

Patrick J. Gleason
editor

ENVIRONMENTS OF SOUTH FLORIDA
PRESENT AND PAST II

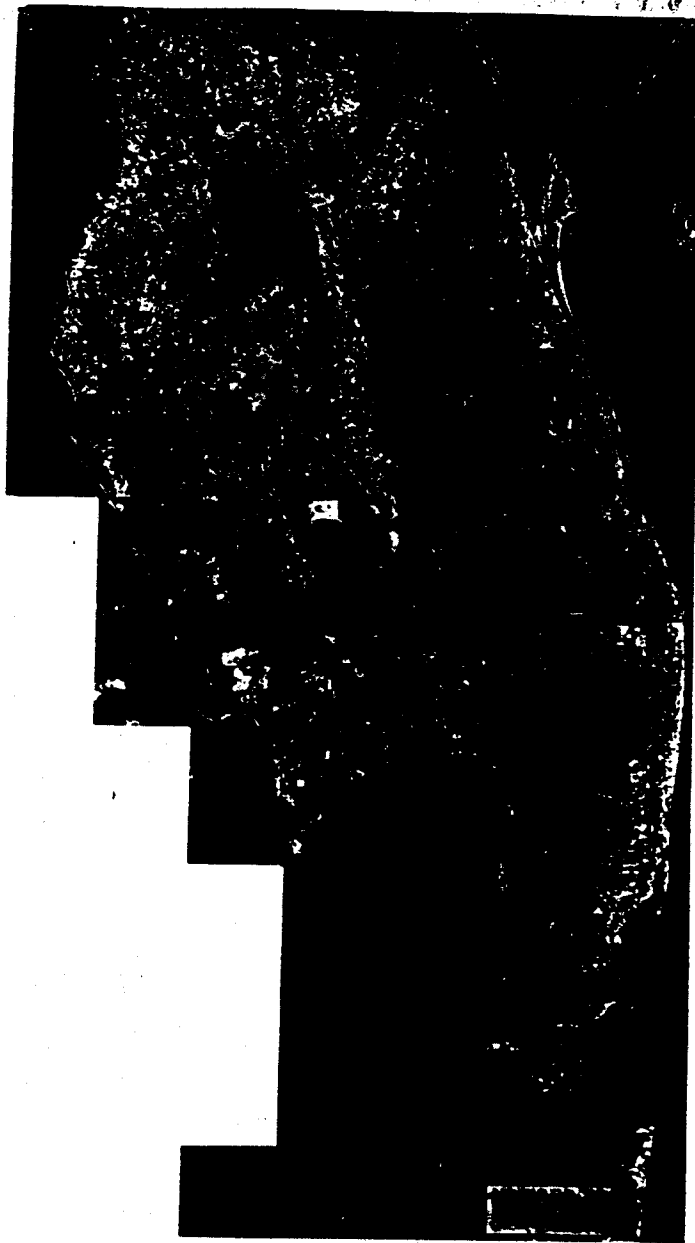
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MIAMI GEOLOGICAL SOCIETY
P.O. BOX 144156
CORAL GABLES, FL 33114

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Patrick J. Gleason
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1984
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CORAL GABLES, FL 33114

*To Jody, Brian, Colleen
and Christopher Cory*

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of the Miami Geological Society, 1974

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PREFACE

Environments of South Florida: Present and Past II represents a substantial revision of the first edition. Seven articles from the first printing were deleted and ten new articles have been added. We have chosen a slightly different direction in this edition by attempting to present more broad summaries of knowledge as opposed to the results of specific investigations. Overviews of South Florida's estuary problems, geology, hydrogeology, the plant communities of Everglades National Park, and an attempt to make sense of the environmental factors affecting plant communities of the Big Cypress have been added. An interesting addition is an article on "Prehistoric Man," which actually describes Indians living in South Florida prior to European discovery rather than ice-age cave-men.

Some information has been updated. A comprehensive reevaluation of rainfall activity is presented through the use of 46 maps showing averages and historical extremes both flood and drought. Periphyton and water quality relationships are detailed in an excellent report from a three year study. And, of course, much has happened in the area of water management since 1974. John DeGrove, now Director of The Department of Community Affairs for the State of Florida, has provided his perspective on this subject as both a participant and eye-witness to many changes.

We present two articles with divergent conclusions on changing sea level. The first article shows evidence for sea level being higher in the recent geologic past than present sea level. The second article presents new data indicating a gradual increase in sea level to its present position. As scientists we are very open-minded.

This book was originally designed as a primary source for people doing research in South Florida. It has evolved into a reference text for both the casual and serious student, the environmentalist, consultant, government official, planner, and basically anyone else who is interested in the past history, present or future of South Florida. It represents an attempt to present what is known about the environments of South Florida for many people who need to become educated easily and quickly. It is our wish that the information in this book may provide motivational reading and help solve some of South Florida's many environmental problems.

PJG

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INTRODUCTION

Saving the Wild Places - A Necessity for Growth

At a recent conference on the dynamics of extinction, Paul Ehrlich of Stanford University concluded that the Earth's biota now appears to be entering a period of extinctions that may rival or surpass those that occurred at the end of the Cretaceous, 65 million years ago. On a global basis, perhaps within 100-200 years, the total number of extinct species could surpass the Cretaceous event which eliminated the fabled dinosaurs, fifty-two percent of marine species, and a substantial portion of terrestrial inhabitants (Lewin, 1983).

The cause of the disappearance of the dinosaurs is not known with absolute certainty but the problem now, of course, is growth. In developed countries it is mainly urban growth including chemical pollution, and in poorer nations it is agricultural development including the extensive felling of tropical forests. Populations are growing so explosively and are modifying the environment so extensively that species are probably being finished-off before they are recognized and documented.

Florida, a microcosm of the global dilemma, has long been at the forefront of the growth-versus-environment conflict and all indications are that it will get worse before it gets better. Florida is still a boom state and growth continues to pave-over, build-over, and grass-over what is left of our remaining natural areas. It is rushing head-long into future growth in a way that by 1990 will make it the 4th most populous state in the country, a jump upward from its current 7th ranking. South Florida will continue to absorb most of this meteoric rise in population. By the year 2000, every third resident in South Florida will be someone who is not here now. By the year 2010, South Florida may be home to 2½ million new residents.

As a consequence of past growth, major destruction of significant pieces of the South Florida ecosystem has occurred (Figures 1 and 2). Interior wetlands, mangrove forests, tropical hardwood hammocks, pinelands, estuaries, beaches, seagrass beds and reefs have been altered. A few highly-mobile and wide-ranging animal species for which South Florida was all or part of their habitat are now extinct. These are the Florida red wolf, West Indian monk seal, Carolina parakeet, and passenger pigeon. Many species of animals and plants are endangered and threatened due to habitat devastation, disruption of complex food chains, and alteration of hydroperiod.

Recent surveys of extirpated, endangered, and threatened species indicate that ten species have been totally eliminated from South Florida, 75 species are now endangered and 103 species are threatened (Appendixes 1-8).

Habitat destruction is of paramount concern. The South Florida mainland has experienced a tremendous loss of fresh-water habitat in the last 100 years. The Center for Wetlands at the University of Florida conducted a comprehensive assessment of wetlands' loss between 1900 and 1973. Their study showed that about 32% of the wetlands or about 2 million acres of habitat have been lost over an area roughly covering South Florida and the Kissimmee River Basin (Browder et al., 1977). Lake Okeechobee doesn't overflow its southern boundary and spill water into the "River of Grass" as Marjory Stoneman Douglas describes the Everglades. 700,000 acres of Everglades habitat adjacent to Lake Okeechobee have been converted to rich agricultural lands yielding sugar cane, cattle pasture and winter vegetable crops. From Disney World to Homestead, 700 miles of canals and innumerable control structures predetermine the path of every raindrop from cloud to sea.

The mangrove community has been removed from most of the Intracoastal Waterway along the Gold Coast. This detritus-based community provides the driving force behind the productivity of bordering estuaries. Leaves from mangroves provide food for many organisms which range from bacteria to herbivorous fish such as the striped mullet. Organisms feeding on mangrove detritus are part of the food chain which supports such gamefish as snook, tarpon and spotted sea trout.

While wetlands have provided most of the land for agricultural development the coastal uplands have taken the main impact of urban development. 1.7 million acres of upland habitat (pineland, hardwood, and scrub) have been developed in an area comprising South Florida and the Kissimmee River Basin (Browder et al., 1977). These areas are the highest, driest and cheapest to develop. Even today, with the heightened consciousness of environmental values in full force, the upland environments particularly those in the Keys receive little attention. They are slated for extinction by tradeoffs in the battle to contain growth.

In Dade County the predominant forest type prior to development was pineland. 180,000 acres of pineland extended from the Dade-Broward line to Everglades National Park in a 65 mile long, 6 mile-wide curving arc along the coastal area. The land upon which they grew formed the eastern wall containing the Everglades marsh. The continuous Florida slash-pine forest was broken only by 15 narrow transverse glades which allowed water to overflow from the Everglades to Biscayne Bay. Virgin pines known as Dade County pine were reported to be two feet in diameter and over 90 feet tall (Craighead, 1971). Only 6,000 acres or 5% of the original pineland remain in Dade County outside of the Park (Shaw, 1975; Britt, 1983).

Although the pinelands were low in woody-plant diversity they contained extremely diverse pockets of hardwood vegetation. Hammock Forests, unique in the United States, dotted the pineland. More than 500 hammocks (oak-palm and tropical hardwood) once were scattered along the Coastal Ridge. Tropical hardwood hammocks contain up to 170 species of plants including orchids, bromeliads, and tropical forms (gumbo-

limbo, fig, lysiloma, and wild-lime) and many rare species (Craighead, 1971). Only about 125 hammocks remain in the Park and 50 hammocks within Dade County (Shaw, 1975), and their acreage continues to decline as a consequence of encroaching development.

The drastic decline in wading bird population in interior wetlands is a window through which we can view the magnitude of wildlife changes not just in wading birds but in all wildlife populations in South Florida. The number of wading birds totalled approximately 2,500,000 in 1870, 1,500,000 in 1935, 300,000 in 1960 and 70,000 in 1972 (Crowder, 1974). This drastic decline has resulted from not only habitat destruction but also alterations in hydroperiod. In the nesting season beginning in late winter or early spring, the food supply must be adequate to sustain both adult birds and their nestlings. It is only through seasonal reduction in water levels that the previous summer's production of fishes, crustaceans and other parts of their diet can be concentrated in ponds and depressions. If the water level is too high during nesting, the food supply will be so sparse and dispersed that feeding and nesting will not succeed. If the water level is too low no food will be available. Obviously this sensitive arrangement requiring a water level which is "just right" has been disrupted by both urban and agricultural development.

The tremendous impact on wading bird populations begs the question as to whether the needs of growth are compatible with the requirements of nature. Water management strategies generally demand that water levels be held as low as possible during the wet season to insure protection from flooding but as high as possible during the dry season to prevent saltwater intrusion and provide storage and adequate drinking water for coastal areas. These requirements are just the opposite of those needed for optimum proliferation of wetland wildlife.

Growth pressure in the Florida Keys, the most endangered area of South Florida, threatens to remove every indigenous living creature. The Elkhorn and Staghorn corals have been exterminated on a large portion of the Florida reef tract. Six coral species are endangered and seven are threatened (Franz, 1982). Thirteen species of plants from the Keys are endangered and eighteen species are threatened. Three of the six plant species recently extirpated from South Florida were originally found in the Keys. Habitat destruction has also generated a number of endangered and threatened mammals and reptiles. The Cudjoe Key rice rat, Key Largo cotton mouse, Key Largo woodrat, Key deer, American crocodile and Atlantic hawksbill turtle are endangered. The Lower Keys cotton rat, Key Vaca raccoon, Key mud turtle, Florida Keys mole skink, Big Pine Key ringneck snake, Miami black-headed snake and the Keys population of the Florida ribbon snake are threatened (McDiarmid, 1978; Layne, 1978). It is ironic that perhaps no other area in the state is as dependent on ecological stability to provide recreational benefits and the ambiance of an island retreat as the Keys. Yet growth itself threatens the qualities which make it unique and attractive.

This article attempts to review the past and look to the future. The past history of environmental change is examined and ways of minimizing environmental damage by use of existing legislative mechanisms are presented. The role and resources of each of the three major state environmental funds is outlined. This article also examines the mechanism of growth control which is now a reality through the comprehensive planning process.

The depredations of the past are a clear warning that we need to be extremely careful in the future management of South Florida's growth. At some point in time, permanent population growth must be fully controlled around a buildout population simply because unlimited growth will result in unlimited destruction of environmentally sensitive areas. The preservation of natural environments and systems must be the basis for limiting growth because natural environments and systems are inextricably intertwined with essential aspects of life in South Florida such as water quantity and quality, flood control, water-based recreation, and the tourist economy.

The History of Environmental Alteration

Through time our perspective of the benefit derived from development has changed. In the early 1800's, South Florida was regarded as a frontier which if ditched and drained could provide farmland, homes, food, and wealth for a growing America. Draining the Everglades was progress and an honorable task. The patriotic fervor of this desire rings in the letter of Buckingham Smith to the Secretary of the Treasury in 1848:

"The Ever Glades are now suitable only for the haunt of noxious vermin, or the resort of pestilent reptiles. The statesman whose exertions shall cause the millions of acres they contain, now worse than worthless, to teem with the products of agricultural industry; to be changed into a garden in which can be reared many and various exotics, introduced for the first time for cultivation into the United States, whether necessities of life or conveniences, or luxuries merely; than man who thus adds to the resources and wealth and independence of his country, who contributes by such means to the comfort of his fellow men, will merit a high place in public favor, not only with his own generation but with posterity (Smith, 1848)."

South Florida has passed through two phases of both thought and activity impacting our natural areas. It may now be entering a third phase. Each phase succeeding the first has shown greater respect for environmental values and an increasing awareness of the relationship between the quality of life and the proper management of the ecosystem within which we live.

The first phase, the Age of Rapacious Reclamation, was a time of ravaging drainage by men of wealth and organizations with power who had grand visions of future development on an imperial scale. The second phase, the Age of Structural Solutions, was an attempt to control water in South Florida through an extensive network of dikes and canals primarily for the benefit of urban and agricultural development. The third phase, the Age of Enlightenment, may possibly be the next phase. This will be a time during which some of the structural controls are eliminated, and others are operated in order to provide or maximize environmental benefits.

Phase I - Age of Rapacious Drainage

Hamilton Disston began the work of draining Lake Okeechobee and improving the Kissimmee River in 1882. Disston Dredge No. 1, a woodburning stern-wheeler, started from Ft. Myers and moved up the Caloosahatchee River removing snags and logs, then dredged out the falls at Fort Thompson which held back a ten-foot head of water (Tebeau, 1971). It dug Reedy Canal from Lake Flirt to Lake Hicpochee and finally Three-Mile Canal from Hicpochee to Lake Okeechobee (Dodson, 1973). Another dredge straightened and deepened the Kissimmee River which meandered in tortuous fashion. Disston planned to drain the Everglades by means of a canal from Lake Okeechobee to the headwaters of the Shark River but after digging southward following the stream bed of the small Ritta River, the dredge encountered rock which it could not remove (Tebeau, 1971). Disston's effort to reclaim land subsequently bogged down but the concept was again rekindled by the Everglades Drainage District.

Beginning in 1905 with construction of two dredges on the banks of the New River where Ft. Lauderdale now stands, four main canals were cut from Lake Okeechobee to the Ocean. By 1913, the North New River Canal opened navigation from the Lake to Ft. Lauderdale. The Miami Canal was completed that same year. All four canals including the Hillsboro and West Palm Beach Canal were fully operational by 1921. The Everglades Drainage District proceeded to construct the St. Lucie Canal in 1916 and water first flowed out to the Atlantic in 1924. An earth levee was constructed separating the Lake from the Everglades on the east, west, and south sides between 1924 and 1938. The total length of this levee was 85 miles with top elevations ranging from 34 to 38 feet (Leach et al., 1972).

In Collier County, the Barron River Canal was completed in 1926, providing material to construct the road from Everglades to Immokalee. It was also the first major drainage canal into the Big Cypress Swamp. The Tamiami Canal was completed in 1928 and provided not only a road across the Everglades but also intercepted and distributed flow between the Big Cypress and the Everglades (Klein et al., 1974).

The Lake Worth Drainage District in Palm Beach County began operations in the 1930's. Its drainage system covered about 200 square miles of land from West Palm Beach southward to the Broward County Line. It consisted of 50 shallow east-west lateral canals and 4 north-south equalizing canals (Klein et al., 1974).

By 1940 the main-frame concept of the Everglades drainage system was in place. However, the Everglades Drainage District system was a poor suitor and the Everglades, a reluctant maiden. The canal system was neither able to retain water during droughts nor control high water during floods. And then came the "Eleventh Hour."

During 1943-1945 South Florida experienced one of the most severe droughts on record. Its impact was even more devastating because of the deleterious effects of uncontrolled drainage. Marjory Stoneman Douglas describes the event in cinematic prose: *"The whole Everglades was burning. What had been a river of grass and sweet water that had given meaning and life and uniqueness to this whole enormous geography through centuries in which man had no place here was made, in one chaotic gesture of greed and ignorance and folly, a river of fire."*

"The acrid smoke drifted over the cities, and people choked and suffocated in it. Many left."

"Men watching from fire towers got tired of counting smokes against which they could do nothing. There was no water in the canals with which to fight them. Houses, trees, groves were burned. The fires swept along the Tamiami Trail and burned the camps as the Indians fled from them. There were weeks when the Trail and the other roads were closed to traffic, blinded by the dense covering choking smoke."

"Far south where Royal Palm State Park had kept the beauties of Paradise Key as they had been, a dark tropical jungle dominated by majestic native royal palm trees, the fires raged across the sawgrass. There was no one to watch the flames. In a week in which the fires spread into drying jungles, flashed across the firebreaks, the flames worked and smoldered deep in the roots and hearts of the beautiful old oaks. All the fine tropical trees of the jungle were eaten out. Birds, snakes, deer, small animals were caught in the flames. The delicate tree snails were burned, the orchids, the air plants, the ancient leather ferns, the butterflies. What had been unique and lovely and strange was a black monotony of destruction."

"Thousands, choking in acrid smoke, saw for the first time what the drainage of the Glades had brought to pass (Douglas, 1947)."

Then the rains came. The autumn rains in 1945 put out the fires. In 1946, heavy rainfall fell covering the Everglades with a blanket of water. Then in September a hurricane struck and then another in October. 102 inches of rainfall were recorded at Dania in Broward County between January and October 1947. Water smothered eleven counties from five to eighty-five percent (Tebeau, 1974). Movement through Hialeah was by boat. Thirty percent of Ft. Lauderdale was under water (Secretary of the Army, 1948). South Florida in 1947 was reeling from an out-of-control system that threatened the Everglades as well as human life. In 1947, Marjory Stoneman Douglas wrote:

"The work of the Soil Conservation Service and of the Geological Survey has pointed the way to what should be done. The Army Engineers have now taken the initiative in putting all that research to practical use. How far they will go with the great plan for the whole Everglades will depend on the co-operation of the people of the Everglades and their willingness at last, to do something intelligent for themselves."

