, the waters run through rapids scarcely a foot in depth. The fall of these rapids is, ..., upwards of 6 feet..." (Senate Doc. 89, 1911).

4. Several township plat maps from the 1870s also recognized the Peat Transverse Glades. In T 51 R 42, one of the Transverse Glades is labelled simply as "Glades," another as "Waters of Snake Creek" (Williams (1870)-T51 R42). In T 52 R 41, the main Everglades are explicitly labelled as "Everglades," while a Transverse Glade leading eastward is labelled as "Undefined Waters of Arch Creek" (Williams (1870)-T51 R42). In T 52 R 42, the Glade bordering "Little Snake Creek" is labelled as "Principal Passage to the Everglades" (Williams (1870)-T52 R42).

5. A 1904 report by C. G. Elliott, drainage engineer for the U.S. Dept. of Agriculture, indicates that these Glades were one of the first parts of the Everglades to be drained for agriculture. Even with these drainage efforts by the railroad company, they were still covered with water during the larger portion of the year:

> "Arms of the Glade land 0.5 to 2 miles wide extend from the head end of these small streams back into the Everglades proper for a distance of 2 or 3 miles, bordered by pine woods, beyond which is the open expanse known as the Everglades. These lands are called 'prairies' and are covered with saw grass. Two types are best known, the marl and the sand prairies [see below]. The soil varies in depth from 1 inch to several feet and in all cases rests upon a base of coral rock. ...
>
> A great deal of money has been expended in drainage works by the Florida East Coast Railway Co. The operations of this company so far have been directed toward opening and enlarging the natural streams for the purpose of lowering the water of the arms of the Glades during the winter season, in order to facilitate the growing of winter vegetables. ...
>
> During this [dry season ... between the months of November and March] portions of the prairie lands are planted to vegetables, principally tomatoes ... The remainder of the year these lands are frequently covered with water and are largely abandoned until the opening of the winter season, when they are again plowed and planted.
>
> None of the Glades land proper [i.e., the main Everglades], as far as examined, has been so drained as to be suitable for the growing of trees or of vegetables requiring the entire season..." (U.S.D.A. Annual Report of Irrigation and Drainage Investigations, 1904, excerpted in Senate Doc. 89, 1911).

Note that Elliott's categories, "marl prairie" and "sand prairie" very likely correspond to the Marl Transverse Glades and the Peat Transverse Glades. Elliott's term "sand prairies" most likely refers to the substrate underlying the surface peat, or to sand bottoms in any channels present within the glade. Numerous accounts indicate a peat layer above the sand in these glades; it would not have made sense to begin cultivation on bare, infertile sands, particularly if they needed drainage as well.

6. Dr. John DuPuis, an early settler of Lemon City in Dade County, described a Peat Transverse Glade associated with the Little River as he knew it after 1898 and before the opening of the Miami Canal locks in 1911:

> "Between what is now 69th and 72nd Streets on N.E. Second Avenue [of Miami/Little River], water stood two to six feet deep, full of fish and the alligators leisurely swimming on the surface any time of day." (DuPuis 1954a - Early medicine).

Dr. DuPuis observed a significant lowering of the regional water table after the opening of the Miami Canal locks in 1911 (see endnote No. __, Everglades Keys section).

7. Fourteen years later, although drier than prior to opening of the locks, the muck land of a portion of the same Transverse Glade two miles further west was still,

> "subject to overflow and could not be used during certain seasons of the year. Many of the students' crops were being routinely destroyed by flood waters" (DuPuis 1954b - Early public schools),

prompting Dr. DuPuis to form the Little River Valley Drainage District in 1925.

8. John Gifford's description appears to recognize some of the Peat Transverse Glades that were independent of the coastal rivers:

> "These ridges, like fingers, project into the Everglades and are usually covered with pine. Between these ridges are small glades on the edge of the main or 'big glade.' The accepted definition of a glade is a narrow strip of grassy land between forests." (Gifford 1911).

9. Harshberger's studies in 1913 were made after Lake Okeechobee levels had already been affected by the canals of the 1880s. The effects of this and of the partially completed North New River, Hillsboro, and Miami Canals on the Everglades is difficult to quantify, but water levels had likely been reduced. If so, outflow from the Everglades would have also been reduced, leaving the surrounding pinelands as a more important post-drainage source of water. Harshberger's description of the Peat Transverse Glades and their relation to the uplands is very similar to Gifford's. Harshberger describes a particular Glade west of Miami that he visited in 1910. His species list suggests a plant community most similar to the Sawgrass Plains, but also including a few species more characteristic of the Ridge and Slough landscape:

> "Occasionally a part of the Everglades extends into the pineland as a a long, narrow finger-like extension, where the level is sufficiently beneath pineland to collect the drainage water of the surrounding pine forest. Such a glade was visited 3 kilometers west of Miami on December 27, 1910, and the following species were collected in the area controlled by saw-grass, *Cladium effusum* [Note: species authors included by Harshberger omitted for brevity.] Along its edges were the ferns *Acrostichum aureum, Blechnum serrulatum*, and the royal-fern, *Osmunda regalis*. Associated with the saw-grass were other grass-like plants, grasses and sedges, viz. *Andropogon glomeratus, Dichromena colorata, Rhynchospora divergens*. In the wetter soil between the clumps of saw-grass were gathered *Sagittaria lancifolia* and spider-lilies, *Crinum americanum*, while such herbs as *Agalinus linifolia*, tall *Eupatorium capillifolium* and *Flaveria linearis* were scattered about in the grass. Two vines were collected, *Ampelopsis arborea* (=*Cissus bipannata*), and the climbing *Mikania batatifolia*." (Harshberger 1914).

10. The Peat Transverse Glades labelled on the 1870 and 1845 township maps were still recognizable 70 and 100 years later on a 1940 set of aerial photos (USDA-SCA 1940). The cultivated Glades, described above by Elliott in 1904 (Senate Doc. 89, 1911), can be recognized on the individual aerial photos (scale 1:40,000) as patterns of irregular agricultural field shapes filling the narrow curving outlines characteristic of the Transverse Glades. Often the surrounding upland pinelands--less fertile and drier--were left uncultivated. Peat Transverse Glades that were still too wet in the 1940s to have been cultivated are visible on the index sheets as long, narrow, dark areas (**Plate 31**), see especially southern T 52 R 41 and northeastern T 53 R 41).

11. Similarly, most of the Peat Transverse Glades are visible as elongated soil polygons on the Jones *et al.* (1948b) soil map. In **Figure 3.20**, a clear similarity can be seen in the shapes of the low-lying network of Transverse Glades mapped in 1870 and again in the 1940s, despite the very different mapping approaches.

12. Prior to drainage, when the Everglades extended eastward between the higher-lying portions of the Atlantic Coastal Ridge, the difference between the uplands and lowlands was clear and widely recognized. As noted by archeologists studying Indian settlements bordering the Transverse Glades,

> "... the Everglades border in present day southern Broward and northern Dade County was quite distinctive prior to drainage. The elevated Atlantic Coastal Ridge presented a sharp contrast of pinewoods against the Everglades prairies and sawgrass that provided a visual reference for all early travelers." (Carr and Steele 1991).

13. Parker *et al.* (1955) described the geological origin of the Peat Transverse Glades. Although Parker noted the presence of sand, he did not mention peat soils, very likely because the peats had been almost completely oxidized by the 1940s and 1950s (see **Figure 3.7**, curve B):

> "Between Fort Lauderdale and Miami are several low, shallow valleys, floored with Pamlico sand, that reach to the present shore. These valleys are called transverse glades because of their orientation and their characteristic soils and vegetation. They occupy old drainage courses cut through the Miami oolite, probably in early Wisconsin time, and subsequently partly filled with sand during later Wisconsin and Recent time." (Parker et al. 1955).

14. When Parker observed the Peat Transverse Glades in the 1930s and 1940s, they were still clearly recognizable, but water levels in the Everglades had already declined sufficiently (see Chapter 3) that water no longer flowed from the Everglades out through the Transverse Glades:

> "Numerous small transverse [northwest-southest] sloughs or glades dissect the coastal ridge from Pompano to Homestead and connect the Everglades with the tidal estuaries along the coast. Except in periods of exceptionally high water, these handle principally local drainage." (Parker *et al.* 1955, p. 333)

Prior to the 1890s, when the first drainage of the transverse glades began, outflow from the Everglades would have predominated over local drainage from the surrounding uplands.

Everglades Keys and the Marl Transverse Glades

General Description

The Everglades Keys curve southwestward, separating from the Atlantic Coast south of Township 55, and ending in Long Pine Key (now within Everglades National Park). Prior to drainage, when water levels were considerably higher, the inundated Marl Transverse Glades separated the high ground into a series of "islands," giving rise to the term "Everglades Keys" (**Plate 16**).

This landscape corresponds to the east coast portion of the Slash-pine Formation, Prairie Formations (portions), Banana Hole Associations, and High Hammock Formation (Harshberger 1914); Miami Limestone Region, and transverse glades portion of Marl Prairie (Harper 1927); the Everglades Keys (Small 1929a); and the Miami Rock Ridge (Davis 1943).

The archipelago of islands known as the Everglades Keys formed the southern portion of the rim of the Everglades basin. The northern portions were formed by the Atlantic Coastal Ridge and the Eastern Flatwoods. Without this rim, water and organic soils could not have accumulated within the Everglades basin. Elevations of the cuts, or low points, in this rim controlled the maximum possible elevations of water within the southern (Lower) Everglades. As in the Atlantic Coastal Ridge landscape, the cuts separating the individual Everglades Keys were of two types: coastal rivers with well-defined banks, and transverse glades with low, wide profiles (**Figure 4.30**)

The coastal rivers passing between the individual Everglades Keys had their headwaters in the Everglades, usually with rapids. The Marl Transverse Glades were simply eastward extensions of the Everglades, having essentially identical soils, hydrology, and vegetation as the marl forming marshes (**Figure 4.21).**

Formed from a slightly elevated ridge of highly porous Miami oolitic limestone, the Everglades Keys differed from the Atlantic Coastal Ridge in surface soil, vegetation, and distance from the ocean. Except for some areas of sand, little soil was present, so limestone similar to the pinnacle rock of the Rockland Marl Marsh landscape was visible at the surface. Subsequently, "rock plowing," a technique for pulverizing the surface rock, was invented and applied to form a thin layer of soil for agricultural use.

The Everglades Keys were vegetated by an open pine forest with an undergrowth of saw palmetto *(Serenoa repens)* and coontie (*Zamia integrifolia*)(**Figure 4.31**). A number of distinct tropical hammocks (e.g. Castellow and Ross Hammocks [Nixon, Brickell]) were present, containing tropical hardwoods, sinkholes, ferns, and a layer of rich organic soil.

