CHAPTER 2- SOURCES AND GENERAL METHODS

OVERVIEW OF METHODS

Ecological characterization of a region ideally begins with field surveys. This is no longer possible for the pre-drainage Everglades, so we conducted the necessary surveys indirectly, through the eyes of others. To accomplish this task, a variety of historical sources were used, including the descriptions, maps, measurements, routes, and photographs of first-hand observers such as early explorers, soldiers, surveyors, and scientists. As many sources as possible were located, catalogued, and annotated.

Comparing these sources with historical and modern maps, we were able to reconstruct the nature and extent of the various landscapes present within the Everglades prior to drainage (1820–1880). Consistency between diverse historical sources provided confidence in the accuracy of our reconstruction of the individual landscapes. The importance of constant cross-checking among multiple sources cannot be overemphasized. The approach was multi-disciplinary — combining information and concepts from soil science, plant ecology, hydrology, and environmental history.

Numerous historical, and more recent, maps were enlarged or reduced to obtain common scales, and overlaid to search for spatial patterns. In almost all cases, patterns were easily recognized, even between maps produced with very different technologies and as much as 150 years apart. For example, the Marl Transverse Glades — natural cuts between the higher-lying Everglades Keys — were drawn on township plat maps by John Jackson in 1847 (**Figure 2.1**); these same cuts are clearly recognizable on a drainage map drawn 60 years later (**Figure 2.8**) and on a soil map published 100 years later (Jones *et al.* 1948).

At the scale of the entire Everglades basin, overlays of maps of bedrock topography, ground surface topography, soils and vegetation (**Plate 3, Plate 4**, **Plate 5**) revealed clearly related spatial patterns. Combined with soil surveyor's descriptions of individual soil types, these overlays helped us develop an understanding of the different soils of the Everglades, and of the influence of drainage upon them. With an understanding of the adjustments necessary to account for drainage effects, the soil map made of the Everglades Drainage District in the 1940s (Jones *et* *al.* 1948) became a key tool for interpreting other historical observations of the pre-drainage Everglades.

Repeatedly, observations from narrative sources, expeditions, government township survey notes, etc., were first located on the soil map and then evaluated within the context suggested by the surrounding soil types. Similarly, observations were compared with township survey plat maps from the 1840s and 1870s. These often indicated vegetation types — "Pine [forest]," "Cypress," "Sawgrass," "Everglades," etc.— and showed locations of topographic highs and lows, Indian settlements, and natural drainage ways.

This process of using maps to provide context for individual observations aided in the delineation of pre-drainage landscapes, as well as in the estimation of hydrologic characteristics for each of these landscapes.

Our landscape classification system tends to follow names used by authors prior to the 1950s, due to our stated focus on the historical sources of information concerning the pre-canal drainage Everglades, rather than on modern scientific analyses. Similarly, we use the soil nomenclature from the Jones *et al.* (1948a) soil map, recognizing that it differs from contemporary soil taxonomy, but also noting that Jones *et al.* (1948b) remains, at present, the only comprehensive soil classification of the entire Everglades basin.

OVERVIEW OF PRIMARY SOURCES

A diverse range of source materials was consulted. These materials included vegetation, soil and topographic mapping studies from the 1940s, government township surveys, accounts of expeditions into the Everglades, early maps, narrative accounts by persons acquainted with the pre-drainage Everglades, early photographs, construction surveys and profiles, and scientific studies (pre-drainage as well as post-drainage). Each category of source material was analyzed differently, as discussed in the following sections.

The timeline shown in **Table 2.1** gives an overview of the time of observation of the main sources used in this study, and their relation to the timing of drainage milestones.

Table 2.1 Chronology of Everglades drainage activities (left column) and key sources used in this study (right column).

Drainage Activity/Relevant History	Year	Information Source
	1775	B. Romans, *Concise Natural Hist. E. and W. Fla.*
	1823	C. Vignoles, *Observations Upon the Floridas;*
	1823	William Cooley settles on the New River
	1837	John L. Williams, *Terrritory of Florida*
2nd Seminole War	1835-42	
	1840-1	Col. Harney Expeditions
U.S. Gov't Resolution to reclaim Everglades	1845	Geo, MacKay Township Surveys
	1847	John Jackson Township Surveys
	1848	Buckingham Smith Report
Swamp & Overflowed Lands Act passed	1850	
Internal Improvement Fund established	1855	
	1856	J. C. Ives Military Map
	1870s	M. Williams Township Surveys
Disston drains 50,000 acres in Kissimmee Valley	1880s	
	1883	Times-Democrat Expedition
Canal dredged from Lake Okee. to Caloosahatchee	1884	
	1885-6	Mickler Township Surveys
	1892	Ingraham Expedition; Kraemer (1892) Map
	1897	Willoughby Expedition
Creation of the Everglades Drainage District	1905	
Miami, No. New River and Hillsboro Canals begun	1906	
	1907	John Stewart Report
Opening of Miami Canal Locks	1911	Senate Doc. 89, "Everglades of F1orida"
	1911-18	Many TIIF Township Surveys
Completion of North New River Canal	1912	
Last uninterrupted natural overflow from Lake 0.	1912	
	1913	Harshberger Vegetation Map
	1915	Baldwin and Hawker Soil Map
West Palm Beach Canal	1917	John King surveys & reports
Tamiami Trail & Canal completed	1928	
	1940	First aerial photos of whole Everglades
	1943	John Davis Vegetation Map
Impoundment of WCAs by levees	1954-63	
	1948	Jones *et al*. Soil Map
Levee 30 constructed; southward flow pushed west	1953	
Levee 67 constructed; southward flow pushed west	1963	

The major phases of these events include early descriptions of the Everglades that were recorded prior to 1840; expeditions, surveys, and maps that were conducted and prepared from 1840 to 1910; canal construction North and West of Lake Okeechobee in the 1880s; and construction of major canals during the period from 1906 to 1963. Major scientific investigation of the Everglades began in the middle of the 20th Century.

Mapping Studies from the 1940s

The decade 1938–1948, here referred to as the 1940s, is a key period in the scientific investigation of the Everglades. Three major efforts, each distinguished by extensive field work and a synoptic analysis of the Everglades as a whole, occurred during this period. John H. Davis, Jr. of the Florida Geological Survey described, classified and mapped the vegetation of south Florida (Davis 1943a, b). A multi-agency team of researchers from the University of Florida Agricultural Experiment Stations, the U.S. Dept. of Agriculture-Soil Conservation Service, the U.S. Geological Survey, and the Everglades Drainage District surveyed surface elevations, bedrock elevations, classified and mapped the soils and mapped (in simplified form) the natural vegetation or human land use (Jones *et al.* 1948 a, b). The U.S. Geological Survey, under the direction of Gerald Parker and numerous colleagues, conducted extensive hydrological studies, particularly in the southern Everglades (Parker *et al.* 1955).

All three studies made use of the earliest set of aerial photographs of the Everglades (USDA-SCS 1940). This series of aerial photos, covering the whole of the Everglades and the Atlantic Coastal Ridge, is a key source of information. In spite of some degree of development for urban or agricultural land use, and in spite of hydrologic changes, many pre-drainage landscape patterns are still visible in these photographs. Earlier aerial photographs of the coastal portions of South Florida exist (U.S. Coast and Geodetic Survey 1928), but these do not include the interior (main body) of the Everglades.

We note that the index for these aerial photos was compiled in early June 1940, implying that the area was flown during the dry season, sometime between January and May 1940. In terms of rainfall, 1940 and 1939 were average years; 1938 was one of the sixth driest out of the 100 year record. The photos therefore can be expected to reflect seasonally dry conditions in addition to a relatively dry period of record. The soil and landcover maps produced by Jones *et al*. (1948b) (**Plate 3, Plate 5**), and the vegetation map produced by Davis (1943b) (**Plate 4**) are particularly important to the research presented here, and will be referenced repeatedly. Their importance stems from two sources: (1) the timing of the field research in relation to the chronology of drainage and drainage effects, and (2) the researchers' approach to classification of vegetation communities and soil types.

These two maps were made 60 years after managed drainage began, and approximately 25 years after completion of the four major canals — the West Palm Beach, Hillsboro, North New River, and Miami. As described in **Chapter 3**, the researchers were mapping an altered ecosystem. While it would have been ideal if the mapping had taken place prior to any drainage, these maps are nevertheless very useful, for three reasons. First, because at the time of mapping in the 1940s, agricultural and urban land use of South Florida was still restricted mostly to the upland areas. Much of the Everglades therefore remained undeveloped and contained some form of native, albeit partially disturbed, vegetation (USDASCS 1940). Second, the extensive system of levees that would later impound the Everglades into a series of basins had not yet been constructed. The third and most important reason relates to lag time required for Everglades vegetation and soils to change in response to the long term hydrological stress imposed by drainage. This lag is not sharply defined and may require decades or longer depending on the characteristic temporal scale of the variable for change (Gunderson 1994). For those areas with longer lag times, this means that a map made 30 years after drainage began will still contain substantial information concerning pre-drainage conditions. The process of adjusting (hindcasting) those portions of the Jones *et al.* (1948b) map that were affected by drainage is discussed in more detail in Chapter 4.

The other important aspect of the Davis (1943a, b) and Jones *et al.* (1948a,b) maps is their approach to classification. These classification systems were clearly based on consideration of the Everglades as an entire ecosystem. Field observations from all parts of the Everglades and surrounding uplands were evaluated to develop the descriptions of vegetation communities and soil types, from the western border with the Big Cypress Swamp to the eastern border along the Atlantic Coastal Ridge, from north of Lake Okeechobee to the mangrove fringe along the southern coast. Unfortunately, subsequent mapping efforts lack this ecosystem-wide perspective.