The Corps of Engineers had a plan for South Florida as well as the Kissimmee River. It was general and in some cases vague, subject to later definition in specific areas in order to meet specific needs. Newly created Everglades National Park commented on the plan fully realizing that the health of the Park would rely on the provision of water from the Corps' works.

State and federal governments did not deliberate at length over the pros and cons of potential environmental impact by the project but acted swiftly to avert repetition of another crisis. Congress eagerly embraced the plan and approved authorization of the project in the Flood Control Act of 1948. The next year, the state legislature created the local sponsor, the Central and Southern Florida Flood Control District, and Phase I came to an end.

Phase II - The Age of Structural Solutions

The Corps began construction of the East Coast Containment Dike which extended from Palm Beach County to Dade County in order to keep flood waters from overflowing the Everglades into urban areas. Working quickly, this was completed by 1953. Water Conservation Areas 1 and 2 were finally enclosed by levees in Palm Beach and Broward counties in 1960 (Klein et al., 1974). By the end of 1962, just as another drought struck, Water Conservation Area 3 was enclosed on the South side and surface water flow into Everglades National Park came under the total control of the Corps and the Central and Southern Florida Flood Control District (Leach et al., 1972).

Unfortunately, the Corps placed the main structures discharging water into Everglades National Park west of the main channel of the Shark River Slough. This was done purposely to direct flood water flows away from the populated coastal area. The four S-12 structures were not placed at the lowest elevation of the Slough but to the west where the land is at least two feet higher (Figure 2). This makes delivery of water into the Park difficult at low stages and changes the flow pattern at all times (Browder et al., 1977). The historical flow path (northeastern Shark River Slough) was isolated from the new discharges and in part was left in private ownership. This area is now known as the East Everglades Area. But this was only one problem.

The Corps' work on construction of the Kissimmee Canal (C-38) began in 1962 and was completed by 1971 changing a meandering stream of 90 miles to a straight channel of 52 miles. The original Corps' plan for the Kissimmee River said nothing about creating a Kissimmee Ditch. By the time construction was drawing to a close a few people began to realize that the plan which was developed in the 1930's and 1940's was out of touch with environmental concepts of the 1970's.

Behind the ditching and diking, the Corps' plan for South Florida was one that had grand management objectives. Flood protection was not the only goal. Storage of surface water, prevention of soil subsidence, protection and enhancement of municipal water supplies, prevention of saltwater intrusion, and maintenance of habitat for fish and wildlife in the water conservation areas constituted the spectrum of noble intentions.

One of the major problems was prioritization of these functions. In time of crisis, who could get the water? The showdown between man and nature came during the drought years of 1962-1965 immediately after construction of the levee along Tamiami Trail when the Park received no significant water from the Everglades within the Water Conservation Areas north of the Trail.

The Corps acknowledged the need by the Park for water but there were no specific plans to meet the Park's needs. The Park took the attitude that while the Park's needs would not receive priority over the existing needs of other users, its needs should be satisfied before any water went to meet new demands resulting from future growth. The attitude of the Director of the Florida Board of Conservation was that the Park was a "creature of adversity" and should share adversity cheerfully (Carter, 1974). The Flood Control District (FCD) also took the attitude that the Park should share in the adversity, but there was a definite concern for the Park. At no time did the FCD refuse to provide water to the Park. At the April 5, 1963 Board meeting of the FCD, the drought situation and ways of providing more water to the Park from Lake Okeechobee were discussed. The problem was that Water Conservation Area 3 was 2.7 feet below the desired stage of 9.8 ft MSL as a consequence of the drought and the project works at the time had a very limited capability of conveying water to the Park from Lake Okeechobee. Lake Okeechobee was at its regulation stage and discharges were being made to the Conservation areas but there was little hope expressed that water could be discharged in significant quantities to Water Conservation Area 3 to, in turn, provide water to the Park. A Corps' study to transfer water to Conservation Area 3 and then to the Park was mentioned. This plan would incorporate a mile-wide floodway located between the Miami and North New River Canals running south from Lake Okeechobee to Water Conservation Area 3 as a third major outlet (the other two are the Caloosahatchee and St. Lucie rivers) for Lake Okeechobee during high water periods. But that plan was not in effect, and the gravity discharge of 300 cfs to Water Conservation Area 3 was not having a significant impact on the water level in Area 3.

No discharges occurred through the S-12 spillways into Everglades National Park during 1963, and only a small amount was discharged in 1964 (Leach et al., 1972). In 1965, flows to the Park improved

and then a strange thing happened. Flows in 1966, 1968 and 1969 greatly exceeded the prior record flow of 1947. The effect of the Eastern Containment Dike and L-67 was to route more water to the Park through a cross-section that had not previously seen that much water. By then, the immediate concern over the drought had evaporated but the debate about the allocation of water to the Park in a future crisis raged on. To many environmentalists the FCD became an "adverse creature." It took an Act of Congress to settle the controversy.

Finally, in 1970, Congress guaranteed 315,000 acre feet of water annually to the Park. Senator Edmund Muskie observed during the hearings on the water guarantee that without a policy of controlled growth, "the pressures for making this water available to people rather than wildlife in case of a drought will be overwhelming, whatever policy we write here" (Carter, 1974).

Structural solutions to developmental problems were not unique to southeast Florida but also occurred in southwest Florida. Drainage of the Big Cypress Swamp by Gulf America Corporation in the 1960's resulted in a grid pattern of roads and canals over 100,000 acres of Collier County known as Golden Gate Estates. One hundred and eighty-three miles of canals and 24 water control structures have effectively reduced water levels an average of 2.5 feet. Drainage has shortened the hydroperiod from 5 months in dry years or 7 months in wet years to between 2 and 2.5 months at present (Collier County, 1976).

The Age of Structural Solutions and its gigantic plumbing system which we still live with today not only changed the appearance of South Florida but enabled growth to progress without fear of flooding and with general assurance of a reliable water supply. As a consequence of improved drainage, agricultural development in the Everglades Agricultural Area was able to expand into areas far south of Lake Okeechobee. Urban development moved westward because the Everglades was no longer able to overflow into the coastal areas. Development in western Broward County moved to the base of the Water Conservation Area levee.

Few conservationists will acknowledge that the constructions of the Corps of Engineers are anything but the handiwork of the Prince of Darkness himself. But the Age of Structural Solutions had one primary environmental benefit. If the Corps had not encircled some 900,000 acres of Everglades marsh in the Water Conservation Areas with protective dikes, it is unlikely that the largest parcel of Everglades habitat in existence today would exist today. The rapacious nature of early drainage efforts would probably have destroyed the Everglades outside the Park by overdrainage and consequent fire and soil subsidence. The Park without the protection of the Water Conservation Areas to the north would have fared far worse than it has to date. If the Park is languishing now, it would have perished without the southward flow of water now provided by and guaranteed from the Water Conservation Areas.

Environmental Protection through Regulation

A tremendous amount of regulation exists at the State and Federal level to provide direct protection to environmentally sensitive areas and thus constitutes another type of control on growth (Table 1). The Army Corps of Engineers administers Section 404 of the Clean Water Act of 1977, which gives the Corps authority over the discharge of fill into wetlands. The Clean Water Act extended jurisdiction of the Corps into freshwater wetlands, including marshes, swamps and similar areas that are adjacent to lakes, rivers and streams that are used or are susceptible to use by interstate commerce.

The Corps' regulatory program is particularly valuable in protecting endangered species. In considering any permit action, the Corps must fully consider wildlife habitat particularly those species which are on the federal endangered species list and for which critical habitat is defined. The Corps' regulatory program has been able to provide protection for the Cape Sable Sparrow in the East Everglades Area and may be the sole means of saving the Florida panther habitat in both the Fakahatchee Strand area (Mashborn and Hartman, 1983) until purchase by state funds and in the Big Cypress outside of the Preserve. Unfortunately, the Corps has recently been backing away from action within their jurisdiction and begun issuing general permits for large projects.

The US Fish and Wildlife Service which administers the critical habitat and federal endangered species program (Appendix 1) coordinates with the Corps on the evaluation of any Corps' permit. In addition, it evaluates development plans and permits issued by other federal agencies. The Florida Keys Aqueduct Authority, the water supplier for the Keys, has been restricted from serving habitat areas of the Key Deer and areas where development may disturb the nesting sites of the American Crocodile because the construction loan for the new pipeline came from a federal agency, the Farmer's Home Administration (FMA). The Fish and Wildlife Service also is involved in evaluating the environmental impact of EPA registrations for use of restricted pesticides, HUD grants, interstate highway construction, Indian Reservation activities, and construction by other federal agencies.

The Florida Department of Environmental Regulation regulates dredge and fill pursuant to Chapter 403 FS and 253 FS. Dredge and fill activities below ordinary high water or mean high water on navigable waters are subject to Chapter 253. An ecological survey must show that the dredging will not interfere with the conservation of fish, marine and wildlife, destroy oyster beds, clam beds, or marine productivity. The review of applications for Chapter 403 permits which regulate dredge and fill activities over much more extensive areas than does Chapter 253 is limited to consideration of water quality impacts. Environmental impacts may be considered only to the extent that they affect water quality. The destruction of wetland vegetation may be considered but only to the extent that wetland loss would affect water quality through

loss of biological purification and filtering capabilities (Hamann, 1982). Additional information on Corps and DER dredge and fill regulations is presented in Appendix 13.

An innovative program for wetland protection exists within the surface water management process of the South Florida Water Management District. The regulation of drainage by SFWMD is responsible for recent publicized attempts by developers to begin "designing with nature." As a consequence of retention requirements for drainage about 10% of the land area for every new development, either agricultural or residential, must be utilized for retention of storm water. If wetland areas are present, they are prime candidates for retention areas because of the higher cost of developing these areas. Thus, they serve a dual purpose - retaining water and preserving natural areas.

In general the SFWMD prefers to require large areas for preservation rather than many small pockets which may not survive when surrounded by either intense farming or urban runoff. Small parcels are traded-off for larger areas where wetlands may have already been destroyed but where they can be recreated by controlling water level elevations within the retention basin. Evaluation of saving the big vs the small wetlands is needed but this program is potentially a solution to the problem of protecting numerous scattered wetlands which are perhaps too undistinguished to merit priority for purchase as endangered lands.

Resource Alert Watch Line

The state's concern over protection of our natural areas has resulted in a Resource Alert Watch Line, 1-800-342-1821 or 1-800-342-1829 (emergency). This toll-free line connects to the Florida Marine Patrol Radio headquarters in Tallahassee and is open on a 24 hour basis. The line has been provided to allow citizens to report activities which are or may be damaging to habitat or wildlife.

TABLE 1

Environmentally Important Legislation

Federal

River and Harbor Act of 1899 (Section 10)
Fish and Wildlife Coordination Act of 1958
National Environmental Policy Act of 1969
Marine Protection, Research and Sanctuaries Act of 1972
Coastal Zone Management Act of 1972
Clean Water Act of 1972 (Federal Water Pollution Control Act Section 404)
Endangered Species Act of 1973
Clean Water Act of 1977

State

Water Resource Act of 1972
Florida Environmental Land and Water Management Act of 1972
 Developments of Regional Impact
 Areas of Critical State Concern
Local Government Comprehensive Planning Act of 1975
Land Conservation Act of 1972
 Environmentally Endangered Lands
Land Acquisition Trust Fund
Florida Air and Water Pollution Control Act
Beach and Shore Preservation Act
State Parks and Preserves
 State Wilderness System Act
 Florida Aquatic Preserve Act of 1975
Game and Fresh Water Fish Commission
Public Lands and Property
Florida Endangered and Threatened Species Act of 1977
Endangered Plant Act
Florida Coastal Management Act of 1978
Administrative Procedures Act

Environmental Salvation - What shall we protect totally?

All existing legislation is limited in its ability to totally protect environmentally sensitive areas because of the "taking" issue. Protection of wetlands and other areas is generally subject to compromise in order to avoid costly and time consuming court actions which neither government nor the developer wants. But some environmentally endangered lands are so critical and important that they cannot be compromised. To insure protection of these lands both the State of Florida and private foundations have established funds for the acquisition of property.

This leads to an interesting question. With a limited amount of money which parcels of the South Florida ecosystem are the chosen few to be saved?

In a 1981 document from the US Fish and Wildlife Service titled "Significant Wildlife Resource Areas of Florida", about 325,000 acres in South Florida were identified as areas which have important wildlife value and are in danger of destruction (Table 2). These sites list acquisition of tracts in the Florida Keys which are under intense development pressure as a number one priority. These are followed by Taylor Slough Tracts comprising a large portion of the East Everglades Area. The East Everglades Area is a sawgrass and tree island area which historically was the main flowway of Shark River Slough. The remaining five sites in South Florida include Fakahatchee Strand Prairies in the Big Cypress, the Ten Thousand Islands area southeast of Collier-Seminole State Park, Fisheating Creek Refuge and Wildlife Management Area in Glades County, Keewaydin Island, which is part of the Rookery Bay ecosystem, and Hutchinson Island.

There are a number of other lists of natural areas established by public funds considered important but for reasons not all of which are necessarily wildlife related although they all have wildlife benefits. The Save Our Rivers fund objectives are to preserve and enhance the quantity and quality of fresh water available for all uses and provide the ability to manage the freshwater resource. The South Florida Water Management District which in South Florida administers the fund, recently approved purchase of 32,860 acres in Dade County. This includes 12,160 acres in the East Everglades Area adjacent to Everglades National Park and 20,700 acres south of Homestead but north of the Park boundary in that area. This latter parcel comprises much of the Critical Habitat of the Cape Sable Sparrow. The District also approved a \$25 million bond issue to purchase additional areas in its Five Year Program. Acquisition of the Kissimmee River flood plain amounting to between 18,000 and 30,000 acres, the headwaters corridor of the Loxahatchee River of 1250 acres, Nicodemus Slough on the west side of Lake Okeechobee, 88,000 acres of fee title and 147,000 acres of oil, gas and other mineral rights in the Water Conservation Areas cover the breadth of the Five Year Plan.

Save Our Coasts which is administered by the Department of Natural Resources (DNR) has recreational benefits as its major objective to insure public access to sandy beaches. The Save Our Coasts projects in South Florida include North Beach (Broward), portions of Hutchinson Island (St. Lucie), the Lovers Key Group (Lee), Posner Tract (Broward), Bahia Honda additions (Monroe), plus additional parcels in Martin, St. Lucie and Dade counties.

The Conservation and Recreational Lands Fund (CARL) which is also administered by DNR has a multitude of objectives including acquisition of environmentally endangered lands, protection of water quality and quantity for fish and wildlife habitat, provision of recreational areas, restoration of altered ecosystems to correct environmental damage, and preservation of archaeological or historical sites. This fund evolved from the Environmentally Endangered Lands (EEL) program.

The CARL Program has recently closed on a purchase of 17,300 acres of the East Everglades Area adjacent to SFWRD's purchase thereby returning about 30,000 acres of the Shark River Slough to public ownership. CARL has recently purchased the ITT Tract of 644 acres also in Dade County located immediately south of Matheson Hammock County Park. This property has been transferred to Dade County. Other projects in South Florida which are on the list include North Key Largo Hammocks, Rookery Bay additions, Cayo Costa/North Captiva, West Lake in Broward County, Savannas parcels and Fakahatchee Strand.

The Nature Conservancy under contract with the Department of Natural Resources using CARL funds is conducting a Florida Natural Areas Inventory. This should be completed in April 1984. This is a data gathering group which will make recommendations to the CARL Fund and supply environmental data on sites under consideration. All three funds cooperate with one another to effect purchase of lands where mutual interests overlap.

Current resources for all three programs are about \$43 million as shown in Table 3. Protecting our environment is an expensive business and a long term one. In coastal areas such as Hutchinson Island, the cost of beachfront property runs up to \$3000 per linear foot. Thus a \$1 million expenditure may only purchase 350 feet of beach.

Two national organizations have performed yeoman service in purchasing endangered lands. These are The Nature Conservancy (1331 Palmetto Avenue, Suite 205, Winter Park, 32789) and the Trust for Public Lands (219 East 5th Avenue, Tallahassee, 32303). Both of these organizations function as holding companies which can move quickly to purchase a piece of land if it is in immediate danger of development and then, in time, convey the land to federal, state, or local government, universities or other organizations with appropriate deed restrictions to insure that the land is kept undeveloped. The Nature Conservancy has been involved in the purchase of 27 parcels totalling 23,000 acres in South Florida. The Trust for Public Lands was until recently the fee title holder of 32,000 acres of the East Everglades Area with an option to purchase an additional 18,000 acres. Both the CARL and Save Our Rivers programs are purchasing these lands from the

Trust in order to put them under state ownership.

Purchasing lands for preservation is a slow process which is, oddly enough, fueled by environmental destruction. All three of the public funds derive monies from growth-related activities. They depend on either development of our mineral resources or real estate transactions for revenue generation. In the race between saving our wild places and growth, environmental preservation can't totally win or, in fact, even get off the starting block first. Development will always stay a step ahead of preservation because of the large amount of development needed to generate an adequate purchasing fund and the time delays in collection, selection, appraisals, and bargaining. Perhaps an additional source of funding should be considered such as an ad valorem tax on all real estate in as much as environmental protection is in everyone's best interest.

TABLE 2

Summary of Areas Identified for Preservation in Priority
Ranking by US Fish and Wildlife Service (1981)
for South Florida

State-wide Ranking	Name of Area	Acreage	Significance of Area	Threat
1	Lower Keys Tracts (No Name Key, Cudjoe Key, Fresh Water Marsh, Torch	2,200	Four federally-listed species 14 state-listed species; one federally proposed species; only known habitat for the Key mud turtle and silver rice rat; one of the few habitats for the Key deer.	Threatened by residential development, mosquito control practices, fragmentation of ownership.
3	Taylor Slough Tracts	63,000	Six federally-listed species; nine state-listed species; one federally proposed species; only habitat for Cape Sable seaside sparrow outside Everglades National Park; important wading bird habitat; the associated estuarine areas (within the Park) support additional endangered species.	Imminent threat; this area is threatened by intensive agricultural practices and possibly residential housing developments.
4	Fakahatchee Strand Prairies	68,000	Four federally-listed species; eight state-listed species; only confirmed private land with a population of Florida panthers; surrounds and protects the Fakahatchee Strand which has many rare and endangered plants.	Threatened by fragmentation of ownership, possible residential development and intensive agricultural practices.
7	Hutchinson Island	2,000-4,000	Three federally-listed sea turtles nest here; it is the primary U.S. rookery for both the green sea turtle and the loggerhead sea turtle. The leatherback sea turtle also nests here occasionally.	The threat to this area is development, which has already begun. The turtles are being harassed by beach-combers and people in dune buggies.
10	Ten Thousand Islands	40,000	Six federally-listed species; 20 state-listed species; mangrove islands; bays, tidal rivers, marshes, etc.; supports a tremendous diversity of terrestrial and marine animal life.	Threatened by fragmentation of ownership, possible agricultural and residential development.
11	Fisheating Creek Refuge and Wildlife Management Area	150,000	Six federally-listed species; 11 state-listed species; many habitat types.	Future threats might include intensive agricultural and forestry practices.