Seasonal Changes in Water Levels

The Everglades Keys (after about the 1940s known as the Miami Rock Ridge) -- was punctuated by a series of shallow cuts, the marl transverse glades (**Figure 4.32** show a 1938 aerial view of some of the Marl Transverse Glades, by this time sufficiently dry to allow farming. Leon Griswold gives a typical pre-drainage description, based on his explorations in 1896. At that time, forty years earlier, these transverse glades, here called "broad undulations," were still inundated in the wet season:

> "The oolite [of the Everglades Keys] rises to an elevation of about twenty feet, and then maintains a generally level surface, with the exceptions of occasional broad undulations, having axes about east to west or north to south, and sinks. The hollows of the broad undulations are filled with water during the rainy season, so that pines do not grow in them; in the dry season grass grows luxuriantly, and some of the sinks are cultivated. Some soil has accumulated in these `prairies,' whereas among the pines there is scarcely any soil to hide the jagged rock surface and loose fragments." (Griswold 1896, p. 53). Griswold's description of "luxuriant grass" between the pines matches a 1911 photograph **(Figure 4.30).** Numerous observations from twonship survey field notes made in 1847 indicate that the "grass" was sawgrass (**Appendix A**).

These cuts or outflows were dry enough in the dry season to walk on (Mott 1840s) and farm (Model Lands refs - Otto Richter Library). In the wet season, the marl transverse glades rewetted as water levels rose in the Everglades (Simmons 1998).

Elevations

Plate 16 indicates that the elevation of most of the marl transverse glades is between 8 and 9 feet above sea level. **Plate 16** also shows the presence of a slightly higher, narrow ledge (9 - 10 feet elevation) to the west of the heads of the transverse glades. Griswold, who explored south and west of Miami in 1896, described what appears to be the eastern edge of the same ledge:

> "The rivers [the Miami and adjacent rivers] have a well marked fall line on the limestone, -a few hundred yards of swift water just west of the pines, and representing the progress made by the rivers in cutting back from their mouths." (Griswold 1896).

The known elevations of the marl transverse glades and of the ledge, combined with the knowledge that the marl transverse glades flowed in the wet season provides a strong measure for wet season water elevations in Shark Slough and in the bordering marl marshes (**Figure 4.4).** The typical annual high water level appears to have been approximately 9 feet above sea level; the mean annual low approximately 7 feet above sea level. This high water elevation would bring Everglades water directly to the edge of the Everglades Keys, corresponding to the description given by Griswold in 1896:

> "At the border of the Everglades the rough surface of the oolite becomes concealed for the most part beneath a mat of grass, and pines grow no further west (Plate XXIV. Figure 1). In the zone of oscillation of water the grasses change in character from a small wiry variety near the pines to saw-grass six feet or more tall, and flags and cane growing in water." (Griswold 1896).

It would also be consistent with observations by township surveyors of a distinct edge to the pinewoods, (i.e. the Everglades Keys), beyond which the Everglades and standing water could be directly seen (as shown in Jackson 1847).

Everglades Keys Endnotes

1. Capt. Bernard Romans, an extensively travelled surveyor, botanist, and seaman, provides a navigator's description of the northern portion of the Miami Rock Ridge in the late 1700s. From his descriptions and accompanying map, the "rivulets" to which Romans refers can be readily identified as Snake Creek (Rio Ratones), Arch Creek, Little River, and the Miami River. (Romans' use of "rivulet" probably does not accurately reflect the actual size of the coastal rivers. The introduction to the 1961 reprinting notes, "One must bear in mind that Romans was a foreigner struggling with the intricacies of the English language." Romans himself notes that "...the rivulets in the grand marsh will supply any quantity for a ship of considerable force..." (Romans 1776 [1961], p. 193).) Particularly significant is his mention of the Everglades--indicative of their close proximity to the shore in this area--and his mention of submarine freshwater springs in northern Biscayne Bay, north of the Miami River:

   > "West from this [Cape Florida] is the river *Rattones* [Snake Creek], being a fine stream, and pretty considerable, with a little good rich soil on its banks, where many tropical plants grow... To the southward of this river is a large body of marsh [i.e., the Everglades, or "Grand Marsh" on Romans' map], through which several rivulets of fine water empty themselves into the sound [Biscayne Bay], back of the [Biscayne and Virginia] keys, which begin here, that a man may here stand with one foot in fresh, and the other in salt water; nay when the tide is out fresh water boils up through the sand." (Romans 1775 [1961], p.192).

2. Continuing southward from the Miami River and the adjacent Everglades "marsh," Romans gives a description of the Everglades Keys very similar to many which followed over the subsequent 100 years:

   > "[South] from this river and marsh the remainder of the land is a heap of stones and rocks, very sharp, and little [drinking] water to be found, there being only a few ponds, and these dry in a dry season. The only growth here is a shrubby pine." (Romans 1776 [1961], p.192).

3. On a foray into the Everglades with Col. William Harney beginning on 21 April, 1838, Army Surgeon Jacob Motte describes landing on the shore of Biscayne Bay at "a part of the coast free from Mangrove, and where the country back off the beach appeared open and having a growth of pine." This unusual configuration identifies the point as the SW corner Section 26, T 55 R 40, the site of the Deering Estate (see also Sunderman 1950). Motte's description of a spring on the beach is similar to Romans' (1775 [1961]) description of submarine springs on northern Biscayne Bay:

   > "...we there found a remarkable spring of fresh water, of the coolest and most delicious flavour I ever drank. This spring was remarkable from the circumstance of its being upon the beach considerably below the high-water mark, and consequently covered by the salt-water twice every twenty-four hours." (Motte, 1838, in Sunderman 1950).

   It is noteworthy that the spring was flowing at the end of the dry season, implying that there was still water present in the Everglades to provide the necessary pressure head.

4. Marching approximately six miles northwest up one of the marl transverse glades [the present "Cutler Drain Canal" or C-100C], Harney's party left the glade and crossed a part of one of the Everglades Keys, likely in Section 6 or 7 of T 55 R 40:

   > "On the 24th of April, we started on foot for the interior... Our first six miles was through a saw-grass prairie, when we struck a trail which led us to an Indian camp...
   >
   > ... [leaving the saw-grass prairie,] we pursued our way through a pine-barren, the ground being formed of coral-rocks jutting out in sharp points like oyster-beds, which caused us great suffering by cutting through our boots and lacerating our feet at every step..." (Motte, 1838, in Sunderman 1950).

5. A military map of southern Florida (MacKay and Blake 1839) clearly shows a "North Creek" extending from the Everglades southeastward through the Everglades Keys to discharge into Biscayne Bay. North Creek is synonymous with Black Creek (Township 56, Ranges 39-40), labelled on Jones et al. (1948). It is shown similarly connected through to the Everglades on several other maps (McLaughlin 1841; Bureau of Topographical Engineers 1846; Harshberger 1913).

6. In 1845, U.S. Deputy Surveyor George MacKay surveyed numerous townships adjoining and extending partially into the Everglades. MacKay crossed the head of the Little River in the second half of April, 1845. This short river was fed directly by an arm of the Everglades (see Peat Transverse Glades landscape). The elevation drop along the rapids in this river was apparently substantial. Note also the 2-1/2 feet depth of water present at the end of the dry season, indicating the presence of water in the Everglades at this time:

   > "exit to Little River rapids -- said to be 8 feet in 1/2 mile. Water 2 1/2 feet deep" (MacKay 1845-T53 R42; N boundary Section 7).

7. MacKay also measured the widths of the rapids in the north and south forks of the Miami River while surveying in an area of hammock vegetation:

   > "exit hammock to North Branch of Miami channelled 9 ft deep thro' solid rock. 0.59 chains [39 feet]: exit river to hammock--Sawmill in operation about 15 chains West."
   >
   > "exit hammock to S. Branch of Miami R. 1.25 chains [83 feet]: River rocky bottom running East rapid." (MacKay 1845-T53 R41; W boundary Section 34 [the present NW 27th Avenue]).

8. A map of the State of Florida (Bureau Topographical Engineers 1846) shows a "Spring" in Range 38, between Townships 57 and 58; i.e., at the south end of the main group of Everglades Keys. The same map also indicates a "North Creek" passing between several of the Everglades Keys (T 56 R 39). The shape and location suggest that part of North Creek corresponds to the present Black Creek.

9. At the request of Buckingham Smith, MacKay in 1847 summarized his observations of the Everglades and the Everglades Keys. From an area most likely just west of the Keys, in the vicinity of Township 54, Range 40

(see also Newman 1908-T54 R40), MacKay reports hearing and seeing water flowing underground from the Everglades and from there through the highly porous rock substrate of the Everglades Keys:

> "...and in the dry season I found that that the course of these currents was, owing to numerous rock basins, in many instances perforated with holes in the bottom like a colander, into which these currents poured and disappeared; and in the pine woods, between the Glades and the Bay of Biscayne [i.e., the ridge formed by the Everglades Keys, most likely in Township 54, Range 41 or 40], may often be heard the rippling sound of running water, and frequently, in the fissures of the rock, it may be seen at from 6 to 8 feet below the general surface of the ground..." (George MacKay, 1847, in Senate Doc. 89, 1911).

Note that these observations were from the dry season.

10. MacKay related the currents passing through the ridge to springs within Biscayne Bay. The substantial three to four foot pressure head is remarkably large:

> "and there are springs in the midst of the bay, where, by very indifferent means to shut out the salt water, pure fresh water has been raised 3 or 4 feet above the surface of the ocean, ..." (George MacKay, 1847, in Senate Doc. 89, 1911).

11. Another U.S. Surveyor, John Jackson, surveyed most of the Everglades Keys area in 1847, during the latter half of the dry season (March through May). Jackson's survey maps clearly show the Everglades Keys as distinct areas of rocky pinelands separated from one another by the narrow marl transverse glades. The transverse glades are labeled as "Sawgrass Prairie," "wet Prairie Land," or "wet Sawgrass Prairie" (Jackson 1847-T55 R39; 1847-T55 R40; 1847-T56 R38; 1847-T56 R39; 1847-T56 R40; 1847-T57 R39; 1847-T58 R38). The distinct spatial pattern of the variously shaped Everglades Keys and transverse glades that Jackson mapped in 1847 will be recognizable on all subsequent maps, whether of topography, soils, or vegetation.

12. In the earliest comprehensive report on draining the Everglades, Buckingham Smith (1848) described the ground surface and vegetation found on the Everglades Keys:

> "Oolitic limerock, ... forms the great geological feature of the country. The rock is porous and susceptible of easy excavation. ... On the eastern side of the [southern portion of the Florida] peninsula this rock shows itself through the thin coating of vegetable matter, or mud or sand, that ordinarily covers it; and it is also in detached pieces of different sizes, scattered above the ground. It contributes to the fertility of the soil, and being from its porous nature long retentive of moisture, affords sustenance to trees and plants in seasons of drought. The rim of the Everglades is generally of this character. Along the eastern verge of the Glades, and between them and the sea, there are spots of wet and black prairie land; there are also spots grown up in pine trees, the roots of which are imbedded in a dark soil of vegetable mold, lodged in the crevices and fissures of the rock; and there are tracts of what is called 'dry hammock,' covered with trees of various kinds growing in the same manner." (Buckingham Smith, 1848, in Senate Doc. 89, 1911).