Soil Map

Because vegetation responds more quickly to hydrological change than soils, soil information was weighed more heavily throughout this study as a basis to estimate pre-drainage conditions. We relied extensively upon the Jones *et al.* (1948b) soil map. This map (shown reduced in **Plate 3**) and an associated report, "Soils, Geology, and Water Control in the Everglades Region" (Jones *et al.* 1948a), arose out of a major research effort conducted in the Everglades from 1938 to 1948, involving the Soil Conservation Service, the U.S. Geological Survey, the Everglades Drainage District, the University of Florida Agricultural Experiment Stations, and the Everglades Fire District (Evans and Allison 1942; Henderson 1942; Davis 1943c; Stephens 1943a; Parker and Hoy 1943; Stephens 1943b; Gallatin and Henderson 1943).

The Jones *et al.* (1948b) soil map encompassed the former Everglades Drainage District — specifically, all of Broward County, most of Palm Beach and Dade Counties, the western portions of Collier and Hendry Counties and portions of Monroe, Glades, Highlands, Okeechobee, Martin, and St. Lucie Counties. The map consists of 38 sheets at a scale of 1:63,360 (1 inch = 1 mile). Map sheets are labeled as "complying with the national map accuracy requirements." The mapping was based on a combination of aerial photography at a scale of 1:40,000 (USDA-SCS 1940) and extensive field surveying:

> "Land surface elevations were determined to 0.1 foot at 330-foot intervals, and depths of peat soil were measured by probings at intervals of 660 feet. ... Approximately 2,000 miles of levels were run by Soil Conservation Service engineers.
> ... The intensity of the [field survey] coverage varied greatly, according to nature of the land, existing use, and probable capability for use. In the areas of peat and muck soils, the land now cultivated was investigated in every field where necessary, to locate significant boundaries. On the open sawgrass plains, east-west lines were run every 6 miles and supplementary north-south lines were run wherever additional information appeared to be necessary. .... Borings into the peat and marl were made with a 2-inch auger every half mile. The samples obtained were examined and were preserved for further observation and analysis wherever the material differed appreciably from that obtained in nearby borings." (Jones *et al*. 1948a)

Digitization of the map in 1995 for the present study confirmed the high degree of horizontal surveying accuracy. Map information collected by the Jones *et al*. surveyors concentrated on "soil conditions that influence the use and management of the land:" soil type (64 categories), soil depth (4 categories), ground slope (3 categories), and vegetation cover (7 categories) or land use (5 categories). The collected data formed the basis for a soil map as well as for a map of native vegetation for those areas still undeveloped in the 1940s (**Plate 5**). Soil types were characterized as to texture and structure of the surface soil and subsoil, soil depth, organic matter content, pH, permeability, and type and depth of underlying material.

Soils were classified according to the system prevalent at the time (USDA 1938). Henderson (1942), a member of the Everglades Survey, lists factors important in the classification. The relation to the present soil classification for Palm Beach County (USDA-SCS 1970; McCollum *et al.* 1978) is discussed in McCollum *et al.* (1976). Although classification concepts have changed somewhat since the 1940s, the Jones *et al.* (1948b) soils map still stands as a remarkably insightful and comprehensive description of the Everglades region, and remains the only soil map covering the entire Everglades Basin.

<u>Soil Groups</u>

We aggregated the 64 soil types identified in Jones *et al.* (1948b) (**Appendix K**) into 14 "Soil Groups" representing the principal wetland and adjacent upland soils (**Table 2.2).** The aggregation was based on similarity of the soil profiles, topography and the location of the soils within the Everglades region. In grouping the wetland soils, similarity of the upper horizons of the profiles was emphasized over the lower horizons, since the upper layers were more recently deposited. Three general physiographic regions were readily discernible: wetlands, uplands, and areas of intermediate hydrology. Identification of wetland soils (Okeechobee Mucks, Okeelanta Peaty Muck, Everglades Peats, Loxahatchee Peats, Ochopee Marls, and Perrine Marls soil groups) and of upland soils (the Upland Sands and Rockdale Complexes soil groups) was relatively straightforward.

Identification of the more complex intermediate soils (Hialeah Mucky Marl, Davie Mucky Fine Sands, Davie Fine Sands, Wet Sands and Rockland soil groups) required consideration of both soils that were originally of intermediate hydrology and soils that had become artificially intermediate due to drainage-induced peat oxidation. These intermediate soils occurred on the western and eastern edges of the Everglades basin, where the open Everglades met the adjoining forested uplands. The soils in these areas have been the most severely influenced by drainage. The process of change that took place in the intermediate soils is discussed in **Chapter 3**; the conceptual reversal of these changes to produce a hindcast map of the soils as they likely appeared in the 1850s is discussed in **Chapter 4**.

Table 2.2 Definition of the Soil Groups used in this study, based on Jones *et al*. (1948a,b); and relation of soil groups to the vegetation communities mapped by Davis (1943a; 1943b), and to the physiographic regions described by Gallatin et al. (1958). (For detailed descriptions of soil types in Jones *et al*., (**Appendix K**).

Name of Soil Group	**Soil No. (Jones *et al.*)**	**Vegetation Types(Davis, Plate 4)[1]**	**Physiography (Gallatin *et al.*)**
Okeechobee Mucks	20,21	Custard-apple Zone	————-
Okeelanta Peaty Muck	30	Willow & Elderberry Includes areas of the Custard-apple Zone	————-
Everglades Peats	10,11,12,14, 50,51,53	Saw-grass Marshes (dense, medium dense to sparse) Includes areas of Sawgrass Marshes (with wax-myrtle thickets); Sawgrass Marshes (with abundant ferns and cattails); Willow & Elderberry Zone; Slough, Ponds, and Lakes	Peat marshes
Loxahatchee Peats	40,41,42,43	Slough, Ponds, Lakes Includes areas of Saw-grass Marshes (medium dense to sparse); Marsh Prairies, Southern Everglades	Peat marshes
Gandy Peats	60,61	Tree-islands, Bay Tree Forests	Peat marshes
Hialeah Mucky Marl	71	Saw-grass Marshes (with wax-myrtle)	Marl glades
Davie Mucky fine Sands	83,83S	Wet Prairies Saw-grass marshes (with wax-myrtle) Includes areas of Slough, Ponds, and Lakes; Saw-grass Marshes (medium dense to sparse)	Sandy prairies
Davie fine Sands	82,82S	Wet Prairies Includes areas of Saw-grass Marshes (medium dense to sparse); Sawgrass Marshes (with wax-myrtle thickets); Miami Open Pine Forests	Sandy prairies
Wet Sands	80,81,84,86	Pine Flatwoods Forests Includes areas of Cypress Forests; Wet Prairies; Saw-grass marsh (with wax-myrtle thickets); Freshwater Marsh (outside the Everglades)	Sandy prairies
Upland Sands	85,87,87S,94, 95P96,98	Pine Flatwoods Forests Includes areas of. Saw-palmetto or Dry Prairie	Sandy pinelands
Ochopee Marls	72,72S,73,73S	Cypress Forests Marsh Prairies, So. Everglades Includes areas of. Saw-grass Marshes (medium, dense to sparse)	Marl glades
Perrine Marls	74,74S,74V, 74Y, 74P	Southern Coast Marsh Prairies Includes areas of Tree-islands, Bay Tree Forests; Cypress Forests	Marl glades, Mangrove swamp
Rockland	106	Marsh Prairies, So. Everglades	Rocky glades
Rockdale Complexes	99,100	Miami Rockland Pine Forests	Rocky pinelands
Soils from Jones et al. excluded in this study: 62, 63, 70, 74T, 75, 76, 77, 78, 88, 89, 90, 91, 92, 95, 97, 101, 102, 103, 104, 105, 107.			

[1] Refers to vegetation types identified on legend of Davis (1943b); determinations based on overlaying Davis and Jones *et al.* (1948b) maps.

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Prior Studies

The 300 page bulletin *The Natural Features of southern Florida* (Davis 1943a) provides a thorough analysis of 1940s landscapes and vegetation. The well-known vegetation map (Davis 1943b) included in this bulletin describes the vegetation present at the time of mapping. Exceptions to this occur in some of the areas that had already been cleared for agricultural or urban land use, particularly a strip along the southern shore of Lake Okeechobee and parts of the Eastern Flatwoods and the Atlantic Coastal Ridge. Davis did not research the pre-drainage conditions in detail, nor did he have resources to conduct a spatially precise mapping effort, resulting in approximate delineations of the vegetation originally present in these areas prior to drainage and development. The locations of most tree islands, for example, must be taken as schematic, rather than exact. Regional and subregional patterns found on the Davis vegetation map (1943b) can clearly be recognized by comparison with other maps, but overlays at identical scales do not match precisely. While this reflects a different mapping style than Jones *et al.* (1948), it does not in any way diminish the general accuracy of the vegetation communities mapped by Davis.

More recently, Costanza (1979) used Davis (1943b) as the basis for estimating vegetation present circa 1900 as part of a project addressing the distribution of landuse systems in south Florida from 1900 to 1973. His map differs only slightly from that of Davis.

Government Township Surveys

The township surveys and accompanying field notes were an invaluable resource for this study. These data, recorded primarily in the 1840s, 1870s; and 1910s, extended the view of the Everglades gained from the 1940s soil and vegetation maps further backward, to pre-drainage times (**Figure 2.1**).

Townships are (within measurement error) 6 by 6 mile parcels of land, with the four corners surveyed into place and aligned on a nominally north-south grid. The townships are referred to as "Township X South Range Y East" (usually abbreviated as T54 S R42 E, or simply T54 R42), where X and Y refer to the number of townships away from a zero point in Tallahassee, Florida. The exterior boundaries of the townships were usually surveyed first and separately. The survey crew walked and marked each mile and half mile along the four, 6-mile long boundaries.