TABLE 3

State Purchasing Programs for
Environmentally Sensitive Areas

Fund	Administration	Sources of Funds	<u>Current Funds</u> <u>Annual Funds</u>
Conservation and Recreational Lands (CARL) Fund	Bureau of Land Acquisition Department of Natural Resources 3900 Commonwealth Boulevard Tallahassee, 32303	Severance Tax on phosphate, oil and gas, minerals (Environmentally Endangered Lands Funds are exhausted)	\$27 million \$20 million maximum
Save Our Coasts (SOC)	Recreation and Parks, and Division of State Lands Department of Natural Resources 3900 Commonwealth Boulevard Tallahassee, 32303	Land Acquisition Trust Fund (LATF) obtains funds from documentary stamp tax; LATF backs up bond sales for purchases	\$6.4 million* not predictable**
Save Our Rivers (SOR)	South Florida Water Management District P. O. Box V W. Palm Beach 33402	Documentary stamp tax matched by ad valorem tax money	\$9.5 million est. \$4.5 million**

*\$50 million in bonds sold; This is amount remaining after acquisitions as of August 26, 1983.

**depends on number of real estate transactions.

Controlling Growth

What population growth does the future portend for South Florida? Tremendous growth will occur between now and the year 2000. Table 4 below gives some idea of the magnitude of change we will face. The largest counties will continue to show the greatest increases in population while the smaller counties will experience large percentage increases. Dade, Broward and Palm Beach counties will add 1.3 million people to their population by the year 2000. This amounts to a new resident putting down roots every seven minutes. The ranks of Lee and Collier counties on the west coast will swell with the addition of another quarter million people.

When people think of controlling growth in South Florida they frequently think of limiting growth either by building a "great wall" across the northern Florida border or establishing a population cap. Both the constitutional right to travel and the airplane preclude a physical barrier as a way to control the river of people which daily flows into South Florida.

A mechanism does exist, however, to force growth through a series of orderly steps to a planned build-out population, and that mechanism is the Local Government Comprehensive Planning Act of 1975. This act requires the development of comprehensive plans by every municipality and county. No public or private development can occur without being in conformance with the comprehensive plan. The objective of a plan is to insure that growth does not outstrip resources or services. Through the process of comprehensive planning it is intended that units of local government can prevent overcrowding of land and avoid undue concentration of population, facilitate the provision of transportation, water and sewer, and conserve, develop, utilize and protect natural resources. Most importantly each plan requires a conservation element to explain how natural resources will be protected and conserved. A land use plan element designating conservation areas is required. These plans have legal status and are implemented through the control of zoning. The actions of zoning boards become the primary way in which comprehensive plans are implemented.

TABLE 4

Population Projections For South Florida Counties*

<u>County</u>	<u>1982</u>	<u>1990</u>	<u>2000</u>
Broward	1,067,444	1,314,300	1,566,800
Collier	98,094	140,600	183,500
Dade	1,729,069	1,898,500	2,126,000
Glades	6,399	7,500	8,800
Hendry	20,317	25,700	31,500
Lee	227,259	311,000	400,600
Martin	71,635	99,700	130,100
Monroe	65,748	70,800	76,900
Palm Beach	637,940	843,200	1,051,000
St. Lucie	100,984	138,600	175,900
Total	4,024,889	4,849,900	5,751,100
Percentage increase above 1982	-	20%	43%

*Source: University of Florida, Bureau of Business and Economic Research, Population Division, 1983, Bulletin No. 65.
Medium projections.

The City of Boca Raton had an illuminating experience attempting to control growth using two diverse approaches. The first was by means of a "population cap" and the second was through the comprehensive planning process. As a highly growth-control oriented community Boca Raton approved a 40,000 unit dwelling cap in a referendum on November 7, 1972. In a decision rendered four years later in the courts, the "cap" was soundly defeated.

Judge Thomas Sholts wrote that while he did not object to a city attempting to control growth he found Boca Raton's strategy highly questionable. He found that passage of Boca's cap was without benefit of professional or scientific study and based on emotional guesswork. The city failed to prove that sufficient public benefit was derived from the cap to justify passage. The performance of studies after passage of the cap in order to support the cap found little favor with the court. The court brought up a serious question of public welfare because it appeared that the City attempted to eliminate the possibility of construction of low and moderate income housing. The court felt that the cap transferred an unnecessary housing burden on neighboring communities (Meader, 1979).

Defeated but undaunted, Boca Raton adopted a Comprehensive Plan on June 28, 1979 which established a buildout which is now considered to be 39,286 units, slightly less than the cap. The difference between the Comprehensive Plan and the cap is that under the Plan, everyone is permitted to develop their land to a reasonable use with no land left over which can't be developed. The cap would have cut off all development after 40,000 units with some land owners unable to develop their land. The City is quick to point out that the Comprehensive Plan buildout is not a cap, it just "appears" to be a cap. Additional construction could occur as a consequence of redevelopment if the City desired to do so. With 35,452 units existing and approved, Boca Raton is satisfied that they are controlling growth without a cap.

On July 19, 1976, the City of Sanibel, approved a remarkable comprehensive plan. The effect of the plan including subsequent revisions was to reduce the previous county zoning from 30,000 units to 8900 units. The basis of the plan was that the conservation and preservation of the natural environment was necessary for the health, safety and welfare of the people of Sanibel. Environmental performance standards were established for all major ecological zones. Even on altered land sites no more than 30% of the area could be cleared unless the site was covered with exotics such as Melaleuca, Brazilian Pepper or Australian Pine. The portion in excess of 30% must then be revegetated with native or non-competing plants. A list of plants which should be protected includes slash pine and saw palmetto as well as hammock hardwoods, beach and dune vegetation and wetland plants. Both the Plan and the Sanibel Report (1976) show tremendous insight into the inter-relationship between the quality of life and preservation of natural systems.

Planners were also concerned about water supply and the evacuation potential of the causeway connecting it to the mainland, providing safe streets, adequate sewer service, maintaining the economic base as a resort compatible with a residential community, protecting the wildlife refuge and preserving the quiet ambiance of a small village.

In November 1978, the electorate of Sanibel adopted a rate of growth ordinance which limits to 180 the number of new dwelling units that can be constructed per year.

The Florida 4th District Court of Appeal has recently established itself as one of the most progressive growth-management judicial bodies in the nation (Duncan, 1983). The court has sanctioned impact fees, density caps, restrictive beachfront zoning, and transfer of development rights in three separate rulings. In one ruling against a developer, with property in North Beach within the City of Hollywood (Broward County), the Court commented that:

"Before us is the last unspoiled beach area in the Gold Coast, a veritable Shangri-La in an otherwise endless Himalayan mountain range of cement to the south. It is surely a laudable governmental purpose to restrain excessive hotel and apartment house building on it and it is neither arbitrary nor capricious to do so."

In distinguishing between Hollywood's density cap and Boca Raton's cap the Court pointed out that Boca's cap was the product of a "public referendum" whereas Hollywood did not adopt "any such Alice-in-Wonderland approach. The record is replete with comprehensive plans, studies, reports, public meetings and actual discussions with the developers over a period of years."

The second issue addressed by the Court in this case was the developer's argument that restricting beachfront properties to single family zoning was confiscatory, arbitrary and capricious. The Court disagreed indicating that all reasonable use of the property was not precluded. The Court stated "A restriction placed on the ocean's edge which limits high-rise construction, preserves open space, cuts down on shadow and reduces densities to seven units per acre in order to achieve its ends, is definitely in the public good."

In another case, the Court affirmed Broward County's authority to override municipal development approvals if it determines the project is inconsistent with the County Land Use Plan. The Court was clear in its message that enactment of any growth management tool must be preceded by technically sound planning and proper legal procedures (Duncan, 1983).

In addition to the Comprehensive Planning Act, the Florida Environmental Land and Water Management Act of 1972 established Developments of Regional Impact (DRI) reviews and Areas of Critical State Concern. DRI's constitute large developments which will significantly impact health, safety and welfare of more than one county. Impacts on environmentally sensitive areas, water, sewer, transportation, schools and roads are given close scrutiny. Conditions to the development order may require concessions from the developer, for example, in setting aside important wetland areas in return for allowing higher densities than permissible under the zoning code.

The Area of Critical State Concern (ACSC) program is intended to protect areas of the state in which unsuitable development would endanger nature resources of a state-wide or regional significance. Once a geographical area has been designated an ACSC, local government then assumes the responsibility for promulgating and enforcing regulations after review and approval of the regulations by state-level government in order to implement the intent of the area of critical designation (DER, 1981). Two areas of Critical State Concern now exist in South Florida - the Florida Keys and Big Cypress Swamp. The South Florida Water Management District has requested that the East Everglades Area of Dade County be given the ACSC designation as well because of concern that Dade County will not protect this most important area.

From a number of cases it is clear that if a community desires to control growth, it can. From observations of Sanibel and Boca Raton, controlling growth appears to require a sense of community which unfortunately is unusual for South Florida. Both Sanibel and Boca Raton are success stories because of a significant commitment to saving natural resources and a strong desire to preserve and shape the community through the control of new development. The insufficient sense of community which characterizes much of South Florida has its roots in many factors - transient population, ethnic composition, racial balance, and age mix (Morales, 1981). Many residents of South Florida have been here so briefly that they have little understanding of environmental problems.

Controlling growth is not only necessary for preserving the natural environment but it is also necessary to sustain the existing economic base of South Florida. Natural areas have both developmental

and recreational importance. Upland areas are important as recharge areas and both uplands and wetlands are important as wellfield sites for high quality drinking water—a commodity which is becoming scarce in southeastern Florida particularly Dade County. Wetlands provide storm and floodwater retention and function as purifiers of water. Beaches are the primary site for outdoor recreational activities in South Florida and unless over developed have definite wildlife benefits. Coastal mangroves contribute directly to a food cycle that maintains our coastal fisheries including shellfish, shrimp, crab, lobster, and gamefish such as snook and tarpon. Although frequently removed, the semi-tropical and tropical vegetation provides a unique appearance, the value of which has not been exploited enough as a selling point for South Florida developments.

As expected, numerous problems abound in current growth management in South Florida. Local governments in the Florida Keys have failed to comply with state requirements under the Keys' ACSC designation (de Haven-Smith, 1983). Monroe County most of which is environmentally endangered has not yet filed a completely acceptable Comprehensive Plan. Lee County which has one of the highest percentage population growth rates in the country, has yet to file a Land Use Plan.

A recent conference sponsored by the FAU/FIU Joint Center for Environmental and Urban Problems, concluded that there were several problems related to saving the wild places of South Florida that must be solved to meet the challenge of future growth. First, the current growth management system lacks an effective monitoring and enforcement system to determine whether plans and land development regulations are being observed as evidenced by the Florida Keys and other experiences. Second, state and regional growth plans and policies are needed in order to evaluate the adequacy of and provide guidance to local and county plans (deHaven-Smith, 1983). These issues and the questions of how growth will pay for itself are probably going to be consuming issues of the 1984 Legislative session.

Can Water Limit Growth?

The weaknesses of the application of the existing growth management process rather than the process itself and the political and financial clout of developers is the primary reason many communities have looked to limitations of natural resources, namely water, as an incontrovertible way to both limit and control growth. Water availability has often been proffered as the ultimate regulator of population increase. This simple concept has broad appeal because it "appears" to make sense. "We are going to run out of water some day and that will be the end of growth."

Water can be divided into two categories — cheap water and expensive water. The cheap water is potable water from surface water storage areas and shallow aquifers. The existing surface water storage areas in South Florida have probably reached a limit on their ability to supply future growth with cheap water in as much as they are only marginally capable of supplying the existing level of development with water as shown by the 1981-82 drought. The amount of cheap groundwater is variable depending on the location of wellfields and their proximity to saltwater. The amount of usable cheap groundwater can be increased by moving wellfields inland away from saltwater and building pipelines to carry the water to the coastal area; this is the concept of "regionalization." Although our aquifers are full of cheap water not all of it may be allocated for use because of various types of impacts such as impacts on the wells of other users, lake drawdowns, environmental impacts on wetlands, and the movement of pollutants within the cone of depression towards the wellfield. Groundwater is in general still plentiful although exact quantification is difficult. But eventually groundwater will reach an ultimate level of exploitation. Then what?

We can begin to utilize more expensive water. This is water from low-pressure reverse osmosis treatment or water derived from recharge of aquifers by highly treated wastewater. These latter alternatives make water availability almost unlimited. In South Florida water availability in reality is not as much an issue as water cost. But even so, South Florida is underlain by tremendous quantities of brackish water which is only slightly more expensive to treat by low-pressure reverse osmosis than raw potable water using conventional treatment technology.

The cost of water on Sanibel Island where drinking water is produced by desalination of brackish groundwater is a flat monthly charge of \$10 plus \$2.50 per thousand gallons of water. In Cape Coral which also produces some of its water from reverse osmosis of saline groundwater, the cost is \$8 for the first three thousand gallons and \$1.65 for each additional thousand gallons. These costs are high, two to four times as high as conventionally-treated groundwater but a water bill of \$30 for 8000 gallons of water per month produced by reverse osmosis is not in itself enough to control growth in most South Florida communities.

The cost of water in the Florida Keys was \$10/1000 gallons when the reverse osmosis plant was producing drinking-water from sea water. Although the recession was in full force at that time, the cost of water did not stop the request for new connections from the Keys' water supplier—the Florida Keys Aqueduct Authority. The current cost of water, \$5.68/1000 gallons, is perhaps one of the highest rates in the country, yet many developments are continuing to seek connections.

The cost of water is obviously part of the economic evaluation of how affordable life will be in a community. This is part of the "quality of life evaluation." But the limitations on development of our natural areas should restrict growth prior to the time at which the cost of water becomes a significant factor. If we wait for the cost of water in the Florida Keys to stop growth, development will pirate

away the natural treasures in the Keys forever. The cost of water on Sanibel Island would not prevent over-development if unrestricted development was now possible (which it isn't).

This discussion is not a recommendation that the cost of "expensive" water be ignored in comprehensive planning. Reverse osmosis is power-intensive and power costs in South Florida are rising at a rate of 9.5% per year. The impact of higher water costs in conjunction with the costs of other services does need to be considered in the comprehensive planning process. Higher living costs due in part to water costs may restrict the community to a population with a relatively higher income level and eliminate low income housing. This appears to be happening in the Keys where new residents appear to be more affluent and better able to afford the higher cost of living. The type of community that a local government wants to be in the future can be determined by the Comprehensive Plan. If the projected water use exceeds "cheap" water availability, then the cost of providing water by other power or capital intensive measures can potentially change the socio-economic structure of the community. A community can control this change by the Comprehensive Plan if it knows the limits of "cheap" water availability.

Future Environmental Management and Phase III

On March 10, 1983, Everglades National Park presented a Seven-Point plan to the South Florida Water Management District involving reinstatement of a natural flow regimen to Everglades National Park and the Big Cypress Preserve by knocking holes in levees, filling in canals, and discharging water to the East Everglades Area which comprises the main channel-way of the Shark River Slough. Six months later the Corps of Engineers and the District began construction of modifications to do just that - to begin managing the project to optimize environmental benefits. The Corps began construction of three gaps, six plugs and three culverts in L-28 in order to protect the extreme eastern portion of the Big Cypress from overdrainage and restore overland flow to the Big Cypress National Preserve. This action has initiated a new wave of environmental awareness and one that has the potential to right the wrongs of the past.

South Florida may be entering Phase III, an "Age of Enlightenment" during which growth is managed in harmony with nature. Before we can say definitely that this is occurring, more progress is needed in solving the four major environmental problems which beset South Florida.

These are: First, maintaining or improving the quality of existing wetlands which are under state or federal protection. Although major modifications have been made to the South Florida ecosystem as a consequence of drainage, development, and habitat removal, much of the area of Dade, Broward, Palm Beach and Collier counties has been locked up in non-developable areas. The Water Conservation Areas of the South Florida Water Management District constitute almost one million acres, Everglades National Park encompasses about 1,337,000 acres, and the Big Cypress Preserve amounts to 570,000 acres. We have been successful in protecting these areas from direct development. But will we be able to effectively maintain these environments under current management strategies and as urban developments encroach upon them? Can better management improve them? The partial restoration of natural flow to the Park by the SFWMD is an optimistic start to providing a solution to the problem of better management. Additional work may involve re-defining seasonal water-level management strategies, establishing flow-through, and modifying current routings of flood water discharge to a more natural pre-development pattern.

Second, purchasing the most important and environmentally endangered lands: The governor and legislature have fully committed the State to acquiring lands by legislating acquisition by both eminent domain for many parcels in South Florida and establishment of funds. However, enhanced public support of private funds such as the Nature Conservancy and Trust for Public Lands will be necessary to successfully prevent development of the 325,000 acres which have been identified as important to wildlife and many more thousands of acres which are environmentally significant. People in South Florida who understand the problem will need to open up not only their hearts to the preservation of environmentally sensitive lands but also their wallets. Leadership in the private sector is needed to solve this problem.

Third, controlling growth and maintaining natural systems in and around urbanizing areas. The objective of all comprehensive plans should be to maintain the natural systems in careful balance with man-made systems. Development must be compatible with the preservation, conservation and protection of the natural resources of land, water, air, wildlife, and sea shore. The planning process appears to be sound and adequate to achieve this goal. But a regional plan for growth in South Florida is needed to evaluate the local plans to determine whether they are consistent with regional goals and objectives. We need to know the amount of "cheap" water that is available. Additionally, an enforcement and monitoring system is needed.

Fourth, development of a Comprehensive Ecosystem Management Plan as part of the state-wide comprehensive planning process. The primary tenet of growth management is or should be to preserve the natural system. In South Florida, we have a number of ecosystems which are in turn related to the Kissimmee River basin ecosystem. How should the entire system be managed to maximize the quality of life benefits generated by natural systems and at the same time keep the natural system as healthy as possible? This fourth problem is closely related to the other three problems.

Governor Graham's Save Our Everglades initiative announced on August 8, 1983 is a tremendous step in this direction. Returning natural flow to the Kissimmee River, Everglades National Park, and the Holey Land - Roetenberger Area and purchasing land in the Fakahatchee Slough are important steps in better managing what we have and preserving critical habitat. But we need a longer range plan that will fully integrate and make compatible future population growth and the preservation of natural systems and areas. A considerable amount of executive direction and legislative agreement will be necessary to reach this ultimate plateau in the Age of Enlightenment.