The presence of "dark soil of vegetable mold" suggests that pre-drainage water tables on the Keys were sufficiently high to protect organic soil accumulating in the rock crevices from oxidation, even under the apparently dry and open pinelands canopy.

13. An 1850 report of the Superintendant of the U.S. Coast Survey indicates that the elevation of the waters of the Everglades, near the head of the Miami River, was measured in the latter half of the dry season of that year. The time of measurement can be determined from the report. Assistant F. H. Gerdes commenced detailed coastal surveys of the Florida Keys in December 1848 at Marquesas Keys, working eastward up the Keys to finish in Biscayne Bay (Bache 1850, Sketch F). By April 1849, Gerdes had gone to Washington, D.C., where he became ill and was forced to cease work. As the line of levels was part of the later Biscayne Bay work, the measurements were most likely made in March 1849, or more than two-thirds of the way through the dry season:

> "While on the coast of Key Biscayne bay, Mr. Gerdes, in accordance with a request from the Secretary of the Treasury, ran a line of levels from the Everglades to the low-water mark on the gulf, following the general direction of the Miami River, from the upper falls to near its entrance into Key Biscayne bay. The general course of the line was ESE., its length 3 3/4 miles, and the level of the water in the glades was 6 feet 2.5 inches above low tide in the gulf. When the levelings

> were made, the level of the water in the glades was stated to be lower, and the tide in the gulf higher than ordinary, and Mr. Gerdes, therefore, placed two permanent bench-marks for future reference. No means were at his disposal for ascertaining the depth of water in the Everglades." (Bache 1850, p. 47).

The observation that water levels in the glades were "lower than ordinary" is consistent with the timing of the measurement, late in the dry season. The water elevation at the end of a typical wet season would therefore most likely have been greater than 7.5 feet above mean sea level. ([The Gerdes measurement of 6 feet 2.5 inches] + [2/3 x the annual variation of 2 feet] = 7.5 feet. A correction for the "higher than ordinary" tide in Biscayne Bay would increase this figure.)

14. Sketch F of the same report (Bache 1850) shows a sizeable river connecting the interior area labelled "Everglades" to Florida Bay. The river bisects a coastal prairie area labelled "Prairies and Hammocks" to the west, and "Rocky and Sandy Prairies mixed with Hammocks" to the east. From the position and size, there is little doubt that this is the river presently known as Taylor Slough.

15. Although William Cooley's description of the Everglades Keys is less detailed than Buckingham Smith's, Cooley's reference to soil burning also indicates the presence of organic soils, and, typically, correspondingly wet conditions:

> "at Loyd's Lake ["Loyd's Lake appears on maps from the Seminole War period at the extreme southeastern corner of the Florida Mainland, opposite Key Largo." (Knetsch (1989)] you strike the porous or honeycomb rock which reaches from that point to Rio Ratones [Snake Creek] -- most of this distance this rock appears above ground but in some places it is covered with soil a foot or more -- this rock on this route extends some distance into the everglades but I have not seen it anywhere else in any body -- There are several large Hammocks whose base is this porous rock -- the land or soil is rich but if fired in a dry time it will burn up" (Cooley, 1851, in Knetsch 1989).

16. North of the Miami River, the Everglades Keys intergraded with the sand-covered Atlantic Coastal Ridge. Based on the Jones et al. (1948) soil map (**Plate 3**, and on the extent of the "Miami Rockland Pine Forest" mapped by Davis (1943), **Plate 4**), the transition occurred at approximately the southern boundary of Township 52. Cooley however recalls it extending approximately 15 miles further north, to the New River, and again notes the presence of organic soil:

> "...the land between New River and Key Biscayne is inclined to be very rocky, the rock extending to the Glades -- the soil of some of the Hammock in the Glades between New River and Cape Florida will burn --" (Cooley, 1851, in Knetsch 1989).

17. A map of the State of Florida made in 1856 (Bureau Topographical Engineers 1856) shows the same features as one drawn ten years earlier (Bureau Topographical Engineers 1846), but reflects further exploration in the southernmost areas. Of relevance to Everglades Keys hydrology is the addition of two rivers: "Chi's Cut," a short coastal river draining southeast from the Everglades Keys into southern Biscayne Bay, and "Taylor River," beginning just east of Long Pine Key and Paradise Key and draining into Florida Bay.

18. N. S. Shaler, a professor of geology, investigated the southeastern coast of Florida in 1887-88, particularly the large Everglades Key near Coconut Grove, referring to it as the "Miami Reef," or simply "reef." Like Buckingham Smith and William Cooley forty years earlier, Shaler found wet organic soils on the Key. He also found underground channels leading to submarine springs:

> "...[On] the flat top of the reef, where the waters are less rapidly drained away,--where indeed during the rainy season the surface is, as I am informed, very wet,--the growth of vegetation, and consequently the amount of humus upon the soil, are considerably greater [than on the sloping eastern edge of this Everglades Key]. The effect of the longer presence of the rain-water, and the greater amount of the acids from decaying vegetation, is at once shown in the development of a great number of sinkholes. Portions of the reef are so thickly set with these depressions, that nearly all the rainwater appears to find its way by underground channels to the sea, where we can note its emergence in great springs." (Shaler 1890, p.145-6).

19. Here the Everglades extended very close to the shore of Biscayne Bay, with Everglades waters overflowing as rapids through the low spots (the transverse glades) between the individual Everglades Keys:

> "...the waters of the Everglades [are found] at a distance of only 3 miles from the shore... In the rainy season they often rise to such an altitude that they pour over the reef wherever it is less than 20 feet in altitude. ... The rivers which flow over this part of the reef come down to the sea level over a series of rapids formed upon the harder layers of the reef, and thus the full escape of the Everglade waters is prevented." (Shaler 1890, p.144).

20. As noted under the Rockland Marl Marsh landscape, the marl or "limy matter" that Shaler found there apparently was discharged in large quantities through the coastal rivers:

> "It is a noteworthy fact that Biscayne Bay receives through the Miami and other streams discharging from the swamps of the Everglades on its floor a vast amount of limestone mud. ... It appears to be lime in the form which would be given it by precipitation from water." (Shaler 1890, p. 147).

C.f. Simpson (1920, p. 236-7):

> "There is often a residue of grayish or slate colored marl deposited in and around the border of the Everglades, and some of this is carried down by the streams during high water to form extensive mud flats at their mouths."

21. A note appended to Shaler's article by Alexander Agassiz illustrates the very large volumes of water once stored in the Everglades behind the ridge formed by the Everglades Keys:

> "To the [natural] damming up of the waters in the Everglades, and to the sudden outbursts of gigantic masses of water charged with organic matter and lime, we may trace the immense destruction of fishes which so frequently occurs on the shores of the Florida Keys and the waters surrounding them." (Agassiz, in Shaler 1890, p.158).

22. In an article described by plant ecologist Phillips (1940) as an "excellent description of the area from a naturalist's point of view, ... [regarding] the appearance of the country before the advent of civilization," Charles Richards Dodge discussed the Miami River:

> "...Miami is located at the mouth of the river of the same name, which flows directly from the Everglades ...
>
> The Miami River is one of the principal outlets from the glades on the east coast, and though a sluggish stream at its mouth, it tumbles over the coral rock near its source in splendid rapids against which a boat is dragged, not rowed, with difficulty. We entered the glades by the north fork of the Miami, as beautiful a stream as ever flowed through an unbroken wilderness, the trees in places almost arching the water, its banks clothed with strange vegetation and stranger flowers, the bottom presenting a kaleidoscopic picture of many-colored grasses and aquatic vegetation." (Dodge 1894, p. 360-361).

23. The following description of loss of organic soil when hammocks were cleared was written for the Florida Keys, but very likely also applied to the hammocks of the Everglades Keys:

> "On those [Florida] keys that are more or less covered with "hammock" growth (hard-wood trees), there is quite a surface layer of decomposed vegetation, but in a comparitively short time after being cleared and "cultivated," the white, honey-combed rock comes to the surface and predominates." (Dodge 1894, p. 354).

24. Don Gaby, a present day historian of the Miami River, provides a helpful description of the two forks of the Miami River and respective rapids, as they appeared during the 1890s:

> "The river forked about three miles above its mouth at Biscayne Bay, and the larger north fork of the river, the main stream, terminated in a famous rapids or 'falls' at its source only one mile further on. The south fork also had a rapids, but it was a much smaller stream with much less of a fall at its source. Both forks of the river had their headwaters at the eastern edge of the Everglades, approximately four miles from Biscayne Bay.
>
> ... persons entering the Everglades customarily did so on the south fork where there was less current and a shallow rapids falling less than a foot. Persons coming from the Everglades to Miami ... normally used the north fork, either shooting the rapids or going around them to join the main stream of the river. Here the water fell about six feet while traversing some 450 feet of rapids. The

flow over these rapids could be torrential, especially during the rainy season, and the north fork normally provided a swift current--the exceptions being during periods of extreme drought. At such times, the rapids might be completely dry or with little flow.

...Water from the Everglades spilling over the coastal ridge and a multitude of fresh water springs fed the Miami River. The Everglades water had a darkish cast because of decaying vegetation from its source, but the spring water was perfectly clear. A scientist writing in 1896 described a huge spring which had its issue from one bank of the north fork just below the rapids where, during periods of low water, one could see the clear water from the spring mixing with the darkish water from the 'Glades. There were numerous subterranean springs below the river in addition to others along the shore.” (Gaby 1993, p. 2-3).

25. Geologist Alexander Agassiz’ description of Biscayne Bay in (early?) 1896 suggests substantial outflows of tannin-laden water that was characteristic of the Everglades:

> “The bottom of Key Biscayne Bay near the northern extremity, about three miles from the entrance to the Miami River, is covered with *Thalassia;* the waters of the bay itself are of a dark brownish color, apparently saturated with vegetable matter. The dark color of the inland waters of the sounds back of the keys from Key Biscayne to Blackwater Sound is in marked contrast with the clear sea water which bathes the southern shores of the main line of keys.” (Agassiz 1896, p.42).

Agassiz does not indicate whether tannin-colored water in Biscayne Bay was a frequent or general condition, or instead the result of a particular discharge. There may have been a seasonal variation, with more tannic Everglades surface waters during the wet season, and more of the clear spring water during the dry season. The seagrass *Thalassia* that Agassiz also found growing in Biscayne Bay would certainly be tolerant of periodic tannic water discharges, as it still coexists at present with such discharges in Little Madeira Bay (pers. comm., Dave Rudnick, 1998).