Sometimes, conditions necessitated something other than walking, such as the following excerpt from a 1911 survey:

> "This is about western edge of the cypress ... abandoned line here [middle of Section 34] to be resumed in Glades Boats. Resumed this line some months later.."
> (Ensey 1911-T44 R41; South boundary of township).

As interest in settling the area increased, a separate contract was typically granted to "subdivide" the township. These subdivision surveys crossed the township at one mile intervals, marking the corners of all 36 of the one square mile "Sections." Numbering of the sections was standardized (**Figure 2.2**).

Field notes for the surveys, whether exteriors or subdivisions, included descriptions of the general character of the vegetation traversed during each mile, as well as the species names of specific "witness trees" used to locate the markers placed at each mile and half mile point (**Figure 2.3)**. In the open Everglades, the absence of witness trees was also indicated; this helped us locate the transition between the bordering forests and the Everglades. "Pits and mounds" were sometimes used to mark the mile and half mile points if posts could not be set. Indications in the notes of conditions being, for example, "too wet for pits and mounds" provided additional information on water conditions at the time of the survey.

A change of instructions issued in approximately 1910 ensured that many of the surveys commissioned by the Trustees of the Internal Improvement Fund after that year included additional information on soil type, soil depth and water depth. The surveys done during the 1910–1920 period provide exceptionally detailed information concerning Everglades landscapes; in many townships, explicitly measuring the location of each transition between slough and ridge, ridge and slough, ridge to channel, channel to island, etc. (**Figure 2.3**). We used this information to help determine the pre-drainage extent of the Ridge and Slough landscape (**Chapter 4**), and as a way to quantify average widths of the ridges, sloughs and channels that were characteristic of that landscape (**Appendix B2**). The presence of Ridge and Slough landscape within specific townships was determined through a semi-quantitative analysis of vegetation types encountered along the 6-mile transects traversed by the surveyors (**Appendix B**; **Chapter 4**). Similar tables were prepared for transects extending from the Ridge and Slough landscape into the bordering eastern uplands to better understand this transition (**Appendix C**).

The observations recorded in the township survey notes form a spatially objective assessment of the landscape. The locations of the sample points occur on a pre-determined, fixed grid, without a bias that would emphasize any particular landscape or water depth. This objectivity, combined with accurate knowledge of the observed locations, and often with specific dates, makes the township surveys such an invaluable resource.

Comparison of the township plat maps with the Jones *et al.* (1948) soils map and with the Jones *et al.* (1948) vegetation map was useful for investigating changes in landscape between the time of the township surveys and the 1940s. A special citation style was adopted in this research to uniquely identify specific surveys. This was necessary because the same surveyor often surveyed multiple townships within one year and also because the same township often was surveyed several times by different surveyors. Each survey will be cited in this research as "Surveyor (nnnn)-Txx Ryy," thus Jackson (1847)-T56 R38 refers to John Jackson's survey of Township 56 S Range 38 E in 1847. Our analyses of the Township surveys included the following aspects:

1. Creation of a comprehensive collection of Everglades region Township plats, all reduced to 8.5 x 11 inch size, for reference and comparison. This was helpful in identifying the various surveyors, years and time of year that a township had been surveyed, and in identifying regional patterns, such as the location of the pre-drainage "Edge of the Everglades," which was marked on many plat maps.
2. Creation of a comprehensive collection of field notes for the surveys.
3. Information from the field notes for numerous townships, concerning vegetation, soil and water depth, was compared with that given on the Jones *et al*.(1948b) soils and vegetation maps, and on the Davis (1943b) vegetation map. This helped to develop an understanding of the patterns of soil and vegetation change at particular locations over time.
4. Tabulation of water depths, classified by landscape, location and date. These were classified by landscape and are recorded in **Appendix A**. The township surveys used in this study are shown in **Figure 2.4**. **Table 2.3** indicates which surveyors worked in which parts of South Florida.
5. Tabulation of historical observations of direction of water flow. (**Appendix O**).

Table 2.3 South Florida surveyors (pre-1930): periods and locations worked.

Surveyor	**Year**	**Locations**	**Comments**
George MacKay	1845	Atlantic Coastal Ridge: Ranges 41-43, Townships 44-56	Additional information provided in Knetsch (1994)
A. H. Jones	1845	Upper Glades, East: T 41-43	
John Jackson	1847	Southern Everglades, East: Ranges 38-40, Townships 55-59	Additional information provided in Knetsch (1992a) and Krome (1979)
W. J. Reyes	1855-8	Upper Glades, East: Twps 41-44	
Marcellus Williams	1870-4	Atlantic Coastal Ridge, Western edge of Everglades: Twps 45-59	Additional information provided in Knetsch (1993b)
William Mickler	1885-6	West Glades: T 52-58, R 34-36	
W. C. Sollie	1884	T51 R35, T52 R34	
J. 0. Fries	1898	T 51 R 40-41	
John Newman	1908	Twp 50-51, R 41; Twp 54 R 40	Commissioned by Trustees of the Internal Improvement Fund (T.I.I.F.)
R. F. Ensey	1911-2	Eastern Everglades: T 46-52, R 40-41	Commissioned by T.I.I.F Twp/Range exterior line survey
L. D. Franklin	1911-4	Eastern Everglades: T 47-52, R 40-41	Commissioned by T.I.I.F Twp/Range section survey
T. E. Frederick	1912	T 52-53, R 40	Commissioned by T.I.I.F
N. B. Broward	1918	Eastern Everglades: T 47-53, R 38-39	Commissioned by T.I.I.F

Major Expeditions

Accounts of a number of expeditions into the Everglades prior to, or shortly after, drainage were available in the published literature (**Table 2.4**). We analyzed the best documented expeditions for information concerning the nature of the pre-drainage landscapes, the extent of these landscapes, and for information concerning water depths. For each expedition, we reconstructed the route based on the published courses and distances made each day (**Plate 8**). Maps of these routes were then made on backgrounds of vegetation (Davis 1943b), soils (Jones *et al*. 1948b), and on the landscape map produced in this study.

From the written accounts of the expeditions we extracted quotes regarding water depths, substrate (soil and rock), vegetation, topography and the locations of each segment of the expedition. These quotes were compared, segment by segment, with the above maps, to check for consistency of the landscape descriptions with the soils, vegetation and landscape types indicated by the maps.

Table 2.4 Early expeditions into the Everglades. Expeditions analyzed in detail as part of this study are described in the Appendix shown in first column.

Ap	Leader	Month	Year	Route	Transport	Citation(s)
J2	Wm. Cooley	Fall	1827	No. Fork New River to NW & back	horseback	Knetsch (1989)
J2	Wm. Cooley	Fall & Winter	1827	So. Fork New River to Rio Ratones & Biscayne Bay	"whale boat"	Knetsch (1989)
J2	Wm. Cooley	?	1827-1836	New River to 15 miles west	boats	Knetsch (1989)
J2	Wm. Cooley & Lt. Powell	Fall	1836	So. Fork New River to 30 miles westerly	boats	Knetsch (1989)
	Col. Harney	Apr.	1838	One of the marl Transverse Glades (T 55 R 40)	On foot	Sunderman (1950)
D	Col. Harney	Dec. 4-15	1840	Miami River to Big Cypress to Harney River	16 Cypress Canoes	Anonymous (1960 [1841])
D2	Col. Harney	Jan. 1-10	1841	Ft. Dallas (Little R.) to Ft. Lauderdale; Everglades	4-5 large canoes	Sunshine [Brooks] (1880)
J2	Cpt. M. Burke	Oct. 9-14	1841	Ft. Dallas to Chikikos Isl. to Prophet's Landing	canoes	Sprague (1848), P-333-334
J2	Lt. J. T. McLaughlin	Nov. 16-24	1841	L. Okee. to Loxahatchee Slough to Biscayne Bay	canoes	Sprague (1848), p.334
J2	Major Childs	Dec.(4 d; ca. 4 d back)	1841	Ft. Dallas to Prophet's & Waxy Hadjo's landings & back to Ft. Lauderdale	canoes	Ives (1856); Dix & MacGonigle
J2	Lt. J. T. McLaughlin	Dec. 10-15	1841	Prophet's Landing to Cypress at head of Loxahat.	canoes	Sprague(1848), p.358
	Capt. Wade	Dec. (2 days)	1841	Loxahatchee Slough to Ft. Lauderdale	canoes	Ives(1856)
D3	Lt. J. Rodgers	Feb. 12-22	1842	Ft. Dallas to Rio Ratones to Lake Okeechobee	16 Cypress Canoes	Prebles (1945 [1883])
D3	Lt. J. Rodgers	Apr. 2-10	1842	Lake Okeechobee to Ft. Lauderdale	16 Cypress Canoes	Prebles (1945 (1883])
J2	Buckingham Smith	Sept. 10-18	1847	Ft. Dallas to Prophet's Island and back	"light bateau"	Dix & MacGonigle (1905)
J2	Capt. Dawson	Mar. 1-7	1855	Miami River 18 miles west and back	Canoes, poled	Ives (1856); Gaby (1993)
J2	Capt. Dawson	June	1855	Miami R. to Prophet's Landing and back	Canoes	Ives (1856); Dix & MacGonigle (1905)
	M. A. Williams	Mar 21-24	1874		2 Canoes	Williams (1874)-T57 R39
J2	Pierce & Bradley	Feb (est.)	1882 (est.)	New River to Snake Creek to Biscayne Bay	"Indian canoe"	Pierce (1970)
	J. Henshall	Feb. 22-25	1882	New River to Pine Island and back	Canoe + sail	Reiger (1971)
J2	Pierce & Spencer	Spring	1882 (est.)	New River to Snake Creek to Biscayne Bay	"factory canoe"	Pierce (1970)
E	Major A. P. Williams (Times-Dem)	Nov. 10-Dec. 6	1883	Lake Okeechobee to Shark River	14 Canoes + larger prov.boat	Wintringham (1964); Stewart (1907)
J2	Quimby	Nov-Dec.	1888	Biscayne Bay to Snake Creek to New River	"big Indian canoe"	Pierce (1970)
F	J. Ingraham	Mar. 17-Apr. 5	1892	Ft. Shackleford to Miami River	Cypress skiff + canoes	Marchman (1947); Church (1949)
J2	Griswold	Feb-Mar	1895 or 1896	Everglades Keys west; New River west	canoe	Griswold (1896)
G	Willoughby	Jan. 8 - Jan.23	1897	Shark River to Miami R.	2 canvas canoes	Willoughby (1898)
	Indians	?	1890s -1898	Big City Island to Pine Island	canoes	Fries (1898) -T-
	Dimock	?	1907	Harney R. to Miami R.	Powerboat	Dimock (1907)
H	Stewart	Feb. 8 - Apr. 4	1907	Brown's Store to Pompano	Canoes	Stewart (1907),
I	Stewart	Mar. 19-24	1907	Ft. Lauderdale to Pine Island (T 50 R 41)	Canoe, poled	Stewart (1907)
I	Harshberger		191?	Lake Okeechobee to Ft. Lauderdale (N. New R.)	Steamboat	Harshberger (1914)
	John King	Feb-Mar	1917	Miami . River to Shark R.	2 Canoes ?	Larned (1917)