Saving the wild places is directly tied into preserving the quality of life in South Florida. Damaging the Park, eliminating wildlife, filling wetlands, clear-cutting the natural uplands flora, losing and polluting beaches, destroying mangrove forests and seabeds, killing reefs and polluting our estuaries will eliminate many of the reasons why millions of people are moving to Florida and nearly 40 million people visit Florida each year (Fernald, 1981). Governor Graham (1983) recently wrote: *"We can allow our water, air and other resources to become overwhelmed. We can let the word get out that Florida has become an environmental disaster area. That will limit our growth, eventually."*

People are continuing to find that South Florida is better than many other worlds. Failure to preserve our natural heritage will ultimately limit our growth. Unfortunately, the efforts that have been and will be made to save our wild places will only enhance the rate at which population expands towards the ultimate buildout plateau. Success is its own penalty but to not succeed is to invite disaster.

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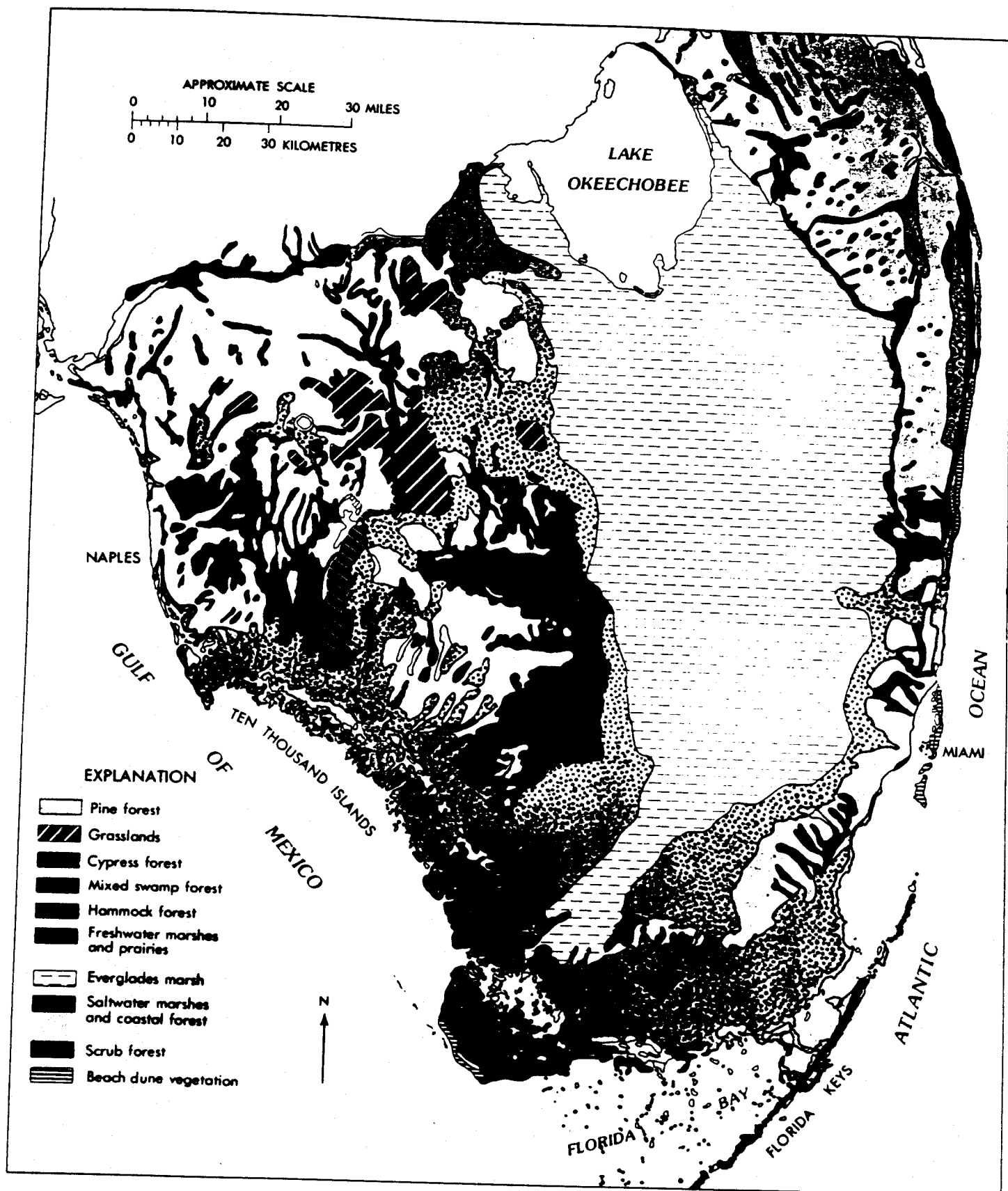


Figure 1. Vegetation in South Florida as it existed before manmade alterations (McPherson et al., 1976).

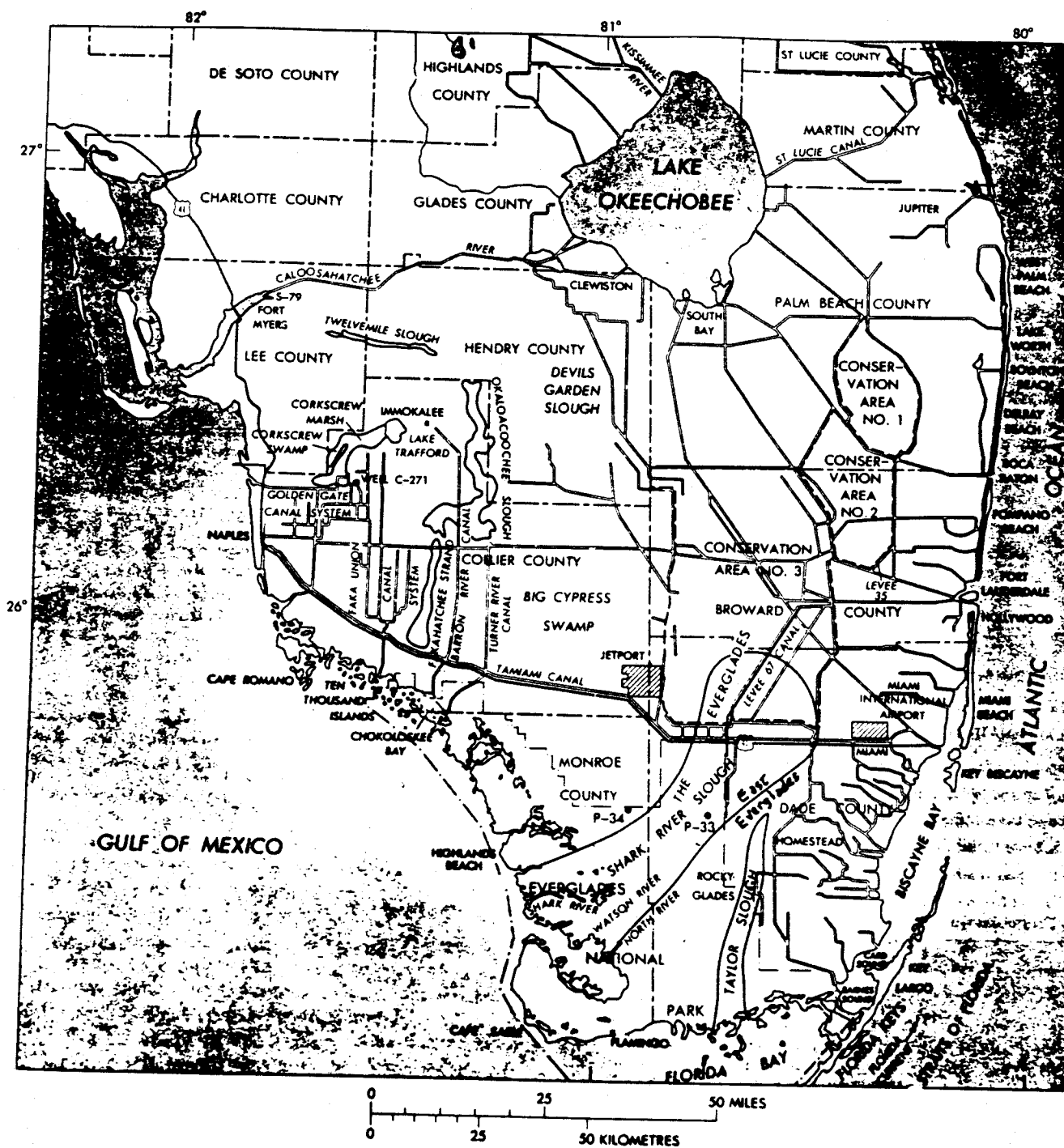


Figure 2. Map of South Florida showing natural and manmade features. (McPherson et al., 1976).

EXPLORATION AND EARLY DESCRIPTIONS OF THE
EVERGLADES, LAKE OKEECHOBEE AND THE KISSIMMEE RIVER

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The Kissimmee River, Lake Okeechobee, and the Everglades together constitute a shallow depression running from north to south through the Florida peninsula. It was pretty much a land of mystery until about a century ago. It has since become the life-line for fresh water thirsty southeast Florida's more than two million inhabitants and for the Everglades National Park. The long drainage basin was almost entirely without human inhabitants, and remains so south of Lake Okeechobee. In fact, all of South Florida was sparsely populated well into this century. In 1900, only 43,344 persons lived south of a line from Cape Canaveral to Charlotte Harbor south of Polk and Orange Counties. This was just over eight per cent of the state's total and 17,000 of them lived in Key West. The remainder lived in villages and small towns and cities on the coast.

Though long unexplored and relatively unknown, the interior was the subject of much curiosity and no little speculation. What puzzled observers along the coast most was the source of the vast amounts of water which flowed east, west and south from it, particularly in the somewhat tropical wet summer season. The peninsula was too narrow for local rainfall to account for it. Perhaps also the idea of such a long depression in which this water accumulated and flowed south seemed a geographical contradiction. There should have been a ridge down the spine of the peninsula as there is north of Lake Placid.

When George Bowen prepared "An Accurate Map of North America" to illustrate for the government of George III the new division of North America after the French and Indian War in 1763, he reflected the great ignorance of South Florida characteristic of the time. He depicted the southern end of the peninsula as an archipelago of large and small islands separated by channels and bays reminiscent of modern maps of the Ten Thousand Islands off the southwest coast. The equally fanciful version of the St. Johns River pictures it flowing both north and south in parts and emptying into the sea in two or more southern outlets.¹

The Spanish era produced very little knowledge of South Florida and almost none of the interior. The Indians and the natural environment in the lower peninsula discouraged them and they devoted almost all of their energies to the northern part of the province, west to the Tallahassee region with a base at Saint Augustine and later a small fort and garrison at St. Marks. The Indians there were more docile and tractable. But Pedro Menendez de Aviles, the founder of Saint Augustine in 1565, was intrigued by the possibility that there was a water passage through the peninsula. He thought that the Saint Johns River might have a common source with rivers flowing into Tampa Bay. And, indeed, the early maps showed the St. Johns rising in Lake Okeechobee until well into the nineteenth century.

The one Spanish report on the interior came quite early. Hernando d'Escalante Fontaneda at age thirteen was shipwrecked on his way from Colombia to Spain where he was to go to school, and spent seventeen years, probably 1545 to 1562, among the Glades Indians, a name given to all of the South Florida Indians by the late John M. Goggin. In 1575 he published in Spain an account of his experiences. He apparently knew best the Calusa Indians on the southwest coast. Of them and their Chief Carlos he wrote that they were masters of a large district that reached inland as far as Lake Mayaimi, the name he gave to modern Okeechobee. Around the lake at the time were many villages. Of more importance for our purpose, he mentions the Tequesta Indians on the lower east coast on a river which extends into the interior 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 Lake Mayaimi. . . ." He also refers to the water in that interior basin which rose in some seasons so high that the food gathering habits of the Indians had to be adjusted to it.²

The British occupation of Florida from 1763 to 1784 produced more information about the coast, but little about the interior. Bernard Romans wrote exclusively about the St. Lucie River, which he was told by a Spanish fisherman and pilot "of good credit" rose in Lake Mayacco, another name for Lake Okeechobee, which was said to be seventy-five miles in circumference. He speculated that the St. Johns and a river flowing into Charlotte Harbor might also rise there. The Indians also told him that in going "far south" they went around a large water, conceivably the Everglades, emptying itself into the Gulf of Mexico. The great amount of water coming down the St. Lucie, enough to make the inlet fresh, convinced him of "some such great water" in the interior.³

Florida became a part of the United States in 1821, and Captain John LeConte of the United States Topographical Engineers made a reconnaissance of the St. Johns River in February and March of the next year. He rejected the idea that the river rose in Lake Mayacco, but in the process rejected also the existence of the lake which was shown on all maps of the time. He did correctly describe the origin of the river in a small lake in the midst of a great marsh or bog which held a great volume of water and which he assumed was what some mistakenly called the Okeechobee.⁴

At almost the same time, Charles Blacher Vignoles published a descriptive history of Florida⁵

based, he said, upon actual observations on the east coast and reliable reports from West Florida. One stated purpose was to account for "The fabulous reports of the inland bays, lakes and waters which have hitherto existed respecting the southern part of the Florida peninsula. . . ." Though he acknowledges the work of Romans and LeConte, it can scarcely be said that he added anything meaningful about the interior. In fact, he apparently accepts LeConte's notion that Lake Okeechobee does not exist for he does not mention it. However, he does write of the Everglades which he calls The Glade, "or as it is emphatically termed, the Never Glade", which appears to occupy the interior from about Jupiter Inlet on the east around to Charlotte Harbor on the west. He reports also that it can be crossed in "three days continued travel in water" at its narrowest point west of Jupiter Inlet. New River and all of its branches originate in the Great Glade and inland communication from New River to Cape Florida is possible by way of the rivers and the Glades.

John Lee Williams published in 1837 the first effort at a general history of Florida.⁶ He admitted scant knowledge of the lower peninsula for which the maps were inadequate if non-existent. Of the Shark River, he wrote that he could not find it and doubted that it existed. Of the Everglades, he reported that he had not the means or the time to explore the "boundless range of grass meadows, interspersed with lagoons and lakes, and swarming with gnats and mosquitoes." On the west coast he wrote of Macaco or Charlotte River, which was supposed to have its source in the heart of the peninsula, but he could find no white man or Indian who had penetrated more than fifty or sixty miles above the bay. He noted several old maps which showed the waters of the interior connecting the principal rivers on sides but doubted that the peninsula had been explored far from either coast. But he also quoted a "respectable gentleman" near the Everglades who described to him a great spring not far from the center of the Everglades, covering several acres and supplying the Everglades with all of the water flowing from the interior.

In 1829 Dr. Benjamin B. Strobel, an assistant surgeon to the army post there, came up from Key West to Miami to hunt sand suitable for the making of mortar. While the sand was being located, he procured a boat and made a trip up the Miami River to the Everglades. He did not penetrate very far inland but he thought it might be called a lake during seasons of high water. The captain of a wreck-er told him that he had once sailed three days in a northerly direction on a fair wind without discovering any bounds in that direction. Another was reported to have sailed in a westerly direction from New River at Fort Lauderdale for two days without reaching the western side.⁷

Dr. Henry Perrine, who planned to introduce tropical plants into Florida, secured a township of land for that purpose which he proposed to locate eastward of Cape Sable. Part of his dream was to construct a canal from the enormous reservoir of Everglades water through the ridge of slightly higher land at the Cape to provide water power for a projected settlement.⁸

In 1847 Col. Robert Butler, the Surveyor General for Florida, reported that the Everglades could not be surveyed without first being drained. Surveys usually extended to the deeper water and ended there. When, under an act of 1850, swamp and overflowed lands were conveyed to the states in which they were situated, Florida accepted them without surveys and they were not surveyed on the ground until well into this century.

The natural phenomenon that accounted for the greater volume of water in the Everglades until about 1910 was the relatively high ridge between the Everglades and the east coast. This kept the level of fresh water in the interior several feet above sea level. The pressure of that vast volume of water produced fresh water seepage and springs east of the ridge along the coast. In fact, the pressure was sufficient to create springs of fresh water in Biscayne Bay, which seamen actually relied upon to fill their casks. Flowing wells could be created on shore by tapping these underground sources. Hugh L. Willoughby,⁹ who crossed the Everglades from Harney River to Miami by boat early in 1897, noted places all along the shore where fresh water came up through the rocks under the salt water with quite a head. Many years earlier, in 1838, Dr. Jacob Rhett Motte, on duty with United States troops in the Second Seminole War, had noted the same phenomenon in the form of fresh water springs below the high water mark and consequently covered by salt water twice every twenty-four hours.¹⁰

The Second Seminole War, 1835-1842, pushed the Indians southward in the peninsula where the army, supported at times by small contingents of navy, pursued them as they took refuge in the hitherto unexplored interior. The accounts of these expeditions, mostly the official reports of the officers in command, usually describe some of the environment. They also provide the earliest maps, crude as they may be. Individuals who were members of the expeditions sometimes published accounts of the adventures. For example, the first recorded crossing of the lower peninsula occurred in December 1840, just five years after the commencement of hostilities in North Florida. The best account, by an anonymous chronicler, appeared in the *Saint Augustine News*, January 8, 1841.¹¹

The party of ninety men in sixteen canoes started from Fort Dallas on the evening of December 4 and ascended the Miami River. On the evening of the tenth they had crossed the Everglades and reached their destination, Chekika's Island on the western edge of the Everglades, just south of U.S. 41, the Tamiami Trail. Much time had been consumed by travelling mostly at night to avoid detection, but water levels were low and the canoes had to be dragged some of the way. Their mission was to find and punish Chekika and his band for the raid on Indian Key in August, in which Dr. Henry Perrine had been killed. Chekika and his followers had made their way southward from the island headquarters by canoe and had returned the same route. The Everglades was a highway of travel for the Indians except when low water

interfered, and Col. William S. Harney was showing the way for the United States Army to make it so for the white man's military operations. Their mission accomplished, Harney made his way to the Gulf of Mexico by what came to be known as Harney River. He had missed the Shark River by which he was directed to travel. Picked up there, they made their way back to Fort Dallas.

The approach to Lake Okeechobee was also difficult. Until it was canalized to the lake by Hamilton Disston about 1880, the Caloosahatchee was not navigable above the "falls" at Fort Thompson. Only at times of extremely high water did enough overflow flood the area to float canoes. Like the Indians, the white man learned to march overland eighteen miles, hauling his canoes, to Fort Center, on Fisheating Creek, and float down that stream to the lake, a journey not lightly undertaken. The practice of limiting military activity to the dry season was self-defeating in the Everglades for the rim of slightly higher land south of the lake became a considerable barrier when the water level fell from summer highs.

Lake Okeechobee could also be reached by way of the Kissimmee River, but that stream must be reached by a long march overland through partially submerged countryside even in winter months. But reach the river and the lake they did. In 1837 Colonel Zachary Taylor started from Fort Brooke on Tampa Bay and marched eastward across the peninsula hunting Indians reportedly gathering northeast of the lake. His men bridged the Kissimmee and constructed Fort Basinger at a point only eighteen miles north of the river as the crow flies, but fifty-five miles by the circuitous route of the river. Taylor's men found the Indians waiting for them and fought the last pitched battle of the war late in December.¹²

Following approximately the same route a year later, Captain E. Backus and his men entered and explored the lake and prepared what is possibly the first map of it (Figure 1). In a brief description on the lower lefthand side of the map, Captain Backus reported many small streams flowing into the lake, but thought it had no outlet except at high water when the lake and the Everglades, called Grassy Water, were united. Indians and Negroes did tell him that they had crossed from one to the other in canoes at high water and had dragged canoes over the portage at low water.¹³

This information did not become very widely known and probably was soon forgotten by those who knew it from experience. A short item in the *Army and Navy Chronicle*, February 22, 1838, for example, refers to Lake Okeechobee as "represented to be a sheet of water of immense extent" about half way between Fort Pierce and Charlotte Harbor. The author speculates that the Indians probably are living on the islands in the lake. It concludes: "This is doubtless that ocean-like lake which we have often heard spoken of as Macaco, and which many have supposed to be entirely fabulous in its existence."