26. Leon Griswold, a geologist and possibly a student of Alexander Agassiz, explored southeastern Florida on foot and by canoe during the spring of 1896. His observations of the Everglades Keys are based on the area west of Cocoanut Grove and a crossing of the southernmost Keys during an unsuccessful search for Long Pine Key. Griswold’s map of his routes, **Plate 9,** is quite accurate and can be overlain on modern maps to locate his travels:

> “The oölite rises to an elevation of about twenty feet, and then maintains a generally level surface, with the exceptions of occasional broad undulations, having axes about east to west or north to south, and sink[hole]s. The hollows of the broad undulations are filled with water during the rainy season, so that pines do not grow in them; in the dry season grass grows luxuriantly, and some of the sinks are cultivated. Some soil has accumulated in these ‘prairies,’ whereas among the pines there is scarcely any soil to hide the jagged rock surface and loose fragments (Plate XXI. Fig. 2). The sinks are sometimes of rounded form, with perhaps a maximum diameter of two hundred feet, or linear, a few hundred yards in extent.” (Griswold 1896, p.53).

The “broad undulations” or “prairies” that Griswold refers to as being filled with water during the rainy season are the same marl transverse glades drawn by Jackson in 1847 on the township survey maps.

27. Like Cooley in 1851, Griswold noted that the same oölitic rock forming the surface of the Everglades Keys also extended well into the Everglades (i.e., into the Rockland Marl Marsh), but there the rock was covered by surface vegetation, and likely by some organic soil:

> “At the border of the Everglades the rough surface of the oölite becomes concealed for the most part beneath a mat of grass, and pines grow no further west (Plate XXIV. Fig. 1). In the zone of oscillation of water the grasses change in character from a small wiry variety near the pines to saw-grass six feet or more tall, and flags and cane growing in water.” (Griswold 1896, p.53).

The presence of tall sawgrass and flags indicates deep water, likely an annual maximum of two feet. Note that Griswold ascribes the transition from pinelands to Everglades not to a change in substrate, but rather to the average eastward extent of the waters of the Everglades. The ground surface elevation at the western edge of the Everglades Keys landscape therefore provides an estimate of a characteristic, long-term elevation of waters of the Rockland Marl Marsh, somewhere between the mean and maximum elevations.

28. Griswold accepted the presence of a groundwater connection between the Everglades and the shoreline springs, but apparently did not find the dramatic "disappearing currents" reported by MacKay (1845):

    "It is locally believed that the underground streams associated with the sinks drain not only the pine land, but help to drain the Everglades to the west, because great springs of constant flow emerge in large numbers along the shore. This is probably true, but the interior drainage perhaps escapes by percolation, or very small channels, for no sinks were seen in or near the Everglades." (Griswold 1896, p.53).

29. The rapids referred to below are those of the Miami River, both forks of Arch Creek, Snake Creek, and the creeks of the Marl Transverse Glades:

    "The rivers have a well marked fall line on the limestone, -- a few hundred yards of swift water just west of the pines, and representing the progress made by the rivers in cutting back from their mouths." (Griswold 1896, p.53).

30. In his memoirs, one of Miami's first mayors, John Sewell, recollects the first efforts in the 1890s to create a public water supply, using a spring close to the edge of the Everglades:

    "Later [sometime after the summer of 1896] Mr. Tuttle arranged with Mr. Flagler to put a pump at a big sulfur spring near the head of the Miami River, which was then known as the rapids, about 4 miles above the city, and piped the water to the city through a 6-inch pipe. ... The water supply was limited to a 6-inch supply as that was the capacity of the spring. While the water was good, we had to have a greater supply to draw from." (Sewell 1933, vol 1., chapt. 6).

    From a comment by Sewell in a previous paragraph, that the shallow limestone wells gave "hard water, which made a great many sick when we first began using it," his description of "good" probably refers here to soft water, and perhaps also to clear water, without the organic coloration typical of surface water from the Everglades.

31. Willoughby gives a vivid account of the current in the south fork of the Miami River during the dry season (January or February) of 1896. This smaller south fork included rapids, but with only a one foot drop:

    "Brewer with his pole in the stern, and myself with the Canadian paddle in the bow, made rapid headway against the current, which was getting stronger and stronger. ... Very soon we saw large white objects ahead, which proved to be balls of foam hurrying down with the current. With a quick turn to the left, after about three miles of paddling, we struck the South Fork, the water becoming swifter and swifter, and the cotton-like balls larger and more numerous. We were on the falls, and how the water did run! I could hear Brewer panting behind me, but I never turned my head or gave any signal that we were conquered, but started in on my old-time stroke, inch by inch crawling up that water, dodging the rocks. After about three-quarters of an hour of the hardest paddling I think I have ever done, the water slowed up a little, and we could get some speed on the canoe. The trees opened up more, the stream becoming narrower and narrower, until we came to an opening where everything was clear ahead.

    This was the edge of the Everglades... The stream here loses itself among the lily-pads and before you lies a sea of apparently pathless grass. On closer observation shallow water-courses are seen running through the grass, cutting in all directions..." (Willoughby 1898, p.39-40)

    Considering this description of the south fork in the dry season, the current in the north fork--which was narrower, but passed a greater volume of water--must have been formidable, especially in the wet season.

32. During a December 1896 trip, Willoughby noted submarine springs along Biscayne Bay, between Coconut Grove and Cutler. From his many explorations of south Florida, it was clear to Willoughby that these springs were fed, through underground channels, by waters of the Everglades:

    "All along this shore there are places where the fresh water comes up through the rock under the salt water with quite a head. It no doubt comes from the Everglades by subterranean passages." (Willoughby 1898, p.65).

33. At the end of his trip across the Everglades in January 1897, Willoughby also noted a spring near the head of the Miami River, likely above the rapids of the north fork, in an area of cypress and pine trees:

> "Near our camp was a pretty spring of clear water that rushed from the side of the hill. (Willoughby 1898, p.164).

At this location, the spring would have been more than six or seven feet above sea level.

34. In an observation dated 1899, Mayor John Sewell notes a spring on the east side of the Everglades Key which formed the north bank of the Miami River, and describes the discovery there of a fresh water, artesian well:

> "There was a spring in Wagner's Creek near 4th and Avenue L which had a larger flow than the one in the Everglades, where we were getting our supply. [According to Parker et al. (1955), Avenue L is now NW. 7th Ave. and 4th St is now NW 8th St., so this would be the SW corner of Sect. 36, T 53 R 42, adjacent to Seybold Canal, the former Wagner Creek. See also Gaby (1993).] He [Dan Cosgrove, a chief engineer] figured that there was a subterranean stream running from the spring in the Everglades and this 4th Street spring, making its way to the ocean. ...He kept drilling [at NW 11th St. and 10th Ave.] until he got his pipe down between 50 and 60 feet in depth. ... As the roof of the river caved in the water had rushed through the pipe with such a flow that it came very near to drowning all of his Negroes before they could get out of the hole [a 5 foot deep drilling excavation.] He was highly elated at the flow of water, clear and pure." (Sewell 1933, vol 1., chapt. 6).

35. Fuller (1904) lists "Mangrove Spring" on Kirk Monroe's property in Cocoanut Grove, reporting that it flowed at 100 gallons per minute at the base of a limestone bluff, and that "The supply of the American fleet off Havana in 1898 was obtained from this spring." The "Devil's Punch Bowl," photographed by Ralph Munroe in the 1890s (Parks 1977), was another famous spring and landmark, located at the beginning of the "Bluffs" near Brickell Hammock and near the causeway to Key Biscayne (**Figure 4.33**)

36. In the context of a system of drainage proposed by the Florida East Coast Drainage & Sugar Co., the elevation of the falls of the north fork of the Miami River was measured in 1898, sometime between July 6 and December 29. The Superintendant of the company, R. E. Rose, had "inaugurated a preliminary survey and reconnaissance of the territory recently acquired by your Company, under contract with the State of Florida," and submitted the following as part of his report, which was in turn incorporated into the minutes of a Dec. 29, 1898 meeting of the Board of Trustees, Internal Improvement Fund:

> "I submit a report of the levels from the interior to the tide level. The Mean of three surveys, 6 ft 11 inches, can be safely taken as the amount of fall from the head of the Rapids of the Miami River to tide water in Biscayne Bay..." (TIIF 1904, p.456).

This measurement of approximately 7 feet is similar to the adjusted 1849 measurement (Bache 1850). Given the Florida East Coast Drainage & Sugar Co.'s interest in agricultural development, it seems likely that the measurement refers to the elevation of the ground surface, rather than to water level.

37. The forester John Gifford, who lived in the Miami area for many years, wrote extensively about the Everglades and the coastal uplands. In an article written in 1904, before extensive drainage had begun, he gives a detailed description of the vegetation, rock and soil then existing on the pinelands of the Everglades Keys:

> "The pineland, although less rich and luxuriant in growth [than the tropical hardwood hammocks], is also peculiarly interesting. The rocky ridges or reefs, with sandy swales in between, are covered with pine and palmetto. The pine, strange to say, seems to shun the sandy swales. The sand of these swales is underlain usually with a reddish calcareous clay, resulting from the disintegration of the coral rock. This rock may be found in all stages of disintegration. In the swales the palmetto is most luxuriant, and no doubt the absence of the pines in these places is due to this fact. The regeneration of these pines, in spite of fire and rock, is generally good. The pine grow right on the rock, the roots penetrate its crevices, and the tree is anchored to such extent that when it upturns the rock sometimes upturns with it. (Gifford, 1904 in Gifford 1911, p.16-17).

The "sandy swales" might refer to marl transverse glades, but the presence of [saw] palmetto and reddish calcareous clay suggest that these were open areas within the pinelands.

38. In and before 1904, fire appears to have been important in the Everglades Keys:

> "Fire sweeps over these pine regions frequently. ... Fire gets down in the crevices of the rock, so that it is next to impossible to extinguish it. The effect of fire on this rock is peculiar. It becomes a

potent geological agent. It converts the rock into lime, which slakes when wet by rain or dew. In burning piles of brush, rocks are often thrown into the heap to check the flames or prevent the wind from blowing sparks. These rocks are burnt with the wood and crumble into soil. (Gifford, 1904 in Gifford 1911, p.16-17).

39. The reference to fire getting into crevices of the rock likely refers to the burning of organic soil collected in these crevices, as does the following mention of the weathering effect of (acidic) organic soil:

    This rock crumbles into soil in the presence of decomposing organic matter." (Gifford, 1904 in Gifford 1911, p.16-17).

    High water tables in the wet season allowed organic soil to accumulate in rock crevices of the Everglades Keys, while drier conditions at other times allowed the soil to burn.

40. Gifford notes that the location of the edge between the forested Everglades Keys and the non-forested Rockland Marl Marsh portion of the Everglades was dictated by the surface water present on the Rockland landscape. Gifford's observation echoes an earlier one by Griswold (1898), and reinforces the concept of using the ground surface elevation at the location of the pre-drainage landscape edge as an estimate of the mean water elevation of the Rockland Marl Marsh:

    "Back of the [Miami] rock ridge, which stretches along the coast from the region of Miami southward, is that vast territory called the Everglades. The extension of tree growth on the Everglades has been restrained by an excess of water. With drainage the hammock islands will quickly extend." (Gifford, 1904 in Gifford 1911).

41. Like Shaler (1890), Gifford found the rock surface of the Everglades Keys to be wet, and like MacKay in 1847, he found flowing underground water that reappeared as coastal springs:

    ... The rock is usually wet, even in the driest times. In fact, under the limestone ridge there are channels of water running from the Everglades and bubbling out in the form of springs along the shore of Biscayne Bay." (Gifford, 1904 in Gifford 1911, p.17).

42. Gifford's description of a hydrologic connection between the Everglades and Biscayne Bay was based on observations made before the time of writing in 1910, and thus just before the Miami River was dredged:

    "Two or three streams of considerable size disappear on the edge of the Glades and appear again in the form of big springs on the edge of Biscayne Bay." (Gifford, 1910, in Gifford 1911, p. 98).

43. S.H. Richmond of Miami, an agent for the Perrine Land Grant, located on the Everglades Keys, connected the marl transverse glades to the Everglades:

    "The low places [within Pine lands south of Miami] are grass rivers which run to the Glades." (Stewart 1907).

44. The historian Don Gaby's description of drainage efforts, 1908-1912, clarifies the fate of the rapids of the north and south forks. The south fork rapids were partially removed, but the north fork rapids simply went dry as water levels in the Everglades were lowered by the Miami Canal:

    "By [1903] there was already a plan to 'take hold of' the south fork of the river by blasting out the rapids and running a ditch westward four or five miles. That effort was delayed until August 1908, when Comfort and Huyler hired J. R. Tatum to direct drainage operations. The Tatum dredge moved up to the south fork in late 1908 or very early 1909. ... About a third of the 'falls' or rapids was removed, with a wooden dam built to retain water for the dredge." (Gaby 1993, p.129-130)

    "Excavation of the nearby Miami Canal began in May 1909. When it opened in 1912, water levels in the Everglades began to fall and soon the flow of water over the rapids of the north fork ceased. Other springs along the river and in the vicinity soon went dry also." (Gaby 1993, p.151)

    "(...This proximity of dates [of the Comfort and the Miami Canals] may explain why some older Miamians confuse the 'dynamiting' of the rapids of the south fork with those of the north fork--which were never removed.)" (Gaby 1993, p.129).

45. In the following discussion of early dredging of the Miami River (1909-1910), Parker et al. (1955) were likely referring to Tatum's dredging of the Comfort-Huyler Canal and the removal of the part of the south fork

rapids. Like Gaby (1993), Parker et al. indicate that these efforts substantially lowered water levels in the nearby portions of the Everglades:

> "However, not until 1909 was dredging begun in the Miami River. By 1910 a channel 10 feet deep had been opened through the 'fall line,' or rapids, at the head of the Miami River, and it was extended about 4 1/4 miles into the Everglades. Water that was formerly ponded in the Everglades behind the coastal ridge and stored within the rocks of the coastal ridge itself was now free to waste through the canals to the ocean..." Parker et al. 1955, p.584).

46. The following description of a decrease in mosquitoes on the Everglades Keys, written by Gifford after the early dredging and drainage, emphasizes two important points. (1) The closeness of the pre-drainage water table to the surface during the rainy season; and (2) the rapidity with which the water table must have lowered after the early drainage efforts:

> "I am glad to say there are very few mosquitoes in the Everglades. They are kept in check, no doubt, by their natural enemies, such as small fishes. The remarkable freedom of the Everglades from mosquitoes is a surprise to most people, but the fact has been known for many years. Years ago I heard the statement that the Indians always left the pineland for the Everglades during the summer to escape the mosquitoes.
>
> With the drainage of the swamp lands and the general removal of mosquito breeding and abiding places, this pest has gradually decreased in the region around Miami [i.e., the pinelands of the Everglades Keys] to such extent that what was once an almost intolerable condition in summer is not now considered a serious drawback, even by the tenderfoot." (Gifford 1911).

47. Dr. John DuPuis, a medical doctor, settled in Dade County in 1898. DuPuis' eye-witness description of lowered water levels in the Miami and Lemon City area after the opening of the Miami Canal corroborates both Gaby's (1993) and Parker et al. 's (1955) descriptions, as well as Giffords' contemporaneous account of reduced mosquito habitat:

> "Lake Okeechobee, ... serves as an elevated tank ... which, with the natural outlets of water on the eastward edge of the Everglades, kept a moisture line steady with a subsoil irrigation, and the east side of the 'Glades and the coral rock strata in the pinelands were productive as valuable farm and fruit lands.
>
> However, when the Miami Canal locks were opened in the early part of 1911, garden vegetables in the edge of the Everglades died, and some of the driven wells, 25 feet deep, went dry as far east as the Florida East Coast Railway, a distance of four miles." (DuPuis 1954 - Early medicine).

Although DuPuis' description sounds somewhat critical of the changes caused by drainage, it is unlikely to be an exaggeration of the actual changes. DuPuis understood the need for drainage, and later himself helped establish the Little River Drainage District.

48. Prior to 1911, Samuel Sanford did extensive geological fieldwork for the Florida East Coast railroad in southeastern Florida and the Florida Keys before joining the U.S. Geological Survey. Sanford wrote the following regarding the ridge formed by the Everglades Keys:

> "The rock ridges of the east coast comprise the prominent outcrops of oolitic limestone that extend from 5 miles north of Miami to Homestead and separate the great saw-grass swamp of the Everglades from the fringe of mangrove swamps and salt prairie along the western shore of Biscayne Bay. This rocky country forms part of the Biscayne pineland. ... The relations of rock ridge and prairie [i.e., Rockland Marl Marsh] along the western edge of the pineland are extremely intricate, the elevation of the outcrop falling gradually to the level of the Everglades and the pineland tapering off in a series of rocky keys or islands (of which Long [Pine] Key is the largest) that extend fully 15 miles beyond the southwest corner of the main body of the pineland. Over many square miles between Miami and Long Key and about Long Key the limestone forms the surface. North of Miami the outcrops are mantled by sand before the elevation of the rock surface has become as low as 6 feet above mean sea level." (Sanford and Matson 1913, p.51)

Sanford refers to the relation between the Everglades Keys and the Rockland Marl Marsh as "intricate" because the vegetation of the marl transverse glades closely resembled that of the Rockland landscape. In water regime, vegetation, and soil, the marl transverse glades were simply long arms of the Everglades (specifically the Rockland landscape), extending eastward between the individual Everglades Keys and out to the coastal sawgrass marshes.

49. Sanford's geological observations of the Everglades Keys are very consistent with earlier reports of underground channels, sinkholes, and "pinnacle rock" at the surface:

> "In the rocky area of the east coast the softer oolitic limestone weathers into angular shapes, producing extremely rough surfaces and making walking a task that requires constant watchfulness. The ground is strewn with loose, sharply angular fragments (products of weathering and of the disruptive power of tree roots), and fixed angular masses a foot or so high, with irregularly pointed summits and jagged outlines, vaguely suggest miniature pagodas.
>
> Hand in hand with this surficial erosion has gone underground solution. Next to the bristling rock surface, the most striking feature of the Biscayne pineland south of Miami is the presence of innumerable holes and hollows. The holes, which communicate with underground solution channels, are of all sizes, varying from not over an inch across to 20 feet or more in diameter. Besides the sharply outlined holes, there are throughout the pineland countless shallow hollows 1 to 3 feet deep and 10 to 100 feet across. A few of these hollows owe their origin to original conditions of deposition, some may be due to the overturning of trees and consequent upheaval of the rocks by roots, and others have been caused by the falling in of the roofs of subterranean watercourses." (Sanford and Matson 1913, p.52).

50. Sanford was aware of numerous springs, mostly along the eastern base of the Everglades Keys, but also one on the west side, and several submarine ones:

> "Along the rock ridges of the Biscayne pineland are a number of springs, some of considerable size. The largest noted rises on the west side of the crest of the ridges just north of Miami and flows into a swamp from Miami River. It is supplied by rainfall on the slightly higher ground of the pineland. [This may be the same spring seen by Willoughby at the end of his trip across the Everglades]. No special use is made of it. Other springs are found along the bay side, some of which may be supplied by water from the Everglades. On the property of Kirk Monroe, at Cocoanut Grove, are several springs, one or two of which emerge below tide level. A few of the bay side springs are used for domestic supplies and by fisherman. ... Their waters are clear but rather hard." (Matson and Sanford 1913, p. 289).

51. The plant ecologist John Harshberger found three vegetation communities on the Everglades Keys--hammocks, sinkholes and pineland--and one, sawgrass prairies, in the marl transverse glades separating the individual Keys. Sparse pinelands, with an undergrowth of saw palmetto and coontie, were the most prevalent community on the Keys:

> "[The] pine forest consists of an even stand of *Pinus caribaea* Morelet, the slash-pine. The trees stand rather far apart, frequently six to ten meters, thus forming an open sunlit forest. The tops are rather small and so do not cast much shade. The trees are so scattered that objects can be seen at a distance of eight hundred to a thousand meters. The saw-palmetto, *Serenoa serrulata* (Michx.) Hook. with prostrate, or underground, rhizomes, as thick as an arm, with the coontie, *Zamia floridiana* DC., form part of the undergrowth which consists otherwise of scattered small shrubs and herbaceous plants." (Harshberger 1914, p. 109).

52. Harshberger (1914) discussed the limestone sinks or pot-holes of the Everglades Keys in detail, referring to them as "banana holes" because some had been used to raise dwarf bananas:

> "The vertically walled banana holes extending down to permanent water level form natural wells, the shallow hollows are best termed pot-holes. ...
>
> The soil which fills these rock basins is a sandy loam and rich in organic matter owing to the collection of vegetal material formed under partially standing water. The edge of these sinks may be a rock rim with vertical sides, or it may blend by gradual slope with the rock surface of the surrounding pineland." (Harshberger 1914, p. 102)

Harshberger examined seventeen "banana holes" on both sides of the Florida East Coast railroad tracks, between the Naranja and Princeton stations (SE 1/4 of T 56 R 39). While studying them in mid-August, 1912, Harshberger described all but one as “filled with water.” Harshberger’s species list--ordered according to the number of banana holes in which he found them--indicate that all of the prevalent plants were water-tolerant:

> “*Sabal palmetto* (12), *Annona glabra* (11), *Chrysobalanus pellocarpus* (8), *Sagittaria lancifolia* (8), *Myrica cerifera* (6), *Persea pubescens* (4), *Vitis Munsoniana* (4), *Proserpinaca platycarpa* (4), ...” (Harshberger 1914, p. 114).