Appendices C through I present an analysis of each expedition and its relevance to the determination of the nature of the pre-drainage landscapes. **Figure 2.5** shows an example of information derived from one of the expeditions, in this case a cross-section (profile) of the soil across the Everglades.

Information from the various accounts was compared and used to correct landscape boundaries on the hindcast map, to improve the definition of the different landscapes, and as a source of quantitative water depths.

Early Maps

The South Florida portions of the early maps listed in **Table 2.5** were located, photocopied to similar scales, compared and scrutinized for useful spatial information. Examples of such information include: (1) any information relating to the landscapes discussed above; (2) landmark points; (3) location and nature of the edge of the Everglades; (4) routes across the Everglades; (5) locations of Indian villages, fields, burial grounds and travel routes; (6) locations of important tree islands; and (7) depths of organic ("muck") soil. Familiarity with a collection of diverse maps from different time periods was useful for locating specific features mentioned in other sources. Such features can be hard to locate on modern maps, because either they no longer exist, or the names have changed, or the features have become unrecognizable. Examples include the "13 Mile Canal," "Brown's Store," "Sam Jones’ Seven Islands," "Big City Island," "Rio Ratones," etc. Comparison of the early maps with modern satellite imagery often was informative.

Several maps merit particular attention. The Military Map of the Peninsula of Florida South of Tampa Bay (Ives 1856a) stands out as a useful and remarkably detailed map of the pre-drainage Everglades region (**Figure 2.6**). Ives' map includes considerable phytogeographical information, showing symbols for Pine, Palmetto, Oak, Cypress, and 'Koontee' (Zamia sp.) plants, as well as hatching to indicate the following landscape types that can still be recognized today: Sawgrass, Swamp, Marsh, Scrub, Wet Prairie, Dry Prairie, Wet Hammock, and Dry Hammock. Spatial accuracy of the map is good along the Atlantic Coastal Ridge, the Everglades Keys (Miami Rock Ridge), and Biscayne Bay, while shapes and sizes of some features

Table 2.5 Maps of South Florida examined in detail for this study.

Title	Year	Comments	Citation
Map of the seat of war in Florida	1839	"Passage for small boats across the Everglades as reported by the Indians"	MacKay and Blake (1839)
The State of Florida, compiled in the Bureau of Topograph. Eng	1846	Many tree islands, Indian Landings on edge marked	Bur. Topo. Eng. (1846)
A plat exhibiting the state of the surveys in the State of Florida	1853	Landings marked. Accuracy limited	Florida. Survey General's Office (1853)
Map of State of Florida	1856	Routes indicated: Child's, Dawson's, Wright's	Bur. Topo. Eng. (1856)
Military map of the peninsula of Florida south of Tampa Bay	1856	See text	Ives (1856 a,b)
Map of Hic-Po-Chee & Okeechobee Sugar Lands,	1892	Clear delineation of sawgrass, slough area and pine land on NW edge of 'Glades	Kraemer (1892)
Florida East Coast Ry.	1903	Details of Everglades Keys south of Miami; Perrine Marl Marsh vegetation	W. F. Krome (1903)
Official Map of Canals	1908		T.I.I.F. (1908)
The Florida Everglades	1908	Stewart's W->E survey route	Wright (1908)
Map of the Southern Portion of the Peninsula of Florida	1911	Canal status	Senate Doc. 89 (1911)
Map of Everglades Drainage District	1911	Muck depths, dredge locations	T.I.I.F. (1911)
State of Florida	1913	State of canal completion	FL Ever. Eng. Comm. (1914)
Phytogeographic map of South Florida	1913	See text	Harshberger (1913)
Florida So. of Lat. 28° 30' [p.12-13]	1915	Recommended canals; note alignments	Hassan (1915)
Soils of the Ft. Lauderdale Area	1915	First soil map based on detailed field survey	Baldwin & Hawker (1915)
Map showing results of examination of the Tamiami Trail Lands	1917	First known map of sloughs and sawgrass [ridges]	King (1917e)
Contemplated location and dimension of the Miami Drainage Canals in the Southern Drainage District	1917	Tree island orientation and edge between Miami Rock ridge and Everglades	King (1917h)

(e.g. Long [Pine] Key, Cape Sable, and Lake Okeechobee) are distorted. Despite these distortions, Ives' map earned respect from later users in the field (Knetsch 1995). Harshberger, a plant ecologist, prepared the earliest map specifically delineating Everglades vegetation (**Figure 2.7**). The map contains little detail of the interior of the Everglades but does address the borders and adjoining uplands in detail. An early agricultural land capability map by Kraemer (1892) was an important source to determine the pre-drainage extent of sawgrass and depths of sawgrass-peat soils in a large area southeast of Lake Okeechobee (**Plate 6**).

In 1915, the soil scientists Baldwin and Hawker surveyed upland soils near Ft. Lauderdale and a 6 mile-wide band along the full length of the North New River Canal, creating the first detailed soil map of south Florida (Baldwin and Hawker 1915). The combination of high quality with timing (shortly after the onset of drainage) made this study an extremely important complement to the Jones *et al*. (1948a, b) soil study. Many similarities were found in the areas of upland sands, while the differences in the organic soils of the Everglades helped us develop an understanding of the soil changes caused by drainage (**Chapter 3**).

A detailed, but unpublished map, originally prepared for drainage planning (King 1917h) provided useful information regarding the Ridge and Slough landscape near the present Tamiami Trail and the adjoining portions of the Everglades Keys landscape. King mapped the Everglades Keys and Marl Transverse Glades (**Figure 2.8**) independently of the township maps, but indicates very similar spatial patterns. King's map provides one of the earliest graphic indications of strand tree islands oriented parallel to the NE to SW direction of water flow.

Narrative Accounts

Narrative accounts did not necessarily yield specific information in terms of water depths or landscape boundaries, but they often helped round out information from other sources. Descriptions of vegetation, when included, provided a way of identifying the landscapes described by the authors. Similarities in landscape or hydrologic descriptions given by different authors helped extend the time periods for which a recognizable landscape was known to occur. Key accounts include Vignoles (1823), Williams (1837), Buckingham Smith (1848), Cooley in 1851 (in Knetsch 1989), Senate Doc. 89 (1911) and Larned (1917). Vignoles (1823) gives quite detailed descriptions of plant communities along the uplands east of the Everglades. Vignoles' plant classification scheme is similar to that found in Matson and Sanford (1913), and in the Harshberger (1913) phytogeographic map.

Williams (1837) had frequent contact with Seminole Indians, and through them developed a good understanding of the large directional tree islands in the vicinity of the present Tamiami Canal. Buckingham Smith's well-known account was reprinted in Senate Doc. 89 (1911). In spite of his account being strongly in favor of drainage of the Everglades, Smith drafted a lyrical description of the then undisturbed Everglades. Observations detailed in letters sent to Smith from individuals with experience in the Everglades were also used for background information. Cooley was a settler who lived on the New River from 1823 to 1836. His letter reprinted in Knetsch (1989) gives remarkable detail concerning the eastern Everglades. Larned (1917) provides a serialized account of the engineer and naturalist John King's trip from Miami to Florida Bay.

Photographs

Although photographs can be invaluable for characterizing and recognizing pre-drainage Everglades landscapes, we encountered several practical limitations. To serve as qualified sources, each photograph's location, orientation and date should be identified by the photographer. In our experience, these conditions were rarely met. Nevertheless, most photographs are easily rated for presence or absence of water; and in some cases even approximate locations and dates may still be helpful. Photographs have been particularly useful for identifying landscape types and the boundaries between them. We examined photographs from the following sources: Willoughby (1898), Senate Doc. 89 (1911), Harshberger (1914), Baldwin and Hawker (1915), King (1917c), Parker (1940), Brown (1943), and the J.K. Small collection in the Florida State Archives.

Other Surveys, Profiles and Studies

Linear surveys associated with the building of canals, railroads and roads (Tamiami Trail) were used in addition to government township and expedition related surveys as sources of information concerning soil and/or water depths (**Table 2.6)**. Unfortunately, field notes were not located for all the surveys listed.

Table 2.6 Construction surveys and soil profiles used in this study.

