INTRODUCTION

The purpose of the Environmental Protection Guide (EPG) is to direct the protection of Dade County's natural environment from the adverse effects of urbanization. While there are many aspects to Dade County's total environment, including those concerned with noise and aesthetics, the scope of this document and its recommendations are limited to protecting and improving the natural - as opposed to the man-made - environment. Because the greatest potential for environmental problems lies in the undeveloped portions of the County, the recommendations made in this document are aimed more directly at these areas than at the already-developed sections.

This Guide consists of a: description and analysis of existing environmental conditions in Dade County; a discussion of major threats to the natural environment; a statement of policy upon which this Guide is based; an explanation of the methodology used in delineating Environmental Protection Zones and formulating guidelines relating thereto; and proposed tools for implementing the guidelines.

The recommendations of the Environmental Protection Guide are designed to: (1) preserve the remaining viable, functioning natural areas in Dade County; (2) insure that urban development will not either infringe on these natural areas directly or adversely affect adjacent areas such that the natural areas will not be able to function in their present state; and (3) establish a balance between urban natural resource demands (e.g., water) and natural area resource demands.

The bases for the guidelines are hydrological conditions, soil suitability, and the character and viability of the vegetation. Guidelines for each of eight Environmental Protection Zones which, combined, encompasses the entire County is detailed in terms of such things as amount of scarification permitted; sanitary facilities permitted; placement of structures; activities permitted; maintenance of water quality and quantity; bulkheading; public access; landscaping; drainage, and prohibitions against the removal of certain vegetation.

The Environmental Protection Guide is an important first step in insuring the protection of Dade County's wetlands and other unique natural areas. The determination of the environmental constraints on land use should provide proper general guidelines for the development pattern proposed in Part 3 of the Comprehensive Development Master Plan. In conjunction with the availability of services, the suitability of areas for development as defined by the Environmental Protection Guide will delimit the areas suitable for growth in Dade County.

The proposed guidelines and implementation tools of the Environmental Protection Guide and the other two parts of the Comprehensive Development Master Plan may be used by local and state officials in conjunction with legislation such as the State of Florida's guidelines for "Developments of Regional Impact" and "Areas of Critical Concern". The combination of these state and local efforts should constitute an important first step in integrating environmental concerns into the land use planning process of Dade County.

BACKGROUND INFORMATION

The purpose of this chapter is (1) to provide one with a perspective of the present environmental conditions in Dade County; and (2) to assess the evolution of existing problems and elaborate on the impact these problems have had on the natural environment. The following discussion explains some of the major effects that urbanization has on the proper functioning of the natural ecosystems of Dade County.

Water Quality

One of the most prevalent environmental problems in Dade County today is water pollution. Deterioration of surface water quality has been evident at least since the 1940's when untreated wastewater was discharged to inland canals and Biscayne Bay.

Evaluation of water quality problems in the county necessarily must consider the Bay and Ocean as well as inland waters. The close interrelation between these water bodies is exemplified by the interaction between the ground-water, the inland surface water, and the bay. That is, the canals, which recharge ground-water during dry periods and receive water from the ground during wet periods, discharge water into the bay, which in turn exchanges water with the ocean. Moreover, this interrelationship is indicative of the need for an awareness of the potential adverse effects that deteriorated water can have on natural ecosystems. Poor quality water emanating from urban areas and flowing into estuarine waters can have serious effects on marine wildlife populations in the estuaries which serve as food for species higher in the food chain.

The problem of deteriorated water flowing into the Everglades could also develop in association with proposed backpumping schemes, if water quality problems are not solved. The effects of poor water quality on the urban environment are as important as their effects on natural areas. Damage to recreational waters, aesthetic pollution, adverse effects on commercial fishing and, most importantly, the potential health hazards are all significant environmental issues.

Water quality trends indicate that parts of the Bay and most inland waterways have been severely degraded. Discharges of poorly treated or untreated wastewater and excessive nutrient loads appear to be the primary causes of water deterioration. Although there is some indication that the concentrations of pollution have decreased in recent years, most canals are still unfit for human activity.[1] For years, industrial pollution, municipal waste, street runoff, and agricultural pollution have degraded these slow-moving, poorly flushed canals to a point where animal life cannot exist in many areas. Elimination of part of the problem was achieved by prohibiting the discharge of municipal waste into inland canals which became effective January 1, 1973. The recently enacted "live-aboard" ordinance which prohibits discharges into . local waters should also help to reduce the pollution of waterways. An aggressive policy of enforcement by Dade County Pollution Control authorities is making progress in reducing industrial pollution. The County ordinance banning the use of phosphate detergents for home use is a step toward improving water quality. Although these steps are making progress in improving water quality, they must be only the beginning of an effort to improve waters to a level acceptable for recreational use. It should be noted that Biscayne Bay and its estuarine reaches have been designated an aquatic preserve and regulations to protect this water body should soon be developed.

Due to the complexity