The presence of standing water, organic soil, and water-tolerant plants in these shallow sinks all reflect the high water tables formerly prevalent in the pre-drainage Everglades Keys.

53. Of the marl transverse glades (**Figure 4.30** - Harshberger Plate X, Fig.2) Harshberger writes:

> “Here [on the Everglades Keys] the otherwise continuous stretch of pine timber is intersected by transverse prairies some of them a kilometer across, which are submerged during a part of the year, thus serving as a partial barrier to forest fires...” (Harshberger 1914, p.106).

> “...the pineland is characterized by narrow prairies, the names of which from north to south are Peter Prairie, Cauldwell Prairie, Gossman Prairie, Sterritt Prairie, Long Prairie and Big Hammock Prairie. [A map of transverse glades and banana holes included in Harshberger indicates that “Long Prairie” is the same as the “Long ‘Glade” referred to in Simmons and Ogden (1998)]. The long direction of these prairies is approximately at right angles to the eastern edge of the Everglades and the Atlantic coast. They represent probably ancient drainage, or spillways, of the Everglades, and their soil is wet, saturated, or submerged with water by torrential rains. Physiognomically, such prairies (Plate X, Fig. 2) resemble the Everglades, and [J.K.] Small considers them identical with the vast saw-grass marsh to the west, but on account of their geographical location and for other points of difference, I have included them with the prairies. ... the soil of these transverse prairies is a white, calcareous marl, and if it consists largely of shells, it is known as shell marl, while that of the Upper Everglades is a black muck rich in vegetal matter. Another difference is that through natural drainage the prairie surface is dry during certain seasons of the year and firm enough for the pedestrian to walk dry shod over it. Advantage is taken of this dry period by the settlers to raise an extensive acreage of tomatoes.” (Harshberger 1914, p.177-178).

54. Harshberger’s Phytogeographic Map (**Figure 2.7**) shows Snapper Creek (Township 55, Range 41) and Black Creek (Township 56, Ranges 39-40) draining from the Marl Transverse Glades directly to the coast. Other areas of the Marl Transverse Glades discharged more diffusely into the Perrine Marl Marsh or into mangroves.

55. When first drilled in 1899, wells of the City of Miami flowed as artesian wells. As water levels in the Everglades were lowered by drainage in the 1910s, heads in the wells decreased, the wells ceased flowing and it became necessary to pump them. Further decreases in Everglades water levels and in ground water pressure heads then allowed salt water to intrude inland within the aquifer. By 1919, the intruding salt water had reached the wells (see also **Figure 3.6**):

> “In the spring of 1919 some of the wells sprung salt leaks [not “leaks;” simply salt water intrusion into the wellfield area], which gave the water supply some heavy criticism and caused prosecution of the the water company for selling salt water, which they could not help. ... When these wells were originally put down they were put below the water level where they flowed in a reservoir, as a regular artesian well, but later they had to connect pumps to these wells to get enough water for the city...” (Sewell 1933, vol 1., chapt. 6).

56. In spite of the initial drainage effects of the Miami, Hillsboro, and North and South New River Canals, there was apparently still sufficient water in the southern Everglades in the late 1910s for Everglades waters to pass eastward as sheet flow through the marl transverse glades:

> “A low rocky ridge lies between the Everglades and the Atlantic coastal shore. It projects westward far into the swamp in southern Dade County, and finally disappears in the great prairie. This ridge is cut into numerous islands, and water from the Everglades passes through the channels between out to the sea.” (Simpson 1920, p.2).

Water on all sides--the Rockland Marl Marsh to the west, the Perrine Marl Marsh to the east, and the “channels” (marl transverse glades) in between--gave the distinct areas of higher pineland the appearance of islands. This is the origin of the name “Everglades Keys.”

57. In his survey of the natural resources of southern Florida, Harper includes descriptions of the Marl Transverse Glades under two sections; the Miami Limestone Region (i.e., Everglades Keys), and the Marl Prairies:

> It [the Miami Limestone Region or Everglades Keys] is intersected by numerous tranverse glades, averaging a few hundred feet wide, some of which extend all the way through from the Everglades to the coast prairie, while others open only into the latter. These glades are a few inches or feet lower than the pine lands, and are inundated in the wettest seasons." (Harper 1927, p. 176-177).

58. Harper apparently considered the Marl Transverse Glades, the Rockland Marl Marsh, and the Perrine Marsh landscapes of this study sufficiently similar that he provided only a single “Marl Prairie” plant list, based on “observations in some of the transverse glades between Miami and Royal Palm Hammock, and the edges of the Everglades and coast prairie close by:”

> “The south end of the Everglades has a limestone or marl substrate instead of sand, and the same is true of the numerous narrow glades that intersect the Miami pine land, and the coast prairie south of it. The vegetation of these places is similar in aspect to that of the northern part of the Everglades, and other saw-grass marshes, but differs in composition, on account of the calcareous soil, and also because the water is shallower, and absent about half the time. Besides the regular marsh vegetation there are clumps of small trees and bushes in drier spots, and some aquatics in small pools, commonly known as 'gator-holes.
>
> There are many univalve shells in such places, chiefly *Ampullaria* and *Planorbis*, and some fresh-water sponges. In dry weather the ground and bases of the plants are covered with a soft calcareous deposit, which is seldom seen elsewhere.” (Harper 1927, p. 126)

Note that Harper’s observations of water depths and duration of standing water for the Marl Transverse Glades were made in the mid to late 1920s, thus after the significant lowering of the water table noted as early as 1912 (see also Chapter 3). Pre-drainage water depths would very likely have been greater; hydroperiods longer.

59. The botanist J. K. Small studied the tropical flora of the Everglades and the Everglades Keys for several decades beginning about 1900. Like Simpson’s, Small’s description helps one visualize the pre-drainage nature of the Everglades Keys; an archipelago of high points of land, surrounded on all sides by the wetlands of the Everglades or of the marl transverse glades:

> “The Everglades Keys or the Miami Limestone Region, an area of exposed oölitic limestone, consists of a chain of islands enclosed by the southern portion of the Everglades, except where some of the islands come in contact with the upper half of Biscayne Bay. The chain stretches, in crescent form, from somewhat north of the Miami River southwestward toward Cape Sable for a distance of about fifty-five miles.” (Small 1929a, p. 46).

60. Small was particularly interested in the tropical hammocks, denser areas of broad leaf trees within the pinelands:

> “This [Hattie Bauer] hammock, and more than a score similar to it [e.g., the Brickell, Caldwell, Castellow, and Nixon hammocks], are associations of tropical shrubs and trees in the pinelands of the Everglades Keys. The trees are mostly those widely distributed in the West Indies.” (Small 1929a, p.49).

61. After many years of botanical collecting in south Florida, Small became alarmed at the ecological harm being done there by drainage and by resultant increased fire frequencies:

> “...we motored to the big island east of Naranja to see if the fern still grew there. When we first happened upon this virgin island, which is fully three miles long and averages a mile in width, it was unspoiled as yet by the white man. ... This year we found houses nearly everywhere, but not a leaf of the fern! This island had been burned over many times and very likely the fern was thus exterminated. It doubtless met the same fate as in the other localities where it once grew only sparingly, for they lay in the areas of frequent fires.
>
> The prairies about the island had been fire-swept so often that very little nourishment remained in the marl. ...the stunted plants were mostly only about a half foot tall or scarcely a quarter their predecessors were wont to be several years before. Once more, it was impressed upon us that tragic

> truth: Florida is being drained and burned to such an extent that it will soon become a desert!" (Small 1929, p.47-48).

Naranja "island" is now lost within the ridge formed by the former Everglades Keys, but prior to drainage water levels in the Marl Transverse Glades were high enough to surround the area with water. It is clearly marked as an island on an 1847 plat map (Jackson 1847-T56 R39), extending NW-SE through sections 10, 15, 14, 23, 24, 25, and 26. Small (1929) indicated a similar size; three miles long by about a mile wide. Jackson labeled the surrounding Transverse Glades as "Sawgrass Prairie" and indicated pine lands on the island itself.

62. Glenn Simmons was born and raised in Florida City, adjacent to Long Glade, a marl transverse glade that connected the Rockland Marl Marsh of the Everglades hydrologically to the Perrine Marl Marsh (T 57 R 38). His description of this glade in the summers (rainy seasons) of the 1930s suggests, more than anything else, a lake. This much water, coming out of the Everglades, gives an inkling of the water levels that once were present in the Everglades:

> "Long Glade, where we lived and grew up [this description would be from about 1930], was about five miles long, ran southeast and east, and came into Florida City from the northwest. Some places were one-quarter mile wide and some only a few hundred feet. When the water rose in the summer, a glade skiff could be pushed from one end of Long Glade to the other. You could stand on the edge of Long Glade, holler at night, and the echo would rebound off the virgin pines across the glade." (Simmons and Ogden1998, p.6).

63. The changes brought to the region by drainage are so extreme that Simmon's description of the 1930s becomes difficult to imagine:

> "...contemporary life in South Florida has almost eradicated all traces of this breakaway section of the Everglades--where sawgrass marshes literally reached through the pinelands, skirting orchid-filled hammocks. Trailer parks, fast food restaurants, subdivisions, and acres of farmland now obscure this habitat that was once rich with panthers, rabbits, alligators, birds, and freshwater fish. ... A slight dip in the road or depression within a tilled field reveal to Glen the sites of plowed-over gator holes, sloughs, and finger glades. Except for these subtle indicators, the Long Glade is lost from the landscape." (Simmons and Ogden 1998, p.2-3).

64. In a comprehensive study for the proposed Everglades National Park, Daniel Beard described the Everglades Keys, noting that this name appropriately reflects the impression of the region as "a chain of keys surrounded by sawgrass prairies." Beard's description of agriculture on and between these Keys suggests a previously wet area made arable by progressive drainage. In 1938, the Marl Transverse Glades were still too wet to cultivate in the wet season:

> "Stock raising in the Miami oolite area is restricted to the [Transverse] glades, or prairies. ... At one time, agriculture was a difficult and precarious undertaking [on the Everglades Keys]. In the past few years, though, drainage operations have reduced the flood risk during the dry season (nothing is grown during the summer on glade lands), transportation facilities have been improved, fertilizers became available, and there has been a mushroom growth of a metropolitan market nearby. So, at the present time the oolite is scarified in the high pineland (Everglades Keys) and many fruits are raised... High pinelands tomatoes are raised during the later summer under trees while the glades are still wet. In the dry season, the many large and small glades which are situated between the Everglades Keys are cultivated. Potatoes, tomatoes, and string beans are the main crops with broccoli becoming more of a favorite lately." (Beard 1938, p. 9).

65. In a section entitled "The Atlantic Coast Strip and Miami Rock Ridge," Davis gives a description of the Everglades Keys that is very similar to Small's. As late as 1943, the marl transverse glades apparently still flooded sufficiently to retain the island-like nature of these Keys:

> "The rock ridge then extends south of Miami curving west and inland from the coast projecting as a number of elevated rock islands in the southern part of the Everglades basin. These slightly elevated rock islands across the southern part of the Everglades are generally known as the "Everglades Keys" because they are islands of pine or hammock forests often surrounded by water during wet seasons." (Davis 1943, p. 53).

66. Early accounts of lowered water tables suggest that many of the springs associated with the Everglades Keys ceased flowing in the 1910s, very shortly after completion of the major drainage canals. There is no doubt that they had ceased prior to 1947:

    "Springs in Dade County, such as Mangrove Spring at Coconut Grove, Miami Springs, and various bayside springs which were reported to flow in earlier years, no longer flow owing to lowered water tables in the area." (Ferguson et al. 1947).

67. A ledge at 9 to 10 feet above msl, continuous along the back of the Everglades Keys, is equally visible on an independently surveyed map (Corps of Engineers, Jacksonville District 1960b).

68. Parker et al. (1955):

    "During wet years, all the canals in the transverse glades overflow." (Parker et al. 1955, p.509)

69. A soil survey of Dade County published in 1958 mentions lowering of the water table on the pinelands of the Everglades Keys and in the marl transverse glades, even before construction of the comprehensive South Dade Conveyance System of canals:

    "In the east [part of Dade County] many canals have been dug to drain the land. Most of these canals have no mechanical structures to control the flow of water, and they have lowered the water level of adjacent lands considerably. As a result, irrigation is often necessary on the higher lying pinelands, and occasionally on some of the lower lying lands." (Gallatin et al. 1958).

70. The following observation, that flooding in the Marl Transverse Glades persisted into the 1960s--in spite of water tables lowered by drainage (Gallatin et al. 1958)--implies that pre-drainage water depths in the Marl Transverse Glades were deeper than in the 1960s:

    "The transverse glades flooded seasonally, at least in wet years, into the early 1960s. [The] C-111 [canal] and the South Dade Conveyance System ended that." (written personal communication, Bill Robertson, 1997).

71. Kohout studied submerged, offshore freshwater springs for a number of years. In a paper relating biological zonation to freshwater flow through the permeable bottom sediments of Biscayne Bay, Kohout and Kolipinski (1967) discuss the history of springs offshore from the Everglades Keys at Cutler (Section 26, T 55 R 40):

    "Small springs, recognized by the birefringent mixing action of the waters, are reported by local residents to have existed as far as three-quarters of a mile seaward from the shoreline in the Cutler area. Near shore, freshwater springs welled up through the bottom of Biscayne Bay as large boils; one such potable spring just north of the study site is marked by the words 'fresh water' on Coast and Geodetic Survey Navigation Chart No. 166, published in 1896 [Coast and Geodetic Survey (1896)]. The early mariners and spongers customarily lowered kegs to the spring orifice to obtain fresh drinking water." (Kohout and Kolipinski 1967, p.488).

72. The authors also note the changes with the progress of canal drainage, from 1907 through the time of writing:

    "These canals lowered the water table about six feet in the Everglades. As a result of the reduction in freshwater head, many springs ceased flowing and these same orifices now serve as avenues by which salt water intrudes into the Biscayne aquifer. Near shore, however, some of the springs still exist, but their flows are greatly reduced."(Kohout and Kolipinski 1967, p.488).

73. In a study of hydrologic effects of water management in southeastern Florida, three hydrologists concluded that pre-drainage water tables in the Everglades Keys were near or at the land surface:

    "Scattered records of water levels and reports of general hydrologic conditions in different areas, as reported by Parker, Ferguson, Love, and others (1955, p.500-585), indicate that water levels were near or at the land surface along much of the coastal ridge area before drainage. (Leach et al. 1971, p. 102).

    This would be consistent with other historical observations of water in sinkholes, of sheet flow through the Marl Transverse Glades, and with the numerous observations of organic soil among the pinnacle rock of the Everglades Keys. In a rock substrate as porous as the oölite of the Everglades Keys, it is likely that water tables near the land surface could have been maintained only by high surface water levels in the Everglades. Before drainage, wet season water tables on the individual Everglades Keys would have been supported on the west sides by surface water of the Rockland Marl Marsh, between the Keys by sheet flow of water in the Marl Transverse Glades, and on the east sides, by local surface water in the Perrine Marl Marsh.

74. Leach et al. (1971) observed flooding conditions in the Marl Transverse Glades during extremely wet conditions:

> "The high-water conditions resulting from two tropical storms in September 1960 are shown in figure 31. Water-level peaks exceeded 10.5 feet above mean sea level in the high parts of the ridge, sheet flow occurred through the transverse glades, and much of the coastal marsh east of the ridge was flooded." (Leach et al. 1971).

75. Craighead noted that many of the best preserved remanants of natural vegetation occurred in areas that were protected from fire:

> "The Pinelands, Area V, are normally fire resistant and contain many hammocks of tropical hardwoods as well as some 100 endemic species, adapted to survival in repeated light fires. But when these hammocks burned while the duff and peat were dry great damage resulted. There are now only a few of these unique plant communities remaining of the thousand present at the beginning of the century. The best of these survivals are not in the Park but near the early settlements where fires were discouraged as part of home-site protection." (Craighead 1973, p. 57).

76. Three studies of the plant ecology of Castellow Hammock (Sec. 17, T 56 R 39) span fifty years, and convincingly document the effets of declining water tables on a representative Everglades Key (Phillips 1940, Alexander 1967, and Molnar 1990). This tropical hammock is marked also on Jackson (1847-T56 R39). [According to Molnar] Phillips (1940) reported year-round moist conditions within sinkholes and a luxuriant, diverse growth of ferns lining sinkhole walls at Castellow Hammock. In contrast, fifty years later Molnar recorded very different conditions:

> "Most of the sinkholes at the study site in 1985 were characterized by extended dry periods and a general paucity of ferns." (Molnar 1990, p.21).

77. Molnar and Alexander both ascribe the vegetative changes to water tables lowered by drainage:

> "Alexander (1967) suggested that a decrease in species diversity has occurred in Castellow Hammock since 1940 as a result of frequent, prolonged droughts caused by general lowering of the water table in South Dade County. Hydrological data support Alexander's premise of lowered groundwater water levels. Parker, Ferguson and Love (1955) showed that, as a result of the construction of southern Florida's primary drainage canal system, groundwater levels declined 150-180 cm in many portions of the Miami Rockridge [Everglades Keys]. More specifically, in the area of the study site, pre-1961 maximum yearly groundwater levels averaged 50 cm higher than post-1961 levels (Dade County, 1983)." (Molnar 1990, p.21).

Western Flatwoods and Big Cypress

General Description

Pine flatwoods and the Big Cypress swamp formed the western border of the Everglades. Like the Eastern Flatwoods, the Western Pine Flatwoods have a very slight regional slope. Local shallow depressions collected water during the wet season; elevated areas were drier. As a result of being more topographically diverse than the adjacent Everglades peatland, this landscape supported a mosaic of diverse vegetation including pinelands, saw palmetto, ponds, cypress heads and long cypress strands. Generally, flatwoods were predominant to the north and cypress was predominant to the south. Duever (2001) mapped the natural vegetation of this area using GIS analysis combined with historical information.

This study did not conduct an independent analysis of this area. However we provide a list of historical observations in the form of endnotes that present a qualitative impression of water regimes in areas of the Western Flatwoods and Big Cypress that border the Everglades. The hydrologic separation between the Everglades and Big Cypress Swamp was not sharp, particularly during wet years. Historically, water from the northern part of Big Cypress flowed through Mullet Slough (Township 50) into the the Everglades. A discussion of this and other Everglades inflows and outflows will follow in Chapter 5.

Western Flatwoods Endnotes

1. During the Second Seminole War, G.A. McCall led troops through the Western Flatwoods south into the Big Cypress. A series of letters written to his brother from the field during the winter of 1841 and later published in 1868 (McCall 1974) provide vivid insights into pre-drainage conditions in these landscapes bordering the western side of the Everglades. Although somewhat less inundated than Big Cypress, the Western Flatwoods were also covered with water in most places at this time:

   > "We had scarcely advanced [southward, on Dec 3rd, 1841] out of sight of our Post, [on the "Carlos-a-hatchee" (sic)] before we got into water, and were seldom out of it again for two days and a half, when we reached the Cypress. Thus far we had passed through a pine and palmetto country with firm sand bottom. Our progress was slow as we marched through water from six inches to two feet in depth. We passed occasional swells in the land that were not under water; these (though rather of the moistest) served for resting-places, and sometimes for encamping-grounds, when no dry land was to be found." (McCall 1974, p. 381).
   >
   > "The general character of the mainland south of Carlos-a-hatchee is one vast plain of scrub-cypress and stunted pine, all under water, from three to twelve inches, intersected by numerous deep channels and heavy cypress-swamps, dotted with small islands or dry spots of cabbage-tree and pine, with here and there a large dry hummock, or long pine ridge." (McCall 1974, p.392).

2. The following quotes trace a part of McCall's progress through Big Cypress:

   > The first step [into the Big Cypress, 30 miles south of the Caloosahatchee R.] was knee-deep; but suffice it to say, that in two and a half days, sometimes putting six men to each mule to drag him through a bog, we reached this place [8 miles north of the Prophet's Island (in Big Cypress?)], a distance of twenty miles." (McCall 1974, p. 382).
   >
   > … I steered south [from the Prophet's Island], and after wading about two miles, came in sight of a live-oak hummock, lying eastwardly; for this I steered, and soon saw signs of Indians. (McCall 1974, p. 382)
   >
   > … "wherein I informed you that, after finding that the Prophet had abandoned his village and fields, which were snugly ensconced in a heavy cypress swamp, the island on which he had established himself containing about thirty acres of very rich land, and being surrounded by a deep boggy girdle, where the water was nearly waist-deep, I made a little excursion still further south, ..." (McCall 1974, p. 385)

3. This letter from McCall to his brother suggests that designation of Big Cypress as an "upland bordering the Everglades" is perhaps a misleading characterization of pre-drainage conditions. Water levels, at least in this year, appear to have been very similar in depth to those found in the sloughs of the Everglades Ridge and Slough landscape:

   > "You must recollect we had been marching two entire days through a country entirely under water, except occasional small islands of from one to two or three acres. Soon after we started, the third morning, the air being cold enough to make one's fingers tingle, our trail turned into the Big Cypress, and we stepped from water ankle-deep to water knee-deep, and which after some time

reached our waist-bands. In a dark cypress like this, where the direct and cheering ray of the sun never finds its way, the water is proportionally colder, and for five mortal hours, by watch, did we toil through this water, never less than knee-deep, without finding a resting-place, except once for a short time we contrived to cluster on a little island one hundred yards square, which halt was not included in the five hours marching-time. You cannot form the most remote idea of the region we passed through, and which the Indians doubtless thought would prove an impassable barrier. The bottom was boggy, and the water was filled with old logs, snags, cypress-knees, and vines innumerable. The cypress, of towering height, was intermingled with cabbage-trees of several distinct species;..." (McCall 1974, p. 387).

4. At a location within the Western Flatwoods about three miles west of the Everglades (T47 R33), U.S. Surveyor Apthorp noted the dramatic variation in hydrology between dry and wet season; from "perfectly dry" to "whole region under water," and with wet season water levels sufficiently deep to use dugout canoes: A similar description was given for the Brown's Store area (Kersey 1975):

   "[In T47 R33, S36; about 3-3.5 miles from the edge of Everglades] . . . came upon an Indian hut or shelter of palmetto, evidently inhabitated,... Found not far away on the open prairie, perfectly dry now, a dugout canoe, which the Indians use during the rainy season when this whole region is under water. The huts stood in a hammock island. [Further south] the Swamp becomes impracticable, and I did not carry the lines any further south. Friday, May 17th [1872]." (Apthorp 1872-T47 R34, p. 220-221).

5. In mid February of 1874, the U.S. Surveyor J. S. Stearns gave an additional description of Township 47, Range 34, finding it generally wet:

   "East ... between sections 4 and 33 [along South boundary
   ...Land low 3rd rate prairie with scrub

   February 17th, 1874

   It is impracticable to run further East as there is a vast field of overflowed Land with dense sawgrass as far as the Eye can reach."

   …North between sections 33-34

   Land low 3rd rate prairie with some water on surface -- Impracticable to the North and East on account of water and sawgrass."

   …February 17th, 1874

   East ... between sections 21 and 28

   30.00 To overflowed prairie

   40.00 ... in water 12 in. deep -- could not raise Mounds. It is impracticable to proceed any further East, on account of sawgrass and Water which extends as far as East as the Eye can reach. All low prairie 3rd rate low and wet." (Stearns 1874-T47 R34, p. 241-246).

6. Surveyor Stearns' general description of the Township further clarifies the hydrologic connection between the Western Flatwoods and the adjacent Everglades: seasonal overflow in the sandy Flatwoods, and apparently year-round water on the peat soils of the Everglades:

   "General Description

   The quality of the Land in this Township is 3rd rate, the whole area being low and generally poor sandy soil, Except in Northwest portion, where the land is much higher prairie and considerable better soil. The larger part of the land overflows in the wet season, but drains off after cessation of the rains.

   I find the Eastern portion to be one vast sea of overflowed land, as far as the Eye can reach to the Eastward and is known as the Everglades it being impracticable to survey on account of the water and sawgrass." (Stearns 1874-T47 R34, p. 264-1/2).

7. The April 28, 1903 diary entry of Episcopalian Bishop William Crane Gray, mentioned in Kersey (1975), describes a visit to Brown's Store, located within the Western Flatwoods within a few miles of the western edge of the Everglades:

"Tuesday, 28--We slept well in our 'glades cottage' [at the Everglades Cross mission, three miles northwest of Brown's Store] last night, and after an early breakfast drove three miles through water nearly all the way to the 'landing place' where 'Bill Brown' has his store... The house was small and entirely surrounded by water, a number of Indian canoes being fastened at the very door. [After dinner] Frank and Edwin took me out in an Indian canoe far out into the Everglades, where we gathered some beautiful lilies and other flowers [used at the service the next day]." (Kersey 1975, p. 68).

8. Kersey's description helps place Brown's Store in context and helps clarify that the surface water of the Everglades (that is, the unforested, peat soil-based area) extended westward into the Western Flatwoods:

   "[The new Brown's Store / 'Boat Landing'] was the perfect location from which to reap the bounty of the vast, watery hunting grounds which were the Everglades before the drainage programs had begun. The 'Boat Landing' was strategically located at the head of canoe navigation on the western edge of the sawgrass... With the coming of Brown to the water's edge, the hunters... could work the whole width and breadth of the Everglades country south of Lake Okeechobee and never be more than a day or two away from a buyer and source of supplies. The volume of alligator hides, otter and raccoon skins, as well as egret and other plumes coming through the 'Boat Landing' priot to 1908 was high, and these were prosperous years for Brown." (Kersey 1975, p. 61).

9. In 1907, John Stewart, an agricultural engineer, recorded observations from individuals he considered to be reliable, long-term observers of South Florida. The following is from J. F. Shands, "ex-County Surveyor and Superintendant of Lee County Schools:"

   "There is a slight divide beginning near Lake Hicpochee and extending south near Rock Lake to the Shark River, this divide separating the Big Cypress from the Everglades, but at times of high water, the water in the Big Cypress and Everglades is thought to be continuous. On account of the flat surface no deep or disastrous floods can occur, but nearly the entire surface may be covered over with a thin sheet of water during the rainy season. The floods kill the wild grass and young timber and the object to be attained in drainage is to relieve the country of the rainfall in a few days so that it will not lie on the ground for weeks as it does at present." (Stewart 1907, p. 37).

10. According to Stewart, I.S. Singletary, an "Agent [of the] U.S. Dept. of Agriculture," was "raised in southern Florida and has been a resident of Lee County for 32 years. In this time he has been engaged as a cattleman, hunter, guide, county assessor, county collector, timber estimator and surveyor." The following are excerpts from Singletary's descriptions of some of the main components of these landscapes:

   "Prairies.

   The Florida 'prairie' is open, flat land covered with wire grass [*Aristida* spp.] and saw palmetto and dotted with thickets or 'heads' of oak and cabbage palm, and pine islands. ... Water is found over the prairies in numerous ponds, which in the wet season -- June to October -- are full of water. From October until the rains begin again, the ponds shrink, so that the spring finds them no more than small water holes . . . .

   Pine Islands.

   Pine islands are isolated clumps of pine timber, ranging in size from a grove of perhaps 30 trees to a stand covering many hundred acres, scattered throughout the open prairie and cypress country. The soil in these islands is high, dry, sandy and unproductive. The name 'island' is applied to them because they stand out from the flat prairie as an island from the sea. . . .

   Cypress Heads.

   Like pine islands, cypress also appears in isolated clumps, but these 'heads' are always a sure sign of low wet ground, having more or less water in them all the year. The cypress growth in such a head is usually small.

   Ponds.

   The copious rainfall of the wet season drenches the whole land and every depression, little or big, becomes a natural reservoir, storing the water in quantities that may last all the year. Around and in these pools is found a luxurious growth of grasses, whose decay through centuries has left in them a characteristic deposit of rich muck. The different species of grass do not flourish together, and so each has occupied certain ponds exclusively, so that the ponds may be differentiated by the kind of vegetation growing in them, as follows:

A. Saw grass pond. The saw grass is found in either muck or marl, and grows from 2 to 12 feet high, though the latter height is unusual, a little over 6 feet being a mean. It is often so rank as to be impenetrable. The saw grass often grows around the edges of other ponds or heads.

B. Popash [*Fraxinus caroliniana*] pond or head. These ponds found everywhere throughout the region, are usually very low, containing as much as 2 feet of water during the summer. In them grows the popash, a low scrubby tree, seldom growing higher than 25 feet. It occurs in clusters, often 12 or more branches from a single root. The trees are spaced well apart, but so thick a covering do they form that no vegetation can grow underneath. Air plants grow upon the branches, but moss is not found. The popash is a soft white brittle ash.

C. Flag Ponds. These are found in two varieties, fire flags and common or pond lily flags.

a. Fire flags [*Thalia geniculata*] are a species of lily, growing sometimes 10 feet tall, and having a leaf almost exactly similar to that of the banana tree. They indicate a very rich as well as low, soil.

b.Lily flags [*Nuphar luteum*] resemble the ordinary stiff stemmed pond lily of the North, and the ponds where they occur are as a result more open than any of the others. They occur either in sand or muck.

D. Maiden cane [*Panicum hemitomon*] ponds. These ponds may be either sand or muck, but usually are white sand. This indicates soft sweet water, and it is to these ponds that hunters and others turn to seek good water, which may always be obtained at a depth of a few feet. The maiden cane is a tall very slim, and graceful grass, and cattle are very fond of it. It grows from 2 to 6 feet high, and has been baled with good results for fodder, but only to a limited extent." (Stewart 1907, p.4-6).

11. Samuel Sanford, a geologist, naturalist, and careful observer of South Florida, includes the following description of the Western Pine Flatwoods in his section on "Flatlands:"

"On the west coast the surface of the country between the Everglades and the Gulf is even more monotonously level than that of the east coast and the relations of swamp and dry land are more irregular. Much of the pine grows in patches and strips, in places miles in extent, separated by cypress swamps. In consequence, the timberclad flatlands of the west coast are described as pine islands and cypress strands. Prairies are scattered through or fringe the pinelands, and toward the Everglades and north of the Big Cypress great stretches of prairie make excellent cattle ranges." (Sanford in Matson and Sanford 1913, p. 50).

12. The botanist and landscape ecologist John H. Davis, Jr. suggests that the western bordering landscapes had not changed much by the early 1940s:

"Some descriptions of the pinelands, cypress forests, and many ponds and swamps in the areas to the west of the Everglades picture them very similar to present conditions. ... The changes in the Big Cypress region have been very few." (Davis 1943, p.28).

13. The naturalist Barbour's reference to burning of cypress trees probably refers more to cypress on the edge of the Everglades, or dwarf cypress extending into the Everglades than to the Big Cypress itself:

"There are still plenty of cypress trees to be seen from [the western portion of] the Tamiami Trail, pale gray ghosts in winter, but fascinating green forms in spring. The draining of 'the Glades' has brought about the destruction of many, by fire, and at best this was never a region of stands of those giant cypress trees that once existed in other parts of the state. Now the only evidence of the giant cypress is in the form of great dugout canoes tied up at Indian camps along the Trail. No more of thes boats will ever be made; most of them are very old. But they show what the cypress trees once were." (Barbour 1946).

14. Jack Moller, an outdoorsman, conservationist and school principal with extensive field experience in Big Cypress since the 1950s, tends to agree with J. H. Davis that the vegetation of Big Cypress has not changed much since the 1800s: "Pine islands are still pine islands, oak hammocks are still oak hammocks. Cypress most likely hasn't changed much either." Jack noted two exceptions, namely an increase in "Dog's hair cypress," i.e., dense stands of cypress seedlings encroaching into marl flats; and aggressive encroachment of myrtle and milder encroachment of pine seedlings into marl and dwarf cypress flats. Moller ascribes the encroachment of myrtle and pine to a reduction in hot fires and reduction in flooding.