In the early 1870's, the Kissimmee-Okeechobee region began to be explored by hunters and naturalists who reported their discoveries as the first. In April 1883, George Henry Preble, then a rear admiral in the United States Navy, published an account of an expedition to the lake in 1842 to refute the charge that it had never before been visited by white men. The expedition left the brig *Jefferson* at Key Biscayne, Miami, on February 12 and rendezvoused at Fort Dallas, in all eighty-seven persons and sixteen canoes. They entered the Everglades by way of New River in northern Biscayne Bay and made their way toward the lake. Water was relatively low and progress was slow. The men could follow well established trails but were forced at times to drag the canoes. On the 22nd they pulled the canoes over the ridge south of the lake directly from the Glades. On March 3, the expedition moved up Fisheating Creek to Fort Center where they cut cabbage palm trees to replace those broken or rotted in the stockade. They ascended the Kissimmee River to Lake Tohopekaliga. On the 28th they re-entered the lake after eighteen days on the rivers and lakes. On April 2 they started "home" and reached Fort Lauderdale on the tenth. The lake and the northern Everglades had been thoroughly explored.¹⁴

By the end of the war in the summer of 1842, the Everglades had been crossed and recrossed from north to south and east to west, and it was well mapped. Lake Okeechobee had been fully explored and mapped and the Kissimmee was equally well known. Most of the records were in official reports that did not come to public attention. Reports that did reach the press seem to have been forgotten, for speculative reports continued to appear and it was necessary to "rediscover" the region some fifty years later.

The notion of a large lake in the interior that fed the rivers around the peninsula persisted. In 1857, for example, a contributor who signed himself "Key Wester" reported in an item to the *National Intelligencer* that a new vent had broken out from those interior lakes into the Gulf of Mexico. He based his assumption on vast quantities of fresh water in Florida Bay, and calculated that the vent must be somewhere in the neighborhood of Gallivan's Bay. He was probably observing only the condition common to periods of high water when the rivers carried a great volume of fresh water. By contrast, the same streams in low water periods might be only salt water inlets.

The weekly magazine *Forest and Stream*, started in New York in 1873, published numerous accounts of expeditions to the Kissimmee-Lake Okeechobee region and cruises around the peninsula in the 1870's and 1880's. In an early number,¹⁵ there is reprinted from the *New York Herald* a description of the lake which is sheer invention and full of exaggerated error. It reports three islands in the lake, the longest four by six miles, and mentions a line of cliffs about 150 feet high across the width of one of them. The water is measured at 170 feet deep in places. A magnificent forest covers the islands, and giant spiders two feet long and weighing three or four pounds are common on them.

In the spring of 1874, *Forest and Stream* sponsored an expedition that did reach the lake and was

fully reported.¹⁶ The naturalist and writer Fred A. Ober, who led the expedition and wrote the reports, also published what he called the first map of the lake (Figure 2). It may indeed have been the first published, but not the first made. The party marched inland from New Smyrna on the east coast, hauling their boat on a wagon, to Fort Basinger. They followed the military trails of the Seminole War but ignored the implication that others had preceded them on explorations of the interior.

The big lake continued to attract the curious. Late in 1881, Kirk Munroe, a well known author and canoeist, started on a trip that covered 1,600 miles between November 28 and March 12.¹⁷ On a portion of the journey he left Punta Rassa at the mouth of the Caloosahatchee on January 17 and reached Lake Flirt on the 22nd, where the Disston dredges were already at work. He abandoned the effort to reach the lake by that route and crossed over from Fort Thompson to Fort Center on Fisheating Creek and reached the lake on the 30th. He could not find the mouth of the Kissimmee, nor could he find any land, the shore being largely cypress swamp and big sawgrass. On February 7, he hid his canoe and struck out northbound to find land. After walking fifteen miles he found the home of a cow hunter who directed him to Fort Basinger, another fifteen miles. He found a local resident who went with him to retrieve the canoe, and made his way to Kissimmee City where he boarded a train for Sanford on the Saint Johns, from which he launched his canoe for the last leg of his return journey to Jacksonville.

In early 1886, the Wagner Free Institute of Science sent Angelo Heilprin to make an investigation of the Florida West Coast from Cedar Key to the Caloosahatchee and up the river to Lake Okeechobee. His interest was largely geological, but he left useful descriptions of the upper river and the lake. Heilprin and his party reached the lake by way of the narrow and shallow canal dredged by Hamilton Disston from Fort Thompson. Others at times gave up the effort to navigate the canal when it was packed with wind-driven floating plants and debris, but this was but the first stage in the complete canalization of the upper Caloosahatchee so that it had its source in the lake. The mystery was rapidly disappearing from that area.¹⁸

Disston had also done some work to straighten and deepen the tortuous channel of the Kissimmee to make easier the flow of water from his land north of the lake. His plan also included the dredging of a canal down the western side of the Glades to the Shark Valley. He actually started work on what looked the most likely of the short rivers reaching southward from the lake, but he found it too rocky for dredging and abandoned it. The upper part of the Miami Canal eventually followed that route.¹⁹

The *New Orleans Times Democrat*, reflecting the widespread interest being generated in South Florida, sent two expeditions to report on what was happening there and the prospects for investment.²⁰ The first of these visited the Kissimmee-Lake Okeechobee-Calooahatchee where the Disston dredges were at work. Major Archie P. Williams led both expeditions. The second was to consider the feasibility of drainage and the possible value of the land in the Everglades south of the lake, and the possibility of locating a telegraph line by that route. Major Williams reported that all seemed agreed that the water level could be lowered in the Kissimmee Valley and expressed no doubts that the land would be fertile when reclaimed. It would make good sugar cane and rice and grazing land. He was less optimistic about the Glades area. He ruled out the possibility of constructing the telegraph line there. He doubted that the Everglades could be drained. In fact, he assumed that it was below the water level of either coast and must remain a swamp forever. Only some of the higher hammocks in the southern Glades appeared to him to have any value at all for agriculture.

Wholly imaginary stories about the Everglades continued long after their perpetrators knew them to be without foundation in fact. Readers apparently preferred such "reports". Daniel Hosea Bellou, a member of the *Times Democrat* expedition southward through the Glades in 1883, published in *Harper's Weekly*, March 12, 1887, some impressions that had not appeared in the official report. The vast tribes of ducks, curlews and other edible birds never migrate, he wrote. They did not know what the sounds of firearms meant. They could be taken by hand or killed with a stick. They were losing the power of flight, and the flesh was soft, wormy, and unfit to eat. The air, the ground, the water and the trees were full of all manner of insect life with and without legs. The sounds of alligators and owls kept him awake, and leeches were as numerous in water as insects in the air.

All doubts about the nature of the interior were being rapidly removed. The railroad builders made their contribution by exploring the possibility of routes through the Everglades from Fort Myers to Miami. In 1892 James E. Ingraham, president of the South Florida Railroad Company, part of Henry Bradley Plant's system that was opening up the lower west coast as Henry M. Flagler was the east, led such a surveying party.²¹ The official report of the expedition was prepared by the engineer, and Alonzo Church published a more popular account. Curiously enough, Mr. Church reported that they were told at Fort Myers the only white man to have made the journey was carried by the Indians to keep him out of the hands of the law. Alonzo Church reports in his account that the engineer, Captain John M. Newman, explained to Mr. Ingraham that, since rivers of considerable size run into the Gulf on the west, Florida Bay on the south and the Atlantic Ocean on the east and, according to their maps, into Lake Okeechobee on the north, there must be a divide within the Everglades between the headwaters of these rivers, or a common source from which they all flowed. Certainly the engineer's report dispelled such notions if indeed it was anything more than an oft repeated tale.

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Figure 1. In 1838 Captain E. Backus had produced a map of Lake Okeechobee which for a long time remained buried in the national archives records of the Seminole War. It reveals the knowledge of the lake at that time, and his version of the Lower Kissimmee River shows graphically how that crooked and meandering stream flowed fifty-five miles from Fort Basinger to reach the lake only eighteen miles away as the crow flies. In a brief statement in the lower left hand portion of the map, Captain Backus writes: Many small streams flow into Okeechobee on the North-East and West side, & also on the South-East side - but it is not known that it has any outlet, & probably has none, except at high water, when Grassy Lake (The Everglades) and Okeechobee are united, & probably empty through some Streams into the Atlantic. -- This is corroborated by the statements of different Indians and negroes who profess to have crossed from one to the other in a canoe at high water -- & to have carried and dragged a canoe many miles over the portage at low water.

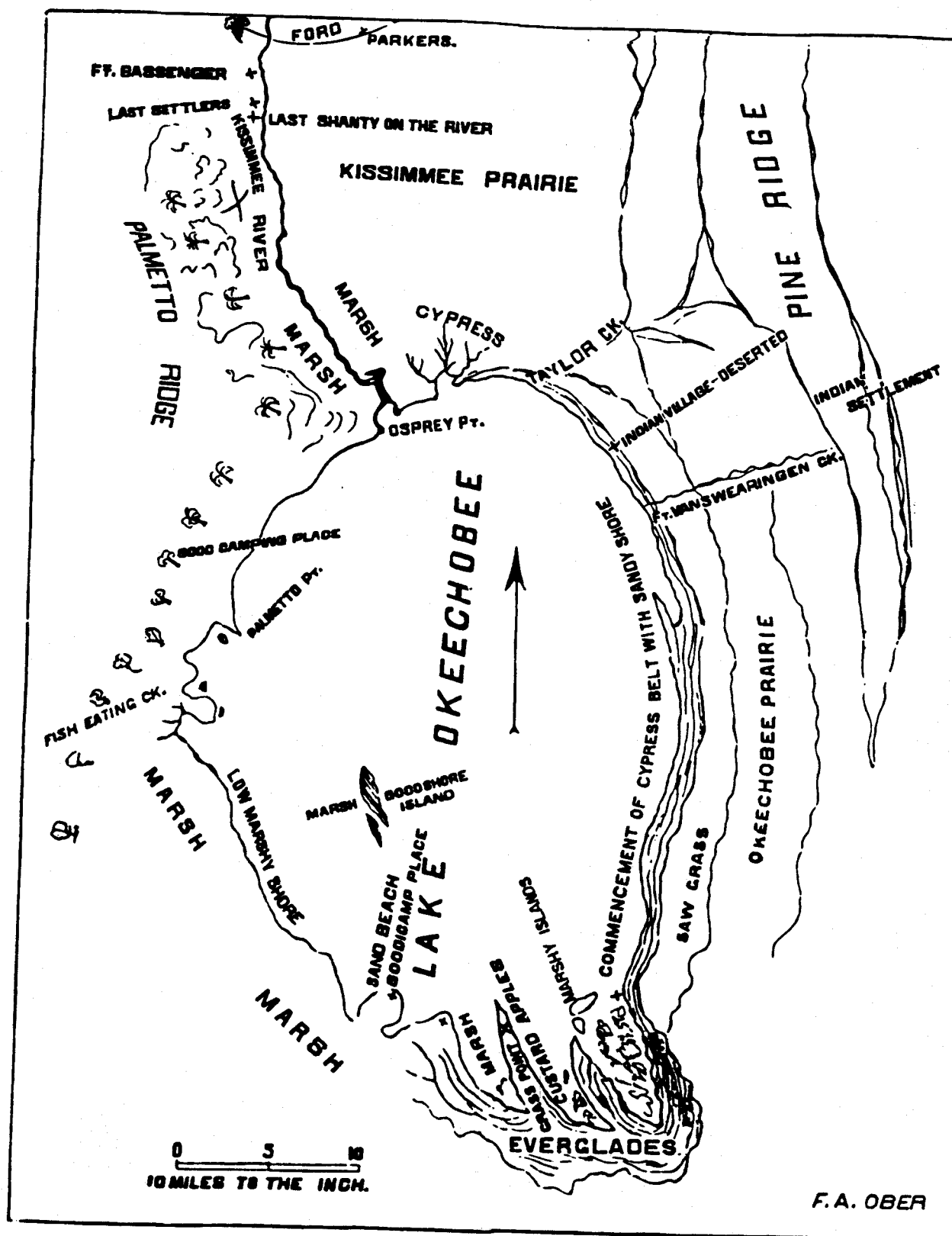


Figure 2. Fred A. Ober's map of Lake Okeechobee from an expedition made in the spring of 1874.

HISTORY OF WATER MANAGEMENT IN SOUTH FLORIDA

by

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EARLY STATE EFFORTS

The first state efforts concerned with water resource management in Central and South Florida were focused on securing some form of federal aid for such a project. Florida's first post statehood legislature, and one of its first United States Senators, James D. Westcott, Jr., made a number of attempts during the 1845-1850 period to secure a grant of federally owned lands to the state. Westcott supported the inclusion of a condition that proceeds derived from the sale or other use of such land would be used solely for purposes of drainage. Disagreement with Florida's other Senator, David L. Yulee, blocked Westcott's initial efforts, but soon thereafter the Swamplands Act of 1850 was approved by Congress.

This important statute granted to the states all federal land within their borders made unfit for cultivation by its swamp or overflow status. The grant was made subject to a very specific proviso that "proceeds of said land...shall be applied, exclusively, as far as necessary, to the purposes of reclaiming said lands by means of levees and drains aforesaid (DeGrove, 1958)." After several unsuccessful experiments, Florida in 1855 created the Internal Improvement Fund, whose ex-officio governing board was composed of the Governor, Attorney General, Commissioner of Agriculture, Treasurer, and the Comptroller. This agency was to administer the supposed trust created by the Swamplands Act, but the program of Internal Improvement prior to 1900, resulting in the alienation of all but about 3 million acres of the approximately 20 million acres of land received by Florida under the grant, virtually ignored drainage, and concentrated on lavish grants of land to railroad and canal companies.

The Internal Improvement Fund emerged from a state of post-Civil War confusion and financial insolvency in 1881 by negotiating a sale of 4 million acres of land for \$1 million. This transaction was made with Hamilton Disston, Philadelphia industrialist, and included a drainage contract that represented the most ambitious and comprehensive plan to drain and reclaim wetlands in central and southern Florida prior to 1947. The scheme envisioned the reclamation of some 9 million acres of land in the Kissimmee, Caloosahatchee, and Lake Okeechobee areas, principally by lowering the level of the lake and constructing channel improvements in the two rivers. The Disston drainage company was to receive one half of all land successfully drained. In terms of actual accomplishment, the end result of this grand plan was extremely modest. Most of the work was done in the Kissimmee Valley area, and a channel was opened from the town of Kissimmee down the river to Lake Okeechobee, through the Lake via the Caloosahatchee River to the Gulf of Mexico at Fort Myers. In spite of company claims of millions of acres successfully drained, and the deeding by the Internal Improvement Fund to it of about 1,600,000 acres of land, only about 80,000 acres were actually drained. Disston's contract with the Internal Improvement Fund ended in 1894, halting major drainage efforts in the area until the Jennings-Broward era.

The administration of Governor W. S. Jennings (1901-1905) and Napoleon Bonaparte Broward (1905-1909) marked the evolution and application of basic policies that allowed a full scale effort to drain and reclaim that section of Florida located generally south of Lake Okeechobee. While no actual construction work started during the Jennings administration, the significance of his work that cleared the way for the future is difficult to overestimate. Jennings led a successful legal battle to prevent the remaining 3 million acres of the swamp and overflow land from being deeded to railroad and land companies. In the course of this struggle, the legality of using such land to carry out the original trust for which it was dedicated was clearly established. Jennings made the public land question an important political issue, and Broward subsequently based his campaign largely on a "save the public lands" battle cry.

In spite of obstructionist tactics by railroad, land, and canal companies, Broward won legislative approval in 1907 for a drainage district in the Everglades region, but only after the courts negated his 1905 success. This district was administered by a drainage board with the same ex-officio membership as the Internal Improvement Fund, that is, the Governor and four other elected members of the Cabinet. The drainage effort was to be supported by a tax of 5¢ per acre on land within the area to be drained. The basic amendment in 1913 definitely established a new agency, the Everglades Drainage District, with boundaries running just north of Lake Okeechobee down the peninsula to the Florida straits. The Everglades Drainage District did not include the Kissimmee or St. Johns valleys, the lower east coast urban areas, or the western part of the Caloosahatchee valley. The basic drainage plan was to lower the level of Lake Okeechobee by outlet canals, and to furnish additional drainage by a series of canals from the southern shores of Lake Okeechobee southeasterly through the Everglades to connect with the short lower east coast rivers.

From the beginning of the operation of the first dredge in New River during the Broward administration down to 1928 the basic system of canals and other works designed to drain the Everglades was installed. No further reclamation work of any significance was done until the beginning of construction in 1949 under the comprehensive plan adopted at that time. However, the federal government, through the Corps of Engineers, did construct the Lake Okeechobee levee, and improved the waterway from Stuart to Fort Myers via the St. Lucie Canal, Lake Okeechobee, and the Caloosahatchee River. The system of works constructed during the first three decades of the twentieth century remains today as an integral part of the water control plan for the area. By January 1, 1929, the Everglades Drainage District had spent almost \$18 million; about \$15 million on excavation, some \$2 million for control works in the canals, almost \$700,000 for levees, and some \$360,000 for other purposes. The canals and levees represented a total excavation of about 79,000,000 cubic yards. The main works consisted of 440 miles of canals, including 5 main canals. The 24 mile St. Lucie was the main control canal from Lake Okeechobee, and it alone cost the Everglades Drainage District almost \$6 million. The series of canals running southeast from the shores of Lake Okeechobee into the mouths of the various short east-west rivers were expected to give gravity drainage to the Everglades agricultural land. The Hillsboro (51 miles long); the North New River (58 miles long); and the Miami (85 miles long) were the principal canals in this category, and they emptied into the Atlantic Ocean at Deerfield Beach, Fort Lauderdale, and Miami, respectively. The 42 mile West Palm Beach canal ran from the lower shore of Lake Okeechobee to the Atlantic just below West Palm Beach.

MANAGEMENT PROBLEMS OF THE EVERGLADES DRAINAGE PROJECT:

1905-1931

The water management effort in south Florida during the 1905-1931 period involved a number of major administrative problems, including that characteristic peculiarity of Florida government - the excessive use of the ex-officio board. Heated disputes arose time and again during the period 1905-1931 over the difficulties inherent in relying on an ex-officio board for carrying out the day to day administration of the project, with board members living in Tallahassee--almost 500 miles from the area of the work. The board problem, in turn, was closely linked with the question of developing a satisfactory system of administrative management for the project. At no time during this period did any of the agency boards involved elect to restrict themselves to matters of policy and select a general manager to administer the routine affairs of the project. During the Broward administration the Governor himself took over the executive management, due to his intense interest in the problem. After that the weaknesses inherent in such an administrative device became increasingly obvious.

Another aspect of the problem of boards as administrative units soon became a part of the bitter political quarrel between north and south Florida. This dispute came to a head during the administration of Governor John W. Martin (1925-1929), in the form of opposition to the Martin sponsored plan to enlarge the project by floating a \$20 million bond issue. Anti-Martin forces demanded "home rule" by a locally elected board that would be required to have its headquarters in, and be composed of, people from the area of the project. Martin bitterly opposed this move, but it was finally adopted in 1931 during the administration of Doyle Carlton. The Governor, however, did retain the power of appointing the five-member board, with the requirement that they all be residents of the Everglades Drainage District, and that no two should come from the same county.

Fiscal issues were a part of the management problems encountered in the effort to drain and reclaim the Everglades in the 1905-1931 period. The most persistent and difficult fiscal problem confronting the Everglades Drainage project was to determine the proper sources from which to draw funds for the program. The issue remains in dispute even to this day. The dispute has centered mainly around the benefit assessment method of raising funds versus the ad valorem tax method, and has pitted the agricultural and ranching groups in the area against the urban interests. When it became apparent in the mid-1920's that new funds would have to be found if the project was to be continued, Governor John W. Martin proposed a \$20 million bond issue that touched off a bitter fight between urban coastal interests and the farm/ranch group. The urban group feared that the "emergency" ad valorem tax allowed under the bond issue would put the main cost upon the urban areas, while the rural areas would receive most of the benefit. Although the urban group won a victory when the courts rejected the Martin bond plan, bankruptcy and the subsequent halting of work on the project delayed any final settlement of the issue. A major problem in attempting to follow a benefit-based tax approach in developing the drainage plan was a lack of any comprehensive plan of development for reclaiming the area. An accurate cost-benefit analysis required a complete plan that would be carried out, but the data on which a plan might have been based were not available. That data collection effort proceeded through the 1930's and into the early 1940's, and subsequently formed the basis for a fundamental realignment of the drainage, reclamation, and flood control effort after 1947.

THE EVOLUTION OF THE MULTI-PURPOSE APPROACH, 1931-1947

After the financial collapse of the Everglades Drainage District in 1928, no significant additions

were made to the drainage system until work started under a new program in 1949. Even basic maintenance was neglected, and the system became progressively less efficient as the drainage district struggled to extract itself from a tangled financial web. In spite of this dark picture, the period from 1931 to 1947 was of utmost significance to the Everglades project. It was during this period that the sentiment for developing a complete water control program to replace the old haphazard drainage efforts became strong enough to reflect itself through new organizations and new comprehensive programs to gather data. Men who had pleaded in vain for listeners as they warned of a sure and swift disaster that would come if a new approach were not adopted now found willing listeners, as the depression decade produced a general atmosphere favorable to change. Names such as R. V. Allison of the Everglades Experiment Station, W. Turner Wallis and Lamar Johnson, both prominent engineers long identified with the drainage project, John C. Stevens of the Soil Conservation Service, and Gerald G. Parker and Nevin D. Hoy of the United States Geological Survey, began to be much discussed in the Everglades as public interest in facing the many sided water control problem increased. In 1939, the Soil Science Society of Florida was organized with R. V. Allison as secretary-treasurer. This organization, through its publications and through a series of special meetings, assumed the leadership in the campaign to win support for a comprehensive water control program and the vast job of data collection and analysis that had to precede the final evolution of any such plan. The Society served as a common meeting ground between specialists studying the problems and the farmers and businessmen of the area.

An analysis of the articles in the Soil Science Proceedings written by Allison, H. A. Vestor, and Ralph Blank, a report to Florida's Governor by Clarence K. Bitting, and many other such publications, reveals a development of new basic concepts regarding the water control problem in central and southern Florida. These concepts can be summarized as follows: (a) the reckless drainage practices of the past had resulted in the needless destruction of soil, wildlife, and vegetation, yet had not provided an effective drainage system; (b) the water problem was not simply a matter of drainage and flood control, but involved almost every element of water resource development, the principal ones being irrigation, municipal and industrial water supply, salt water intrusion control, fish and wildlife protection, and the provision of recreation facilities; (c) the great need was to reconstitute the natural balance between land and water that had existed before drainage began, and that the way to do this was by setting aside large areas in the Everglades unfit for long range agriculture and rewatering them; (d) this rewatering process would help solve almost every phase of the water problem, and most especially would halt the needless destruction of large areas of drained but unused land; (e) the key to the future prosperity of the area lay in the immediate launching of a long range program for the gathering of data that would allow the formulation of a comprehensive water control plan; (f) it was essential to undertake an administrative reorganization that would centralize authority and responsibility for this new plan in one agency; and that (g) the new plan must be supported by adequate legislation limiting the extreme individualism that in times past had prevented the development of the area in the best interest of the public.

The cooperative data gathering program that formed the basis for the new approach to water management in south Florida after 1948 was carried out by a number of agencies, including the State Agricultural Experiment Station, the Soil Conservation Service, the United States Geological Survey, and the Everglades Drainage District. Data collection in this cooperative effort began with work by the U. S. Geological Survey in 1939 using matching funds from local governments in the Dade County area, and was essentially completed by 1947. The resulting publication, Bulletin 442 of the Florida Agricultural Experiment Station, is one of the most important documents ever to appear in connection with water control efforts in central and southern Florida. On the basis of the extensive efforts over almost a full decade to gather and analyze data, this document formed the basis for a comprehensive water control and reclamation plan to replace the haphazard fumbblings of the past carried out for the most part in ignorance of the hydrological data so necessary to any effective plan. The basic plan called for improving the main drainage canals already existing, only one of which had ever been dug to planned depths, and the addition of main and secondary canals sufficient to provide water control for the area set aside for agricultural development. Furthermore, the study designated some 700,000 acres of land in the upper Everglades for long range agricultural development. Knowledge gathered for the study made possible the selection of this particular area of land on which to concentrate future agricultural endeavors. The area selected was a deeper muck and peat soil underlain by relatively impermeable Ft. Thompson formation limestone and/or a layer of sand or marl between the limestone and peat, one or the other of which was necessary for effective water control by diking and ditching.

The second major feature of the plan involved the establishment of large water conservation areas which had their boundaries marked in accordance with the thinner peat soil underlain by the extremely permeable Miami oolite or Tamiami formation. Another type of soil classified as unfit for agriculture was the extremely loose and water-logged peat soil located mainly in the Hillsboro marsh area southwest of West Palm Beach. The Hillsboro marsh section comprised the first water conservation area, while the second lay in Broward County toward the lower east Everglades, west of Pompano and Fort Lauderdale. The third and largest conservation area was located in Broward and Dade Counties, and extended north from the Tamiami Trail about 35 miles toward Lake Okeechobee.

The water conservation areas were proposed in order to serve multi-purpose water control benefits, and in particular to hold water on unused land and thus prevent the peat soil from burning; to raise

the general water table of the area and thus combat salt water intrusion into the water supplies of the lower east coast urban areas; to provide a source of irrigation water; and to help ameliorate winter temperatures. As noted above, the Everglades Drainage District had already acquired much of this land for this very purpose. Acquisition of the water conservation areas, the building of dikes in order to hold water in them, the construction of numerous new canals, and the provision of water control structures in the canals where needed comprised the essence of the plan, and its cost was estimated at \$17,298,000. Bulletin 442's vital significance lay in the fact that for the first time sufficient knowledge was at hand concerning the geology and soils of at least part of the area to allow basic decisions, based on facts, as to what sections could be successfully developed for agriculture and what should be set aside for rewatering in order to gain the multi-purpose benefits that come from such an operation.

The unanticipated consequences of efforts to drain the Everglades for farming had long been evident by the time a new approach based on Agricultural Bulletin 442 and the data it contained was adopted in the 1947-1949 period. The threat and reality of salt water intrusion into the fresh water aquifer in south Florida, long dry spells that produced muck fires that cast palls of smoke over much of south Florida for weeks at a time, the destruction by drainage of fish and wildlife habitat, and the phenomenon of soil subsidence which saw the destruction of muck and peat soils when they were exposed to the air increasingly brought into focus the need to reexamine the old approach to water management in south Florida. A major step in that direction was taken with the adoption of the Central and Southern Florida Flood Control Project involving action by Congress and the State in the late 1940's. When the floods came in 1947 and 1948--the inevitable replacement of a dry cycle by a wet cycle--the stage was set to consider a new approach to water resources in south Florida. The result was the Central and Southern Florida Flood Control Project, which designated about 800,000 acres of land immediately south of Lake Okeechobee for agriculture, but set aside nine hundred thousand acres in the Everglades as water conservation areas which would never be drained or reclaimed and which would form the basis for an effort to mitigate the negative impacts of overdrainage, protect the fresh water supply by pushing back salt water intrusion, and allow maximum recharge of the underground aquifer that supplied the area's fresh water supply. The plan included the construction of a dike on the eastern edge of the Everglades to hold back flood waters from the already rapidly developing urban strip running over 100 miles from north of West Palm Beach to south of Miami. This basic project, while it still envisioned a great deal of drainage and reclaiming and was to be the subject of considerable controversy in the 1960's and 1970's in Florida, was a vast improvement in terms of land and water management over its predecessor plans to drain the entire Everglades. It put in place a basic mechanism which with modifications could be used as part of a more sophisticated effort to stop and even undo some of the environmental damage brought about by indiscriminate drainage schemes carried out with little or no understanding of what the negative impacts would be (Carter, 1974; Blake, 1980; Tebeau, 1971).

THE POST WORLD WAR II DEVELOPMENTS IN WATER MANAGEMENT IN SOUTH FLORIDA

The hopes and dreams of business and political leaders of seeing Florida grow into one of the largest states in the nation were not realized until after World War II. It was then that waves of newcomers, largely from the northeast, midwest, and other sections of the south, began to arrive in numbers that would satisfy the hearts of even the most ardent pro-growth enthusiasts.

Population statistics make it clear that Florida has been in the midst of an explosive growth cycle since 1950. In the period 1950-1976, when the population of the United States grew by some 40%, that of Florida tripled, increasing from 2.8 million in 1950 to 8.5 million in 1976. This phenomenal rate of increase moved Florida from 20th to 8th in population rank among the states by 1976. By 1980, the population had increased to almost 10 million, and Florida ranked 7th in the nation in population. By the end of 1981, the population had exceeded 10 million, and Florida was well on its way to a predicted population in 1990 between 12 and 13 million, at which time it will rank 4th in the nation. To put Florida's growth experience another way, net immigration amounted to 1.6 million persons in the 1950's; 1.3 million in the 1960's; and more than 1.5 million in the first half of the 1970's. Since 1970, Florida has had a net immigration rate that is three times as great as any other state in the nation.

Florida's growth in the 1980's is predicted to be twice that of the sunbelt and three times the national average. The pattern of that population growth means continued pressure on Florida's natural systems, on the ability to provide adequate infrastructure, and most importantly on its water resources. Growth pressures will continue to focus on the south Florida coastal areas and on an urban corridor across central Florida from Tampa Bay to the Daytona/Melbourne area. The state's three largest Standard Metropolitan Statistical Areas--Miami, Tampa-St. Petersburg, and Fort Lauderdale-Hollywood--will absorb more than 40% of the projected population growth in the 1980s. These same areas already have substantial, even severe, growth management problems. A land and growth management system of extraordinary capacity will be required to cope with the growth pressures that will dominate the rest of the century (Anonymous, 1980).

The pressure to build on the base of the new approach to water management in south Florida begun in 1949 has been very great. As the environmental consciousness of the nation and of the state has become stronger, the pressure to further evolve a water management system sensitive to protecting

environmental values and at the same time meeting the needs of industry, agriculture, and people, has become stronger and stronger. Two major issues that evolved during the 1960's in south Florida heightened the sensitivity of supporters of protecting the areas natural systems, and sharpened their political capacity to force action to better protect the environment, and thus to improve the capacity to manage water in the area. One involved the water supply for the Everglades National Park, the only biological national park in the United States. The park had historically received most of its water either by rainfall on the area or by the sheet flow of the water from the Everglades areas lying to the north of the Tamiami Trail. This water was also in demand to recharge the Biscayne Aquifer serving urban areas. Disputes between the Central and Southern Florida Flood Control District, the U. S. Army Corps of Engineers, and interests supporting the park finally resulted in a congressional enactment mandating that certain quantities of water be delivered to the park on an annual basis. This problem continues to be of importance in that efforts to come closer to approximating the natural sheet flow of water into the park are being revived in order to assure the survival of the park's ecology. Another major threat to both the Everglades National Park south of the Tamiami Trail and the Everglades north of the Trail involved the effort to establish a giant jetport in western Dade and eastern Collier County, involving a 39 square mile site in the Big Cypress Swamp. A sustained battle to prevent the further expansion of the site after a training runway was constructed, led in part by the Central and Southern Florida Flood Control District and its then Chairman Robert W. Padrick, resulted in abandonment of the site, and in the further development of political skill and confidence by environmental groups in south Florida (Carter, 1974).

When the rains failed to come in 1970 and 1971, the resulting water shortages were nothing new to south Florida. Water shortages had created a near crisis situation in the 1930's and again in the 1950's. The difference in 1970-1971 was that the water crisis came amid rising general concern with the degradation of the environment in south Florida, and on the heels of other crises that seemed in the eyes of environmentalists and their increasingly large group of supporters to threaten the very values that had attracted many of them to move to Florida in the first place. The water crisis itself, which began in late 1970 and stretched into the summer of 1971, has been described by a leading state Senator and advocate of managed growth, who later was elected Governor. He noted "that a major portion of south Florida suffered from the most extensive drought in recent history. From June of 1970 to July 1971, rainfall in south Florida was almost 22 inches below normal--the lowest amount since 1911, when records were first kept. By May of 1971, Lake Okeechobee and the three water conservation areas were two and three feet below normal level (Graham, 1972)."

The extreme drought brought muck fires in the Everglades and the threat of salt water intrusion into the Biscayne Aquifer. The canals that had been cut from Lake Okeechobee through the coastal ridge, to the ocean made the aquifer extremely vulnerable to salt water intrusion. The point was driven home as never before that indiscriminate drainage and headlong growth in south Florida had combined to produce a resource management crisis of truly major proportions. The response to this crisis brought about a coalition of political and environmental forces that thrust Florida from being among the least growth management oriented states to becoming a state with advanced land and water management tools with which to attempt the management of growth.

Observers of the scene in 1971 all agree that it was the water crisis in south Florida, together with an almost equally serious water problem in the Tampa bay area, that brought about this major policy initiative. A Governor's Conference on Water Management in South Florida convened by Governor Reuben Askew in the late summer of 1971 considered the problem of water management and made a series of recommendations not only to solve that problem, but to address land and water management problems statewide. The report of the Conference recommended a number of legislative initiatives that were taken up by a Task Force on Land Use and Resource Management appointed by Governor Askew which did its work from November 1971 through to February 1972. This group proposed a legislative package of four major bills in the 1972 session, all of which were crucial to the future management of water resources in south Florida. They were: (a) the Environmental Land and Water Management Act of 1972 (Chapter 380); (b) the Florida State Comprehensive Planning Act of 1972 (Chapter 23); (c) the Land Conservation Act of 1972 (Chapter 259); and (d) the Florida Water Resources Act of 1972 (Chapter 373).

Of the four major pieces of legislation passed by the 1972 session of the Legislature, the most significant for water management in south Florida was the Water Resources Act. This legislation put in place a system of water management districts covering the entire state, and gave such districts the authority to manage both surface and ground water through planning, regulation, and management. The old Central and Southern Florida Flood Control District was converted to the South Florida Water Management District, and the former five person board appointed by the Governor was replaced by a nine member board, also appointed by the Governor. The establishment of this expanded planning and management capacity moved the state in general and south Florida in particular farther along in careful husbanding of its water resources in such a way as to meet the legitimate needs of population growth, industry, and agriculture, and at the same time attempt to protect environmental values and even undo some of the negative environmental impacts brought about by indiscriminate drainage, reclamation, and other such efforts (DeGrove, 1980).

In the ten years that have passed since the enactment of the Water Resources Act and the companion Environmental Land and Water Management Act, there has been a steady movement in the direction of attempting to improve the management of south Florida's water resources while at the same time bringing

land and water management more closely together. These efforts are by no means complete, and much remains to be done. However, a series of important steps including a constitutional amendment assuring a stable ad valorem property tax funding source for water management districts approved in 1976 (Anonymous, 1976), the adoption of the Local Government Comprehensive Planning Act in 1975 (Chapter 257), and the Environmental Reorganization Act in 1975 that placed supervisory power over the water management districts in the hands of the new Department of Environmental Regulation all have had the effect of strengthening the capacity of water management in the state in general and south Florida in particular (DeQuine and Thomas, 1975). The establishment of the Department of Environmental Regulation and the assignment of supervisory control over water management districts to this new agency was an especially significant development. For the first time water quality and water quantity issues in Florida were placed in the same agency, with the major responsibility for planning and implementing water quantity problems delegated to the water management districts by the Department of Environmental Regulation. More recently, DER has begun to delegate water quality functions to water management districts, bringing even more closely together the quality and quantity components of water management.

The improved constitutional, statutory, and administrative capacity to manage water resources in south Florida has come none too soon. Continued population pressures have put greater and greater pressure on the fresh water resource in the area. The very best planning and management approaches will be needed to satisfy the growing demand for domestic, commercial and industrial, and agricultural use. Yet for the first time a combination of a heightened environmental sensitivity and improved management capacity promises success for the provision of adequate supplies of water, the protection of water quality, and the general better husbanding of this precious resource for the south Florida region. The decade of the 1980s will involve many problems, but there is reason for optimism as plans go forward for undoing some of the damage done by unwise channeling of the Kissimmee River, improving the natural sheet flow of water to Everglades National Park, further improving the salt water intrusion control system, and establishing far reaching water conservation measures that will involve much more water reuse for the future. Conservation can lessen the strain on the Biscayne aquifer, the Floridan aquifer and other such sources in south Florida. Water management in south Florida is alive, reasonably well, and seems headed in the right direction.

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HYDROLOGY OF THE PRE-DRAINAGE SYSTEM OF THE
EVERGLADES IN SOUTHERN FLORIDA
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ABSTRACT

The Everglades, covering an area of about 3,900 square miles, is the lower segment of a huge, naturally integrated drainage system of about 9,000 square miles. Lake Okeechobee occupies a 730 square-mile basin with its floor at sea level almost in the middle of this huge system. In pre-drainage days, as now, drainage began in the northern-most part of the Kissimmee River basin, near Orlando, and flowed southeast into the lake. During these pre-drainage times most of the KLOE (Kissimmee-Lake Okeechobee-Everglades) drainage system was inundated much of the time and during flood periods when the lake's level rose to heights of about 14.6 feet msl (mean sea level), two separate segments of the lake's southern shore totalling about 19 miles overflowed into the Everglades. When lake levels reached about 18 feet msl, the entire southern shore for a length of about 32 miles poured a sheet flood into the upper glades. Sheet flow continued from there on south to the Bay of Florida with notable discharge to the Atlantic Ocean through such streams as New and Miami Rivers, and through the transverse glades across the coastal ridge. During extended droughts, the sawgrass plains dried out and at times fierce fires swept the glades burning the muck and peat down to the lowered water table. Buried ash layers incorporated into the body of the peat deposits give mute testimony to these pre-historic fires and the severe droughts that allowed them to burn the dried-out peat.

EARLY PRE-DRAINAGE CONDITIONS

The earliest published records or comments relating to drainage conditions of the KLOE hydrologic system (Figure 1) are described by Vignoles (1832). During his travels, he noted the several streams flowing to the Atlantic, but he was most impressed by the "Neverglade" or "Everglade", terms he used for the vast watery, grassy plain that stretched out of sight from where he viewed them, possibly from the western edge of the Atlantic Coastal Ridge. This would have likely been somewhere west or southwest of Miami, for he mentions a sandy soil with large stones (eroded rock outcrops) inundated by about two feet of water. The sawgrass grew so thickly and tall as to greatly hinder the use of boats. Vignoles noted the tree islands, their luxuriant vegetation and rich soils, but he thought it improbable that they could ever become developed as farm land because of their inaccessibility.

Williams (1837) described the "Miami" River as a small stream flowing out of the glades. He was told by inhabitants that the height of the glades was about 40 feet, but he thought that 20 feet was a more likely figure. Williams noted (p. 50) that "The grassy border of this lake (he is referring to the inundated, grassy glades along the eastern border) is usually covered with water during the winter season, not so deep as to hide the grass which is very thick and tall. During the summer, the ground is often dry and hard for 10 miles from (west of) the timbered land." He speculated on possibilities of draining this inundated land by dredging out the channels of the streams draining this area and thus reclaiming the glades for farmland.

The nature of the Everglades and its water conditions became better known as a result of the Seminole Wars, extending from 1835 through 1842. One of the best early maps of the region is that compiled by Captain John Mackay and Lieutenant J. E. Blake from data gathered during the Seminole Wars. Pursuit of the Indian war parties and refugees required forays into and across the Everglades and the Big Cypress Swamp. Mackay's and Blake's map was published "by order of the Senate of the U. States for the Monthly Chronicle, 1840."

During the latter part of the 19th century and the early part of the 20th, geologists and naturalists began scientific explorations of the Florida peninsula. Among those whose published works shed light on the pre-drainage hydrologic conditions of the Everglades are Louis Agassiz (1852), Leon S. Griswold (1896), George C. Matson, F. G. Clapp and Samuel Sanford (Matson and Clapp, 1909; and Matson and Sanford, 1913). Several non-scientist writers include Hugh L. Willoughby (1898), whose graphic account of "A trip across the Everglades" gives one an excellent feel of the conditions just prior to the beginning of dredging of the major drainage canals (1907-1909) and the numerous writings of Fred C. Elliott, former chief drainage engineer for the T.I.I.F. (Trustees of the Internal Improvement Fund), whose descriptions of the hydrologic conditions are entered in the annual reports of the T.I.I.F. and later, when the Everglades Drainage District was formed, in the Annual and Biennial Reports of the E.D.D. (see especially Elliott, F. D., 1925-1926; 1927; 1927-1928 and 1929).

Shaler (1890, p. 144) made extensive studies of southeastern Florida's coastal region in 1887-1888. In describing conditions in the Coconut Grove area he observed that "the waters of the Everglades at a distance of only 3 miles from the shore in their time of lowest levels lie 16 feet above high tide." Shaler's altitude measurements are obviously much too high. Parker's (Parker *et al.*, 1955)

studies of the topographic, geologic and hydrologic conditions in the 1940's indicate that Shaler's "16-foot" level was more than likely about 10 feet above msl (mean sea level), perhaps a bit less. Shaler continues: "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 term "reef" refers to what is now known as the Atlantic Coastal Ridge). A sufficiently wide canal, having a depth of 20 feet and a length of not over 4 miles, would drain the waters of the Everglades into Biscayne Bay. The rivers which flow over this part of the reef come down to sea level over a series of rapids formed upon the harder layers of the reef, and thus the full escape of the Everglades waters is prevented. In the region more to the north, the entanglement of the vegetation about the headwater of the streams, even when they have no rapids in their beds (here he is referring to such streams as the New and Jupiter Rivers), likewise hinders the escape of the marsh waters."

Shaler (1890, p. 146) further describes the "reef" as being so thickly penetrated by sink holes "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." In describing the western side of the "reef" Shaler says, "All portions...which were so situated as to be exposed to the waves of the lake, which in the rainy season covered this district, were very deeply corroded...In the rainy season these waters rise to the height of from 5 to 8 feet above their level during the dry season when I observed the district. After the rainy season passes the water is drained away by numerous exits to the sea." (The italics are mine).

In a note appended to Shaler's paper (1890, p. 158) Alexander Agassiz comments: "To the damming up of the waters in the Everglades and to the outbursts of gigantic masses of water charged with organic matter and lime (hardness, CaCO_3), we may trace the immense destruction of fishes which so frequently occurs on the shores of the Florida Keys and the waters surrounding them."

Griswold (1896, p. 53) mentions "great springs of constant flow (emerging) in large numbers along the shore." Fuller (1904, p. 266) in 1903 observed one of these springs at Coconut Grove flowing at a rate of 100 gpm (gallons per minute) from the base of a limestone bluff (probably at what is now known as Silver Bluff, which is the type locality for the Silver Bluff Terrace, the shoreline of which is about 5 to 8 feet msl). Fuller indicates that the water was used for drinking to supply the American fleet off Havana in the Spanish-American War in 1898. He described the water as being clear and hard, and as containing sulfur.

Matson and Sanford (1913, pp. 179, 256 and 289) mention the existence in 1908 of "springs of some size...flowing from the low ridges of Miami oolite near Biscayne Bay." Apparently these springs were used for domestic supplies and by fishermen.

Griswold (1896, p. 53) mentions the presence of a distinct fall line in the Miami River just west of the pineland. The fall line has also been reported by Lilburn R. Railey, John W. Watson, and E. J. Sewell (personal communication, 1946), all early Miami residents, as having been near, and slightly west of the present N.W. 27th Avenue bridge. Willoughby (1898, p. 39) gives a rather vivid account of the rapids and flow of the Miami River over the fall line. Parker (Parker *et al.*, 1955, p. 581) shows a photo of these rapids taken prior to dredging of the Miami Canal. Unfortunately, no copy is available for the present publication. Willoughby continues (p. 65) to say that "All along this shore (Coconut Grove) there are (December, 1896) places (springs) where the water comes up through rocks under the salt water (of Biscayne Bay) with quite a head. It no doubt comes from the Everglades by subterranean passages."

John Sewell (1933) describes ground-water conditions in the early days in the Miami area. He notes that hard limestone water was then obtainable in wells 50 to 60 feet deep at the mouth of the Miami River and says that flowing wells 50 to 60 feet deep were developed at the old Miami Country Club (N.W. 11th Street and 10th Avenue). Fresh when first drilled (about 1900), they had turned salty by 1918 and therefore were abandoned.

Monroe (1930, pp. 118 and 128), describing early water conditions, says that "The abundant spring water off this shore, while organically pure, and beautifully clean and tasteless, was somewhat hard...." Monroe photographed boatmen pumping fresh water from an off-shore well penetrating the Miami oolite beneath the salt water of Biscayne Bay.

The foregoing information gives valuable background understanding of early water conditions in the coastal ridge and the Everglades. Shaler's observations in particular, indicate a tremendous quantity of water stored in the glades behind the coastal ridge which, although permeable and in many places channeled by the transverse glades (Harper, 1927), none-the-less acted as a dam to the watery Everglades. The transverse glades served as discharge channels from the flooded Everglades prior to man-made drainage and they have continued to do so as late as the great flood of 1947 when water in the glades immediately west of Miami was 6 to 8 feet deep over vast areas of the central glades.

It was the natural dam formed by the coastal ridge that held dry-weather, low-water levels in the glades up to perhaps 8 or 10 feet above sea level at such outlets as the Miami, New and Jupiter Rivers and was thus responsible for the hydraulic heads that caused the springflow noted above.

Numerous early reports by land developers, promoters, their hired surveyors and engineers, and by early settlers preserve additional observed data. They all add up to the judgment that, in pre-drainage days, the Everglades were generally either wet or flooded most of the time but that occasionally a drought of two or more years' duration would occur and the glades would then become dried out. In such

times the surficial soils in the higher parts of this almost perfectly flat land would become powdery dry and deeply cracked. Fires would then sweep the glades, creating deep, burned-out pockets in the organic soils floored with gray-to-black ash layers up to several inches thick.

The writer in his detailed, comprehensive hydrologic and environmental studies of this vast area of organic soils, was privileged to work with many knowledgeable and capable scientists and engineers in the period 1940-1948. Among those who accompanied me in the field work from time to time were Nevin D. Hoy, Russell H. Brown and D. B. Bogart, USGS, Miami, Florida, and Dr. C. Wythe Cooke and Victor T. Stringfield, USGS, Washington, D. C.; John C. Stephens and Melvin H. Gallatin, Soil Conservation Service, Fort Lauderdale, Florida; Dr. Herman Gunter and Dr. John Henry Davis, Jr. of the Florida Geological Survey; Dr. Robert V. Allison of the University of Florida's Agricultural Experiment Station, Belle Glade, Florida; Lamar Johnson of the Everglades Drainage District; and Anson B. De Wolf of the City of Miami Water Department. There were few acres in the entire Everglades that we did not cover on foot, in airboat or glades buggy, or by car, helicopter and plane. In the Kissimmee River Valley my co-workers in the field were chiefly Nevin Hoy, Walter Langbein and John Davis, mentioned above. Numerous publications report our findings, among which the most important with respect to the Everglades are the following: Parker (1942); Parker (1945a); Parker (1945b); Parker (1947); Parker (1951); Parker and Cooke (1944); Parker and Hoy (1943); Parker and Hoy (1944), and Parker *et al.*, (1955). In addition to these reports by Geological Survey scientists, others by members of the Soil Conservation Service, Agriculture Research Service, University of Florida Experiment Stations at Belle Glade and at Homestead, the Everglades Drainage District and others are to be found in the Proceedings of the Soil Science Society of Florida, 1941-1948.

In the course of our field studies soil, water and plant samples were gathered, analyzed and organized for subsequent use. To determine subsurface geologic and hydrologic conditions the USGS drilled, sampled and monitored more than three hundred wells in the southern, central and upper glades and installed numerous automatic recording water level and precipitation gauges. An additional hundred or so wells were scattered over southern Florida in the coastal marshes, the Big Cypress Swamp and in the Kissimmee River Valley. These wells were supplemented in 1942 by about 20 wells jointly put in by the Soil Conservation and the USGS in the central and upper glades, around the shores of Lake Okeechobee, in the Devil's Garden, the Hillsboro Lakes Marsh and the lake-swale-tree island area in the western central glades.

To gain a detailed knowledge of the sawgrass and tree-island soil profiles and of ground-water conditions in the soils, Nevin Hoy and I hand-dug a number of deep pits both in the wet prairies and in the organic soils of the central glades. These pits were about 5' square and dug into bedrock; when digging penetrated below the water table the pits were kept dry by bailing or, if needed, a gasoline-powered pump. It was in the walls of at least two of these pits, one dug in the vicinity of Miami Canal's Broken Dam and the other near the South New River confluence with Miami Canal, that we found ash layers up to about 2 inches thick. These buried ash layers indicate ancient, pre-historic times when there were severe droughts that dried the organic soils of the normally wet glades sufficiently to allow the soils themselves to burn as deep as the existing water table. Unfortunately, it seems that either during one of the several moves of the Miami Office of the USGS since 1948, or by field records being mislaid following use, the data regarding these pits and other related soil and water records have become lost or misplaced. In any event they have disappeared from the Survey's present records, and I cannot now either recall the exact location of these old pit sites or the actual depths of the ash layers above the bedrock (top of Biscayne Aquifer).

It was from these detailed studies of the water, soils and bedrock, reinforced by the work of Davis (1943), and the Soil Conservation Service mapping of the depth of soils and of the configuration of the rock surface beneath the soils, that a clear picture emerged of the nature of the Everglades: its pitted and unevenly channeled rock floor, including at its upper (northern) end the 730 square-mile basin of Lake Okeechobee with its deepest parts about at sea level (Parker *et al.*, 1955). Studies of the soils indicate that they could only have accumulated in a perennially wet, boggy, marshy or swampy environment, beginning about 5,500 years ago (Parker *et al.*, 1955, p. 109). As mentioned above, some such areas still existed during the times of our 1940-1948 studies - and some still do, such as in the Hillsboro Lakes Marsh, an area now included in the Central and South Florida Flood Control District's Conservation Area No. 1.

In the past, under prevailing conditions in the Everglades basin, these organic materials were accumulating slowly under water and gradually building up the glades soils to a depth of about 14 feet in the deeper, upper parts of the glades (Parker *et al.*, 1955, p. 362). These soils are not nearly as permeable as many people suppose. In one of the pits that Hoy and I dug it could be kept dry by lazy bailing with a pint can even though the water table in the surrounding soils stood two feet higher than the bottom of the pit.

PRE-DRAINAGE HYDROLOGY

Although no systematic, comprehensive studies of pre-drainage hydrology were made prior to 1940, a great deal of information may be inferred from the evidence discussed earlier in this paper. We know that the climate has not changed significantly since the glades soils began to accumulate on the bare

rock floor of the Everglades about 5,500 years ago. We know that during most of this time the soils were wet and the low-lying lands generally inundated. We also know that during flood times all but the highest tree islands in the glades were inundated and that the floodwaters slowly swept southward in a 40-mile wide sheet flow. Such flood waters began at Lake Okeechobee's inundated southern shores and, picking up rainfall all the way to the Gulf, while also suffering nearly an 82 percent Et (evapotranspiration) loss, nevertheless maintained force enough to cause the tree islands to develop an alignment pattern parallel to the lines of surface-water and to assume a typical rain-drop shape having a blunt, rounded, up-gradient head and a long, drawn-out, down-gradient tail.

We know, too, that there were times of alternating drought and flood. Some of these droughts were of several years' duration and at times perhaps longer. Although there were no man-made channels then in existence to lower water levels, the Et losses were great enough to reduce regional water levels at times as much as several feet. Under such conditions of desiccation, fires in the glades ravaged the vegetation and even burned the organic soils down to the water table, thus producing the ash layers observed in several places buried in the peat soils. Davis (1943, p. 253) reports information imparted to him by Fred C. Elliott of such ash layers 6 or more inches thick which he observed during excavation of the glades drainage canals, and Johnson's (1974) recent account of his lifetime of work in the Everglades imparts an overview of inestimable value.

ESTIMATING A PRE-DRAINAGE WATER BUDGET

So far our information is mostly descriptive and qualitative. Using the quantitative approach of Langbein (Parker *et al.*, 1955, pp. 511-570) in his classic studies of the KLOE (Kissimmee-Lake Okeechobee-Everglades) hydrologic system, and similar studies by Warren and Parker (Parker *et al.*, pp. 197-234) for the coastal ridge system, we can derive some reasonable ideas of quantities of water involved in the several component parts of the water budget.

As a base for deriving long-term values of precipitation and runoff, the National Weather Service standard period 1931-1960 is used. For determining a reasonably reliable long-range set of values for water-budget estimates, the intensive study period of 1940-1946 is our base because it represents hydrologic conditions most likely to resemble those of pre-drainage times. Data obtained since 1948 tend to be unduly influenced both by the huge drainage, pumping and storage works of the Central and South Florida Flood Control District and by the effects of the explosive urbanization along the Atlantic Coastal Ridge from the Palm Beaches to the Florida Keys.

The water budget is based on the equation of continuity which, in its simplest form is: P (precipitation) = Et (evapotranspiration) + R (runoff). Other elements, including ground-water and surface-water inflow and outflow, and changes in ground-water and surface-water storage must also be included if they are of such magnitude as to be of consequence. By choosing an area that is a hydrologic unit, that is, one which is surrounded by water divides across which no flow occurs, inflow and outflow factors can be ignored. And, if the budgeted period is long enough to begin and end at the same time of the year, normally the changes in storage can also be ignored because a complete cycle of wet and dry seasons will have been completed and the water balance at the end of the period is the same as at the beginning.

The KLOE hydrologic system, covering about 9,000 mi^2 , is not a perfect hydrologic unit; there are inflows in some areas. For example, the Everglades drainage area north of the Tamiami Trail is considerably larger than that of the glades themselves. The drainage area includes a considerable strip of sandy wetlands between the glades and the Atlantic Coastal Ridge on the east and a strip averaging about 10 miles wide on the west, including parts of the Big Cypress Swamp and the sandy flatlands extending beyond the Devil's Garden to the Caloosahatchee River (Figure 2). We shall not include the glades south of the Tamiami Trail (U. S. 41) in our computations because it is impossible to gauge the discharge that flows directly into the Gulf and bays. However, we have an excellent set of discharge records, 1940 to present, for the outlets beneath the Tamiami Trail.

By establishing hydrologic boundaries for the Everglades drainage unit as shown in Figure 2, we can both avoid complicated inflow-outflow measurements and calculations and establish a hydrologic unit for which the water-budget components can be reasonably well determined. Additionally, we end up with an area of almost exactly the same as that of the glades - 3,900 mi^2 .

The following Table is adapted from Langbein's (Parker *et al.*, 1955, p. 512) summary of hydrologic parameters for the 9,000 mi^2 of the entire KLOE system:

Table 1

Summary of Hydrologic Data,
Kissimmee River-Lake Okeechobee-Everglades
Hydrologic System, by Years, 1940-1946¹

Calendar Years	Mean Areal Precipitation (P)	Total Runoff ² (R)	Precipitation minus Runoff (P-R)	Storage, end of Year (S)	Change in Storage (ΔS)	Losses, chiefly Evapotranspiration ($P-R \pm \Delta S = Et$)
1939	----	----	----	7.6	----	----
1940	53.0	8.7	44.3	7.4	-0.2	44.5
1941	59.8	14.2	45.6	8.2	+0.8	44.8
1942	50.0	11.0	39.0	4.9	-3.3	42.3
1943	45.2	3.1	42.1	5.8	+0.9	41.2
1944	43.9	2.7	41.2	4.9	-0.9	42.1
1945	50.5	6.3	44.2	9.3	+4.4	39.8
1946	48.1	6.1	42.0	7.5	-1.8	43.8
1940-1946	350.5	52.1	298.4	----	-0.1	298.5
7-year average	50.1	7.5	42.6	6.95	----	42.6

¹ All data measurements given in inches.

² Does not include ground-water discharge in the inter-canal areas; includes surface-water measured and estimated discharge only.

Precipitation (P) is the sole source of fresh water in Florida, and it averaged about 50 inches during our 7-year study period (1940-1946) of the KLOE system. During this time the average rainfall was almost normal, lacking only 0.5 inch of reaching the long-term average. The period included 1941, one of the wettest and 1944, one of the driest of record. Thus it would appear that our study period is generally representative of pre-drainage rainfall conditions and may be utilized with considerable reliance for our estimations of pre-drainage hydrology of the Everglades.

Runoff (R) from the entire KLOE surface-water system was measured to be equivalent to 7.5 inches over the 9,000 mi^2 area. During this period R from the Kissimmee basin averaged 7.45 inches annually.

P minus R averaged 42.6 inches, most of which is attributed to evapotranspiration. Ground-water discharge during these years, was small. Parker (Parker *et al.*, 1955, p. 107) calculated that ground-water flow into Lake Okeechobee was only about 1 cfs per day of 730 acre-feet per year - a negligible amount. Likewise, ground-water seepage out of the lake is practically negligible.

The range in year-end storage (S) shown in Table 1 was 4.4 inches and the average year-end storage was 6.95 inches. Included in S is all the water stored in Lake Okeechobee and in all other surface and ground-water bodies, plus estimated soil moisture from all drainage areas tributary to the Everglades.

Water losses (Et) to the atmosphere are far greater than any hydrospheric losses, being nearly 5.7 times larger during our period of study. Saying this another way, the atmosphere in the KLOE area is a far more effective means of drainage than any other natural or man-made means. Unfortunately, man can do little to change this situation so as to reduce the Et losses markedly.

With respect to Lake Okeechobee's role in the overall pre-drainage system of the KLOE system, it appears to be relatively neutral because P and Et essentially balance each other. Langbein comments (Parker *et al.*, 1955, p. 560): "Runoff, as it usually occurs in a natural basin, does not occur in Lake Okeechobee, because rain becomes runoff as soon as it falls upon the lake. The lake waters are subject to losses, but the situation is somewhat different from evapotranspiration from the soil and vegetation in other natural basins. Nevertheless, the difference between P and Et is the net increment to the waters passing into and out of the lake basin. As already indicated (p. 551), P during the 7-year study period of record (1940-1946) averaged 44.4 inches. This is about 3 inches below a long-term normal. Since Et losses are of the same order of magnitude as the P, the lake basin contributes almost nothing to the water supply of southeastern Florida."

During the pre-drainage times, Lake Okeechobee water levels fluctuated in an ordinary range of about 8 feet, that is, from about 12 to 20 feet above mean sea level. Concomitantly, the water level in the Everglades adjacent to the lake fluctuated about as the lake did and at relatively the same levels immediately along the southern, southeastern and southwestern shores. Farther downgradient in the glades the water levels generally were close to the muckland surface, in dry times at or below land surface and in times of extreme drought, as in May, 1945, evapotranspiration reduced the water table to slightly more than three feet below sea level at Royal Palm State Park, about 10 miles southwest of Florida City (Parker *et al.*, 1955, p. 210). In wet times the entire glades were generally inundated so that surface-water flow, extremely sluggish in the areas a half mile or so inland from the stream outlets, quickened and became swiftly flowing creeks or rivers once the flow entered the channels cut through the limestone of the coastal ridge.

Flow was sluggish through the glades for two main reasons: (1) the extremely low gradient, and (2) the great resistance caused by the thick mass of vegetation, swamps and low shrubs through which the flow had to take place. The gradient ranged from about 12 feet in 100 miles to 20 feet in 100 miles, depending upon the stage of Lake Okeechobee and water levels in the adjacent glades. A gradient of 15 feet in 100 miles may have been a good average during pre-drainage time. This is a slope of only 0.15 foot to a mile which is equivalent to a slope of about three-tenths of one percent. Even on a perfectly smooth, vegetation-free surface, water will scarcely move down-gradient on a floor having such a flat slope.

But each blade of sawgrass, each lily pad, each stem of a willow, custard-apple tree or a wax myrtle bush is in itself a small dam. Collectively, the thick, lush vegetation retarded almost to a stand-still all flow through the glades excepting during times of high floods. Then the tall sawgrass, as much as 12 feet high and, as one old "glades rat" expressed it, "as thick as the fur on a dog's back," would bend with the force of the great sheetflows. Now and then mats of muck or peat would break loose and float with the flood until they became grounded on a slightly higher part of the glades soil and would either start a new, small tree-island or add to one already established and flourishing.

It seems apparent, then, that with outflow in the lower glades being approximately the same as the volume of the Kissimmee River inflow into Lake Okeechobee, P minus Et in the glades approximately equalled zero. Thus, any flow measured at the Tamiami outlets would have been essentially locally-derived runoff and it would have come chiefly by inflow from the adjacent higher lands. Some of this would have come from the Atlantic Coastal Ridge on the east but most of it flowed out of the Big Cypress Swamp on the west. It is doubtful that many drops of rain from overflow of Lake Okeechobee's southern shore could ever have survived the high evapotranspiration losses during the snail's-pace flow through the Everglades (Figures 3 and 4).

Ground-water movement beneath the floor of the upper and middle glades was likewise extremely slow and, especially under Lake Okeechobee, was essentially stagnant. Salt water, remnants of the sea water that inundated the Everglades basin at the time of the Pleistocene Silver Bluff sea and perhaps even earlier during the 25-foot inundation of the Pamlico sea, occurs beneath the Lake Flirt Marl layer that commonly caps the Fort Thompson Limestone beds. This salty water still remains there largely because of the extremely low gradients and the low permeability of the uppermost layers of rock in this part of the glades.

Farther south, west of Fort Lauderdale and Miami, the highly permeable rocks of the Miami oolite directly underlie the peat and muck soils of the glades, commonly without the Lake Flirt Marl between the organic soils and the solution-riddled oolite. From this area and southward to the bay, the oolite and Fort Thompson Limestone beds of the Biscayne Aquifer are highly permeable and the salt water they once contained had been thoroughly flushed from them in pre-drainage days.

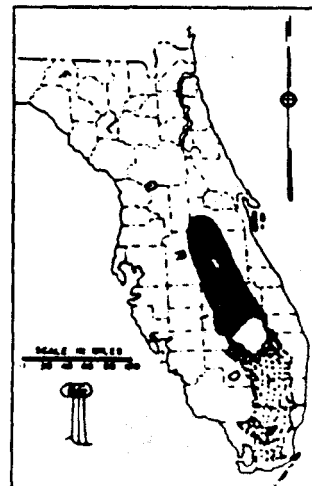
This, then, is a generalized and synthesized picture of pre-drainage conditions in the Everglades and in the larger KLOE hydrologic system of which the glades is the lower, down-gradient part. Much of it is conjecture and based on biologic and geologic understandings of the living flora and fauna and the remnants of prehistoric plants and animals preserved in the Everglades soils. These understandings also help support the inferences drawn regarding pre-drainage weather related to hydrologic conditions. The intensive studies of the KLOE system, made principally by the USGS and the SCS in 1940-1946, have served together with supplementary information from records of early explorers, soldiers, developers and early settlers, to gain an impression of the environment and the hydrology of the area before the great drainage canals and their appurtenant works were constructed beginning about 1907-1909. And finally, I was personally enabled to study first-hand large parts of the KLOE system which, even into the 1940's, were still relatively untouched by man's activities.

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Figure 1. Index map of the Kissimmee River basin-Lake Okeechobee-Everglades hydrologic system, Florida.



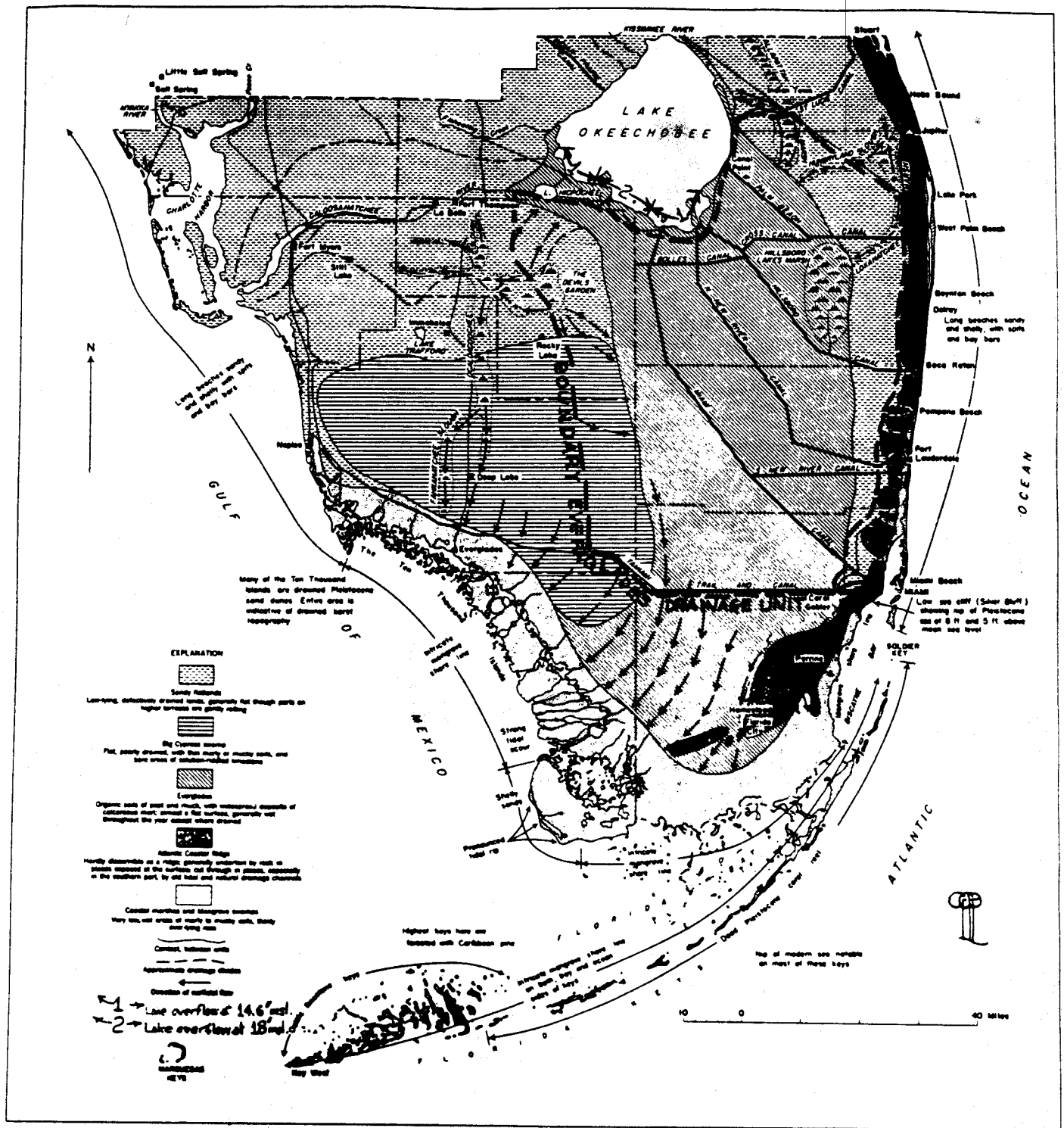


Figure 2. Topographic-ecologic map of southern Florida.

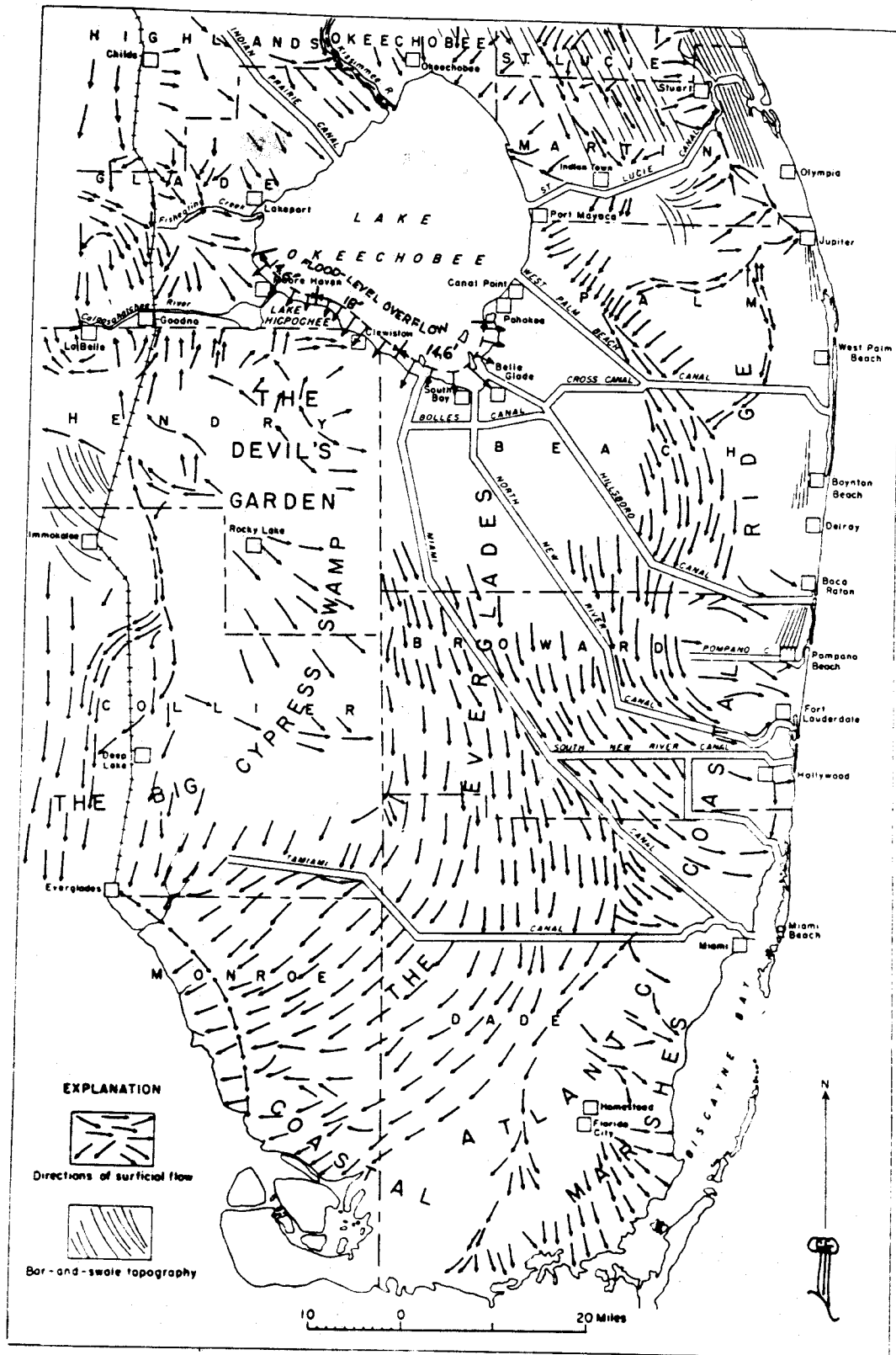


Figure 3. Map of southeastern Florida, showing directions of surficial drainage and trends of bar-and-swale topography.

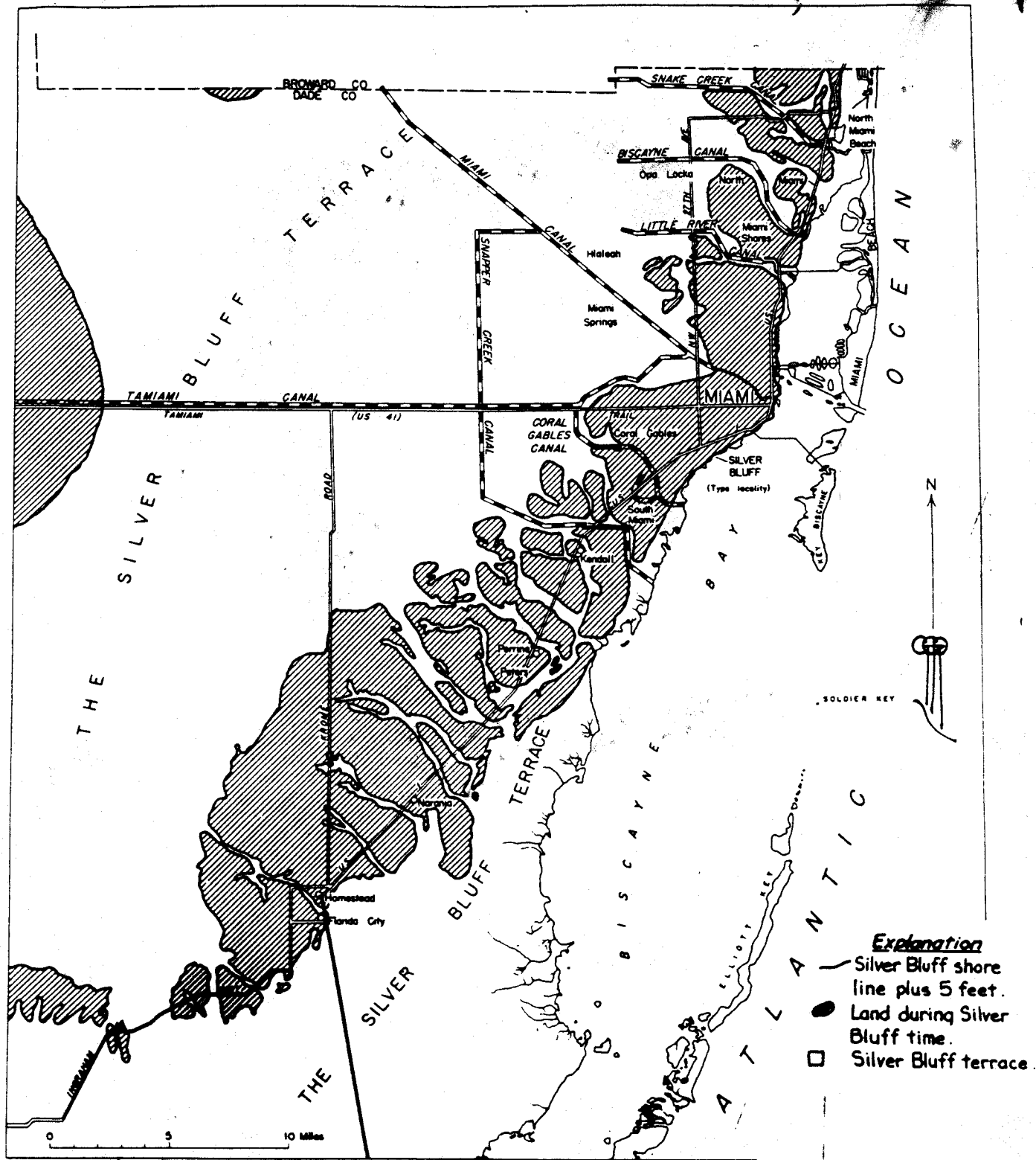


Figure 4. Map showing the Silver Bluff Shoreline and marine terrace, Dade County, Florida.