Location	Type	Citation(s)
T 42-44, R 32-36	Agricultural Survey including muck depths	Kreamer (1892)
South of Miami	F.E.C. Railroad survey	Krome (1902), Krome (1979)
West into glades from U.S. surveys (W of Range 41?)	Agricultural (?); before 1898	Florida.TIIF (1904), p. 455 cited in Stewart (1907)
West Palm Beach to Lake 0., leveling survey in 1913	George B. Hills	Fla. Everglades Engineering Commission (1914)
Southern Everglades	J.B. Phinney & J.A. Moore	Fla. Everglades Engineering Commission (1914)
Major canals	Canal construction surveys	Fla. Everglades Engineering Commission (1914)
North New River Canal	Agricultural soil survey	Baldwin and Hawker (1915)
Township 54 Range 37	Soil depth survey	King (1917d)
Tamiami Trail and Snapper Creek	Proposed canal survey & profile	King (1917h)
Eastern Tamiami Trail	Canal & road surveyed profile	Wilson (1918)
Western Tamiami Trail	Canal & road surveyed profile	Crabtree (1921)
Everglades Drainage District	Muck depths along transects	Ensey and Elliot (1911)
T 51-54, R 39-40	Map of Peat Thickness	Corps of Engineers

In many of these surveys, the soil surface and the underlying bedrock surface were measured and subsequently drawn as profiles (**Figure 2.9**). In some cases, either the survey location or the survey legend permits identification of the soil material: sand, marl or peat (most often referred to as "muck"). We used these profiles to estimate soil depths at the time of the survey, and then compared these graphically with current soil depths (**Figure 3.13**). Additional measurements of “muck depths," if systematically combined with a map of bedrock contours and with the muck depths noted in the township surveys, would permit detailed mapping of the pre- or early post-drainage surface topography. Such a project was beyond the present scope.

Although we know of no published scientific studies conducted in the Everglades before construction of the first drainage canals in 1880, there are several key observational studies completed sufficiently early in the history of drainage to provide useful information. John Stewart worked during 1907 for the U.S. Dept. of Agriculture, Drainage Division. During the first half of that year he traveled extensively throughout south Florida, personally inspecting different parts of the Everglades and interviewing local residents with experience in the area (Stewart 1907). His observations and commentary provide a landscape ecology perspective on the Everglades in the few years just before completion of the main four canals — the West Palm Beach, Hillsboro, North New River and Miami.

Sanford was a geologist and field naturalist who surveyed possible routes for a railroad from West Palm Beach south to Miami and on to the Keys before transferring to the Florida Geological Survey. His descriptions of the Everglades in Matson and Sanford (1913), and particularly of the adjacent Pine Flatwoods and the Atlantic Coastal Ridge, are thorough. The plant ecologist Harshberger (1913) produced a lengthy report with specific descriptions of Everglades landscapes in addition to the phytogeographic map previously mentioned. Similarly, the soil map of Baldwin and Hawker (1915) was accompanied by a report with landscape descriptions of use to this study, particularly of the Sawgrass Plains and the Ridge and Slough landscapes.

Like Sanford in the early 1910s, the botanist/plant ecologist Roland Harper worked for the Florida Geological Survey. He was acutely aware of the changes then being caused by drainage and by agricultural or urban development. Harper's detailed descriptions of the vegetation communities of the Everglades reflect his concern that at least some might disappear permanently in the face of development. This concern was shared by others. In his book, From Eden to Sahara, Florida's Tragedy, botanist John K. Small (1929) reflects an awareness of the Everglades as an ecosystem under assault by over drainage. Small collected botanical specimens in south Florida over a number of years. Although the his technical publications primarily address flora at the species level, his numerous articles provided material for landscape characterization, particularly in the Everglades south of Long Pine Key.

Several soil scientists worked on the organic peat soils of the northern Everglades. Dachnowski-Stokes took many soil cores within what later became the Everglades Agricultural Area (Dachnowski-Stokes 1930). Clayton conducted long-term experiments to measure rates of peat subsidence as a function of height of the water table.

Additional studies were consulted. These were conducted well after Everglades drainage was established, but the authors generally brought a long-term outlook to their work, as well as an interest in pre-drainage conditions. These studies include Dovell (1947), Robertson (1955), Egler (1958), Loveless (1960), Craighead (1971), Tebeau (1973), Alexander and Crook (1973), Anonymous (1990), and various studies by Dan Austin and his graduate students (Austin 1976; Austin and Coleman-Marois, 1977; Austin and Richardson 1977; Steinberg 1980).

Rainfall Records

A quantitative analysis of the influence of weather variations on the historical hydrologic observations that we gathered was beyond the scope of this project. Such an analysis would have been limited by the scarcity of rainfall data available prior to approximately 1890.

We did, however, analyze the available rainfall data to distinguish wet and dry years. The graph shown in **Figure 2.10** was used to place particular hydrological observations from the historical record in context. Data was extracted from databases of the South Florida Water Management District and of the National Oceanic and Atmospheric Administration. The first database includes information from Mitchell and Ensign (1928) and from Florida State Board of Conservation, Division of Water (1954).

For each rainfall station, a long term mean of annual rainfall was calculated from all station data available. For each year, the deviation of the station's rainfall from the station's long term mean was calculated. Finally, for each year a spatial mean and standard deviation for South Florida was calculated from all available stations.

SUMMARY

During the course of this study, a diverse range of source materials was consulted; vegetation, soil and topographic mapping studies from the 1940s, government township surveys from the mid to late 1800s, accounts of expeditions into the Everglades, early maps, narrative accounts by persons acquainted with the pre-drainage Everglades, early photographs, construction surveys and profiles, rainfall records and scientific studies. **Figure 2.11** charts the flow of this information through its assimilation, iterative refinement, and synthesis.

CHAPTER 2 FIGURES

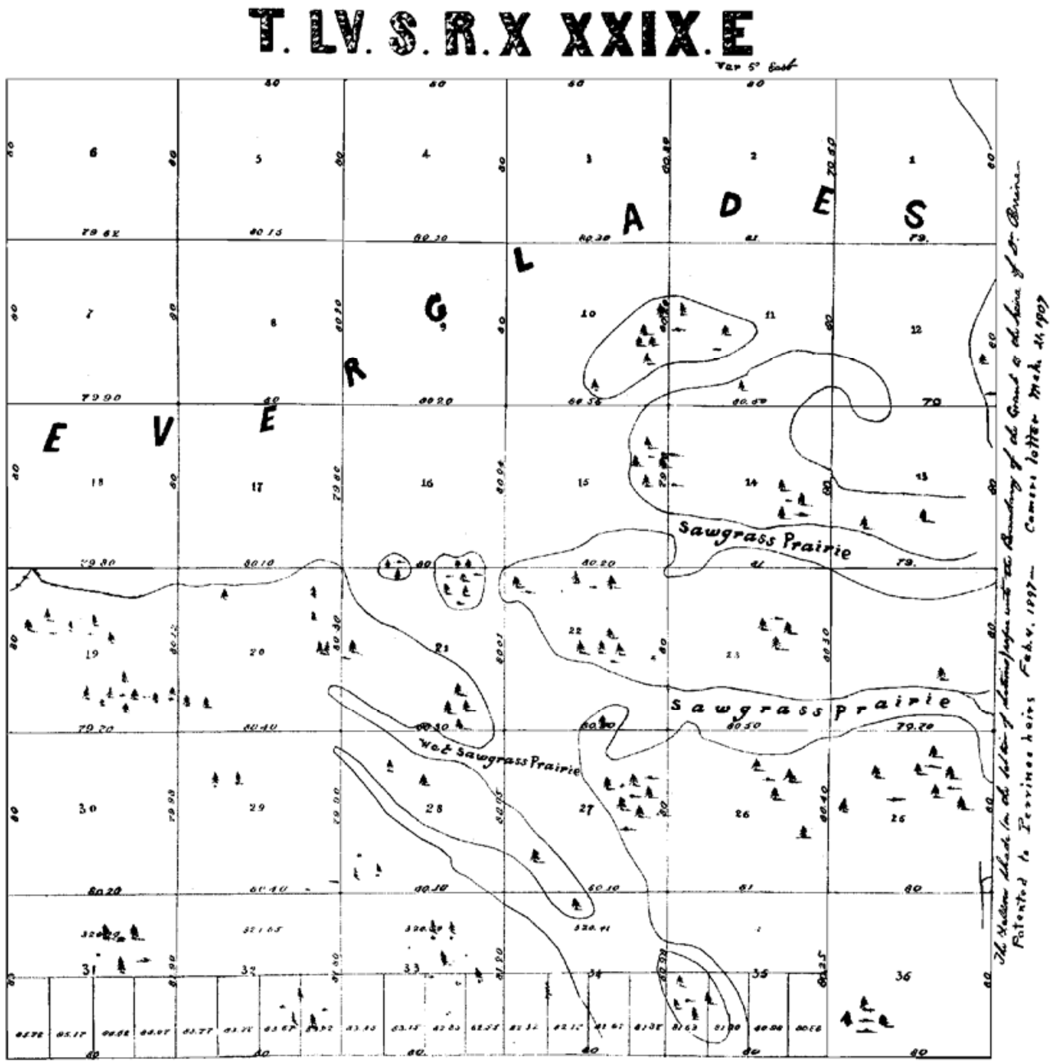
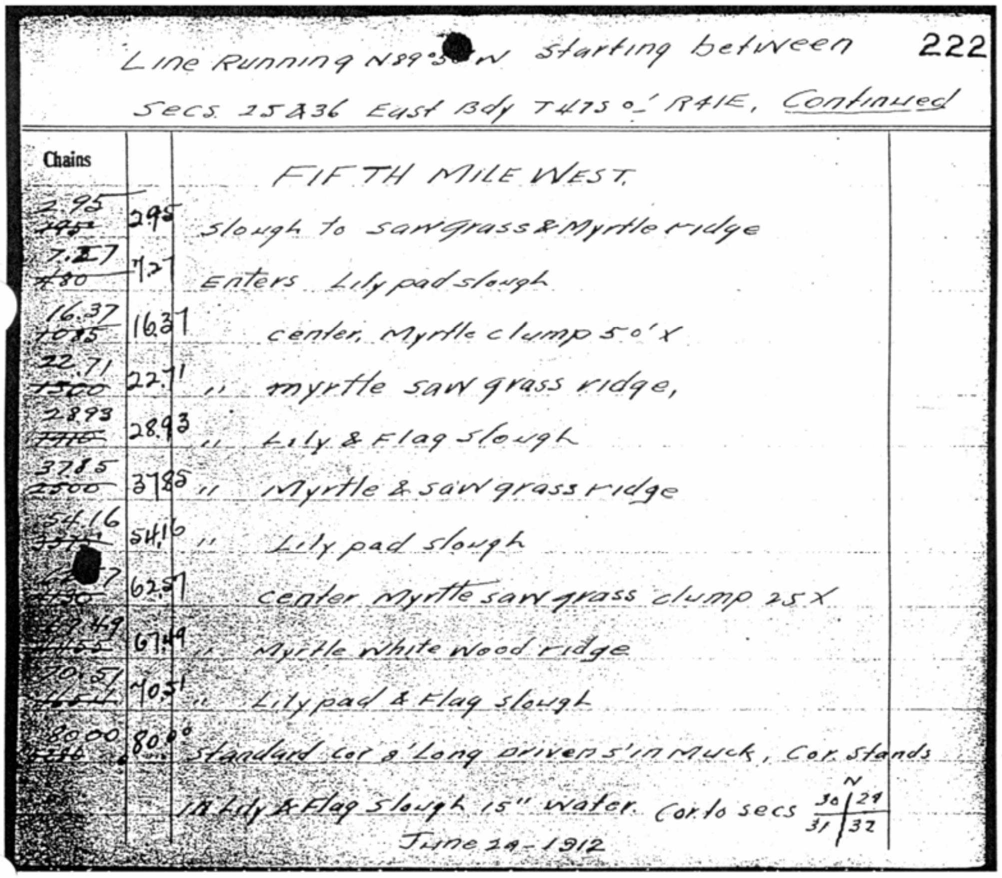


Figure 2.1 Sample township plat map: Township 55 South, Range 39 East. Surveyed by John Jackson in 1847. Shapes in lower half of township represent portions of several higher-lying Everglades Keys; symbols indicate pine woods. Narrow strips between Keys marked "Sawgrass Prairies" are Marl Transverse Glades, now the site of drainage canals (cf. Fig 1-1). Note "Everglades" label.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure 2.2 Standard numbering for the 36 one-mile square sections of a township


Line Running N89°5?'W starting between 222

Secs 25 & 36 East Bdy T47S 0' R41E, Continued

Chains

FIFTH MILE WEST

2.95	295	slough to sawgrass & Myrtle ridge
7.27	727	Enters Lily pad slough
16.37	1637	center Myrtle clump 50' x
22.71	2271	" myrtle saw grass ridge,
28.93	2893	" Lily & Flag slough
37.85	3785	" Myrtle & saw grass ridge
54.16	5416	" Lily pad slough
62.57	6257	center Myrtle saw grass clump 25 X
67.49	6749	" Myrtle white wood ridge
70.51	7051	" Lilypad & Flag slough
80.00	8000	Standard Cor 3' Long driven 5' in Muck, Cor. Stands
		in Lily & Flag slough 15" water. Cor to secs 30/29, 31/32
		June 29 - 1912

Figure 2.3 Sample page from the field notes for the township survey of Township 47 South, Range 41 East conducted in 1912 by R.F. Ensey. Entries show distances in feet (and chains) to the vegetation types entered along a one mile transect between sections 30 and 31.

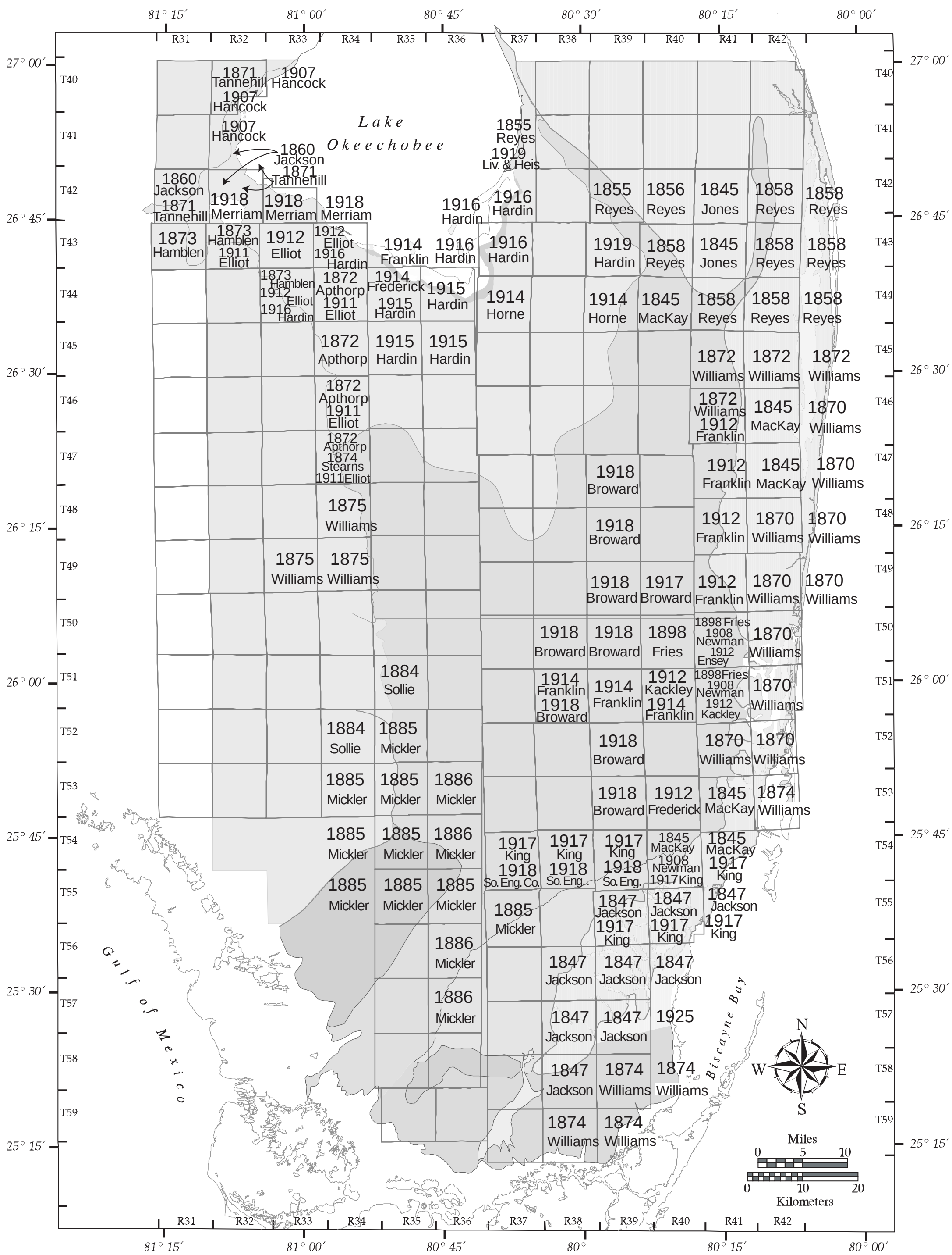
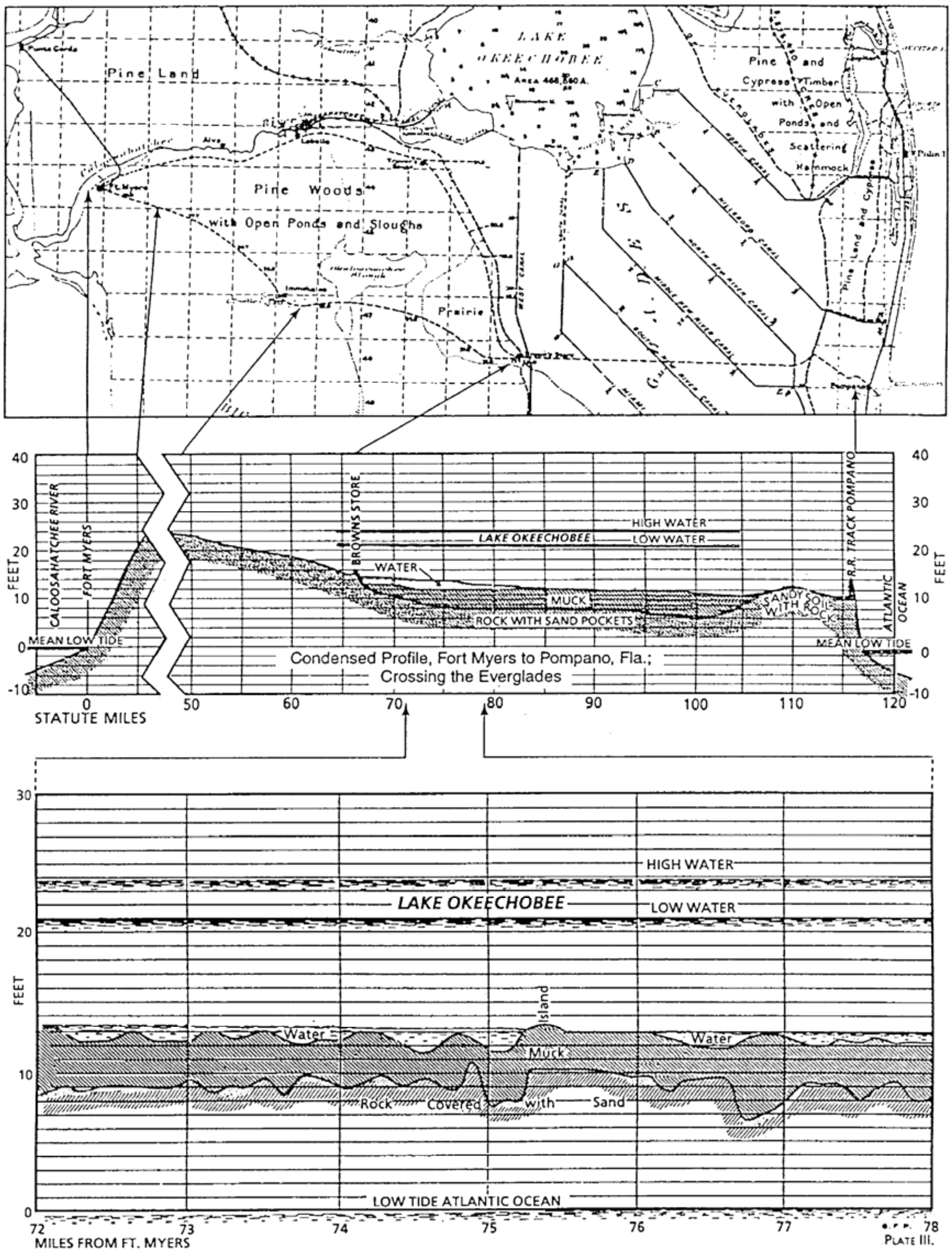


Figure 2.4 Townships studied as part of this research. Numbers indicate year surveyed.



Characteristic Profile of Portion of Surveyed Line through the Everglades. Florida

Figure 2.5 General (middle) and detailed (bottom) profile views of the soils of the Everglades as measured during the 1907 expedition from Brown's Store to Pompano (top). See also Appendix H. Profiles from Senate Document 89 (1911); map from Wright (1907).

Figure 2.6 Everglades portion of the military map of the peninsula of Florida south of Tampa Bay (Ives 1856a). Note the Everglades Keys and the Marl Transverse Glades south of Fort Dallas (Miami), as well as the Everglades bordering directly on the narrow portion of the Atlantic Coastal Ridge south of Fort Lauderdale. Note also the locations of wet prairie and cypress.

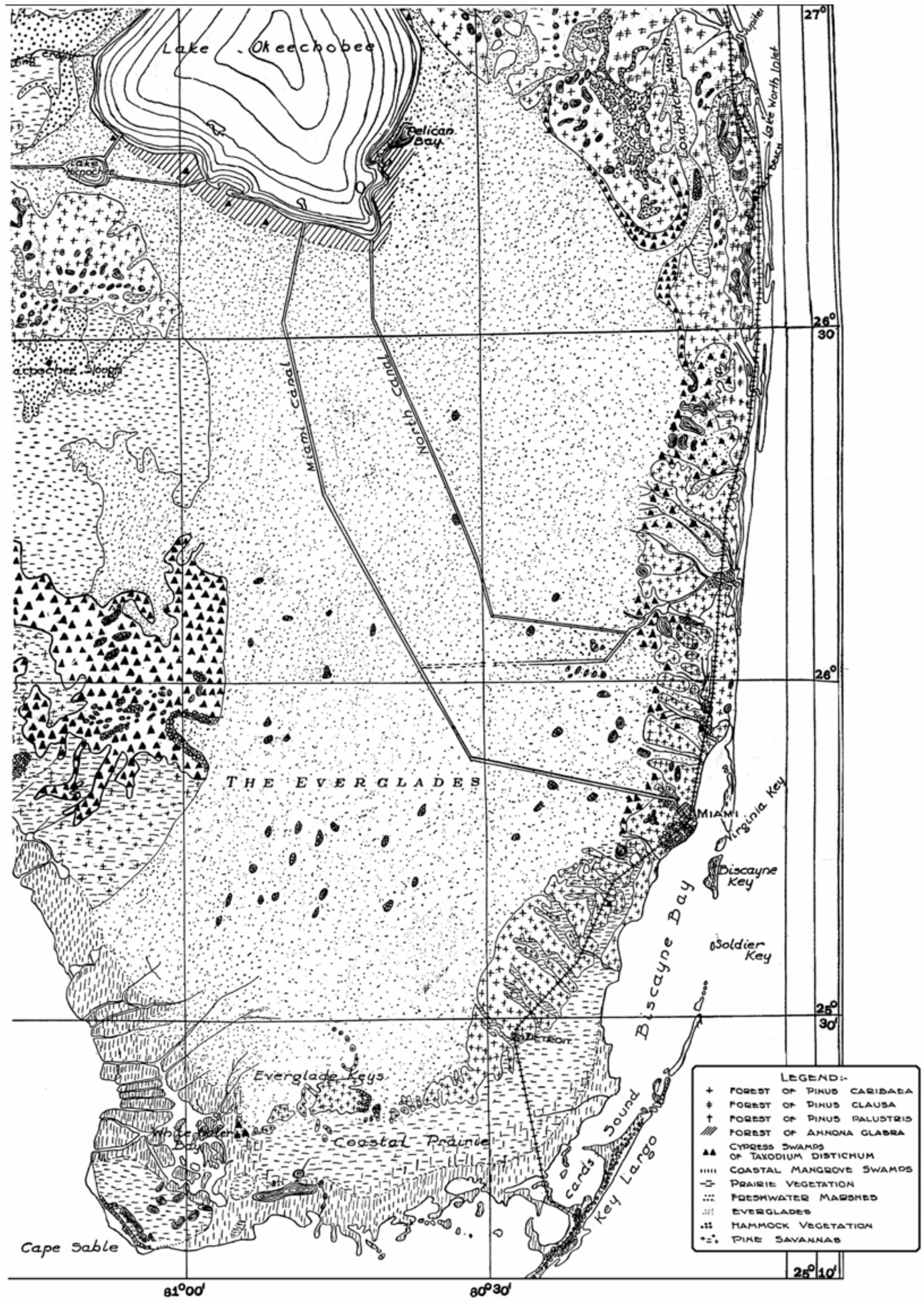


Figure 2.7 Everglades portion of a Phytogeographic Map of South Florida drawn by a plant ecologist (Harshberger 1913). Note the coastal rivers extending into the Everglades and the distinct edge between the Everglades and bordering uplands to the east.

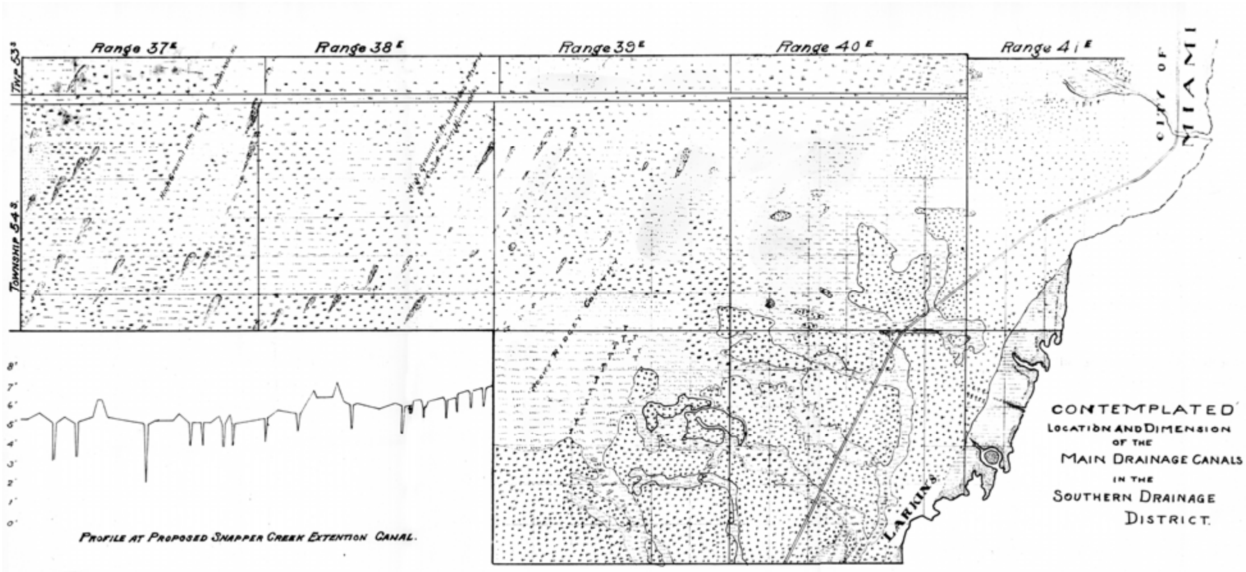


Figure 2.8 Contemplated location and dimensions of the main drainage canals in the southern district. Reproduced from King (1917h). Note the shape and orientation of the strand tree islands in the Ridge and Slough area (Township 53-54, Range 37-40), and the Marl Transverse Glades extending southeastward between the Everglades Keys (Township 55, Ranges 39 and 40).

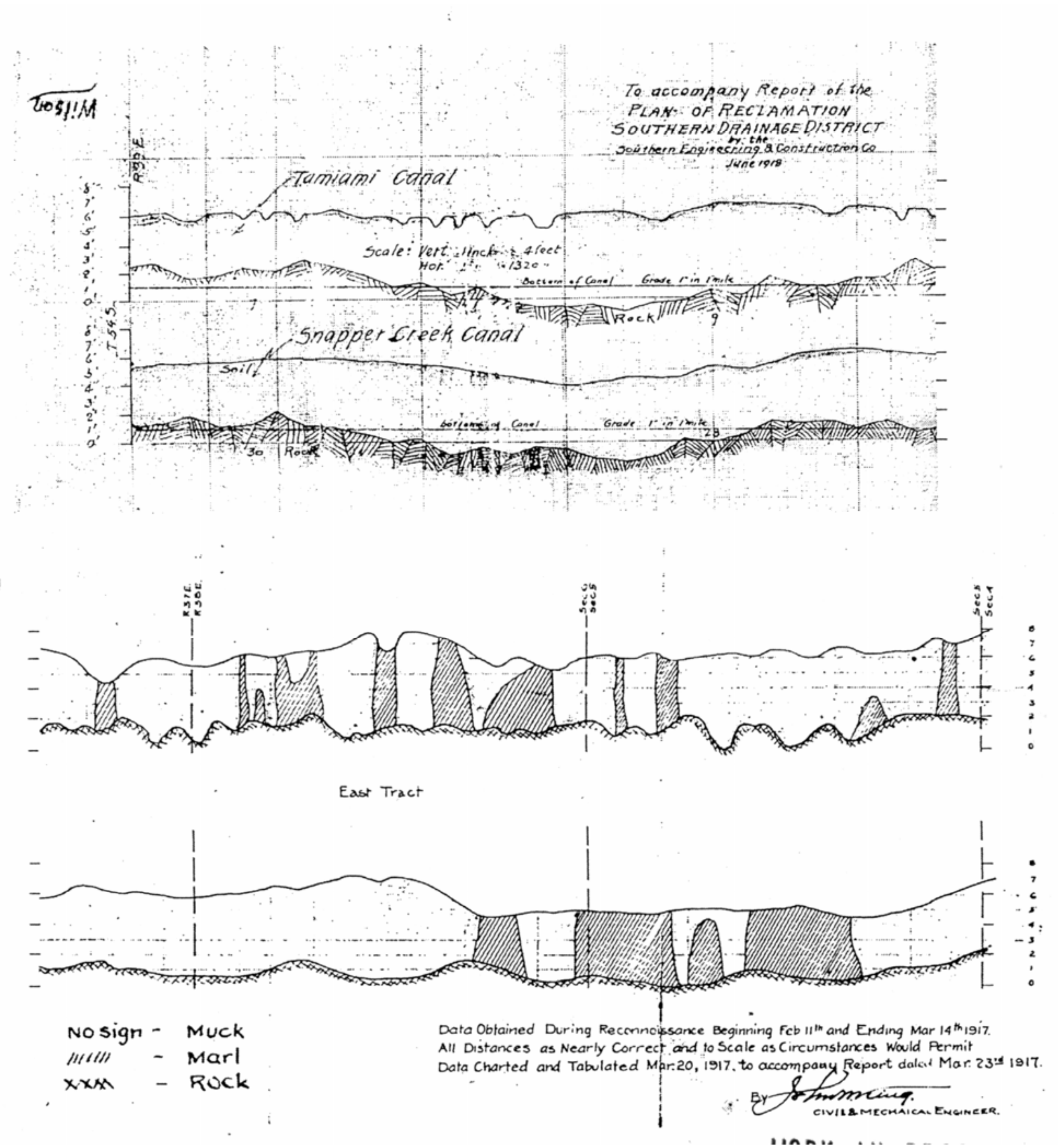


Figure 2.9 Representative portions of early soil profiles, measured in 1917 and 1918 along proposed routes fro the Tamiami and Snapper Creek Extension Canals. (cf. **Figure 2.8**). Note peat thickness, mixture of peat ("muck") and marl soils, and variations in topography. Top: 2.75 mile portion from Wilson (1918); Bottom: 2.5 mile portion from King (1917d).

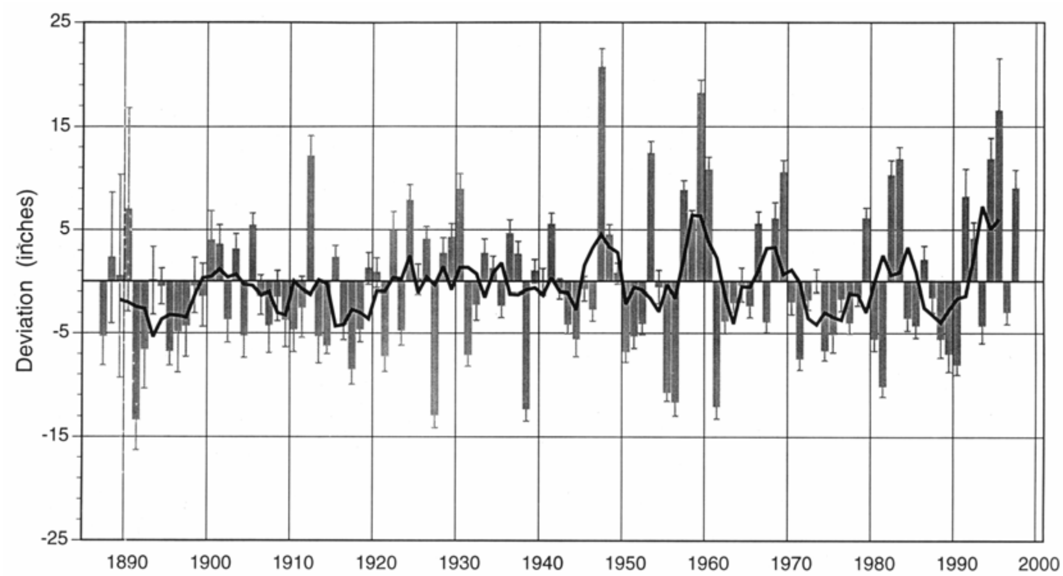


Figure 2.10 Variability of annual rainfall in South Florida, 1887 to 1997. Spatial means of the annual deviations from each rainfall station's long term mean annual rainfall (see text). Solid line is 5-year running average.

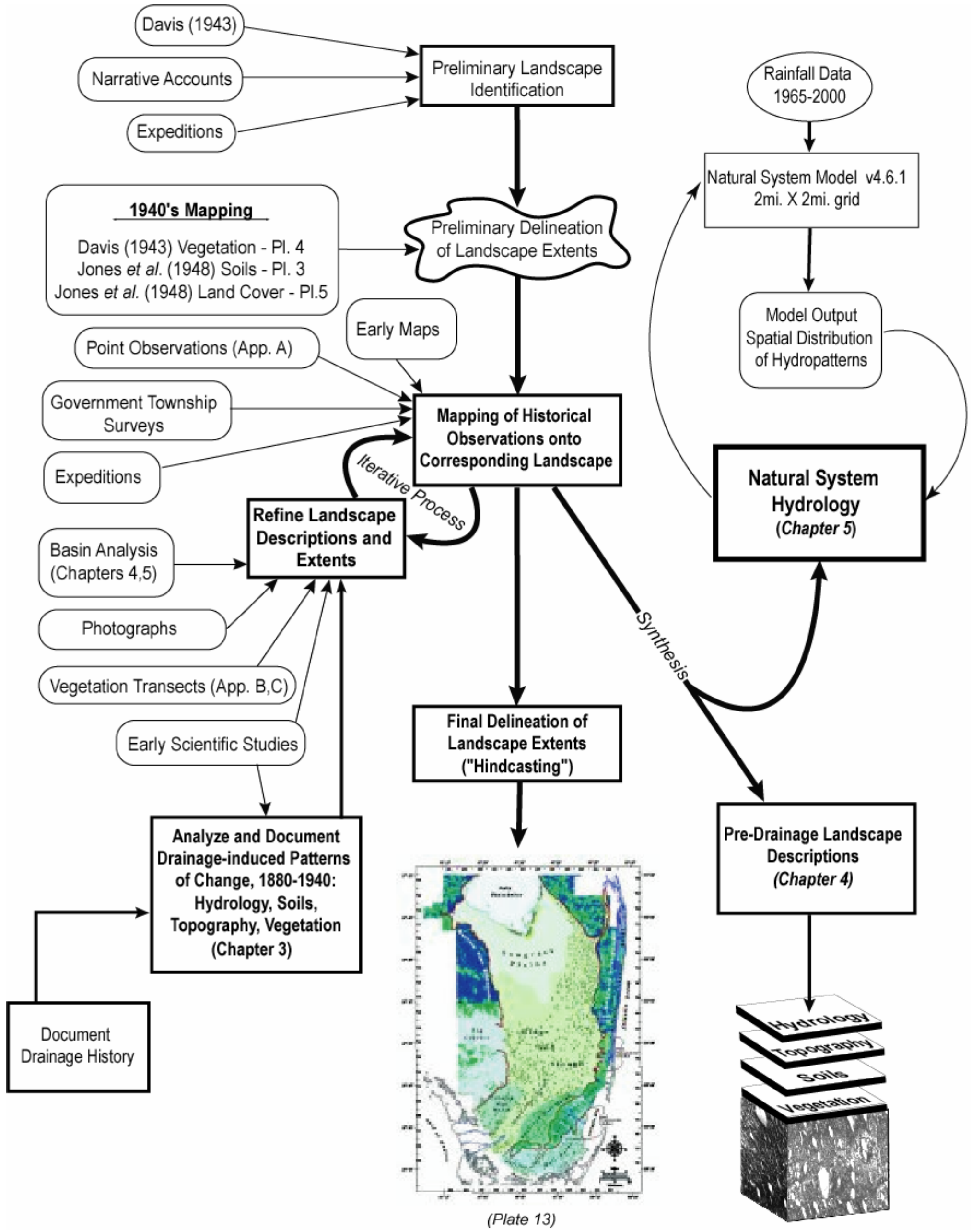


Figure 2.11 Research flow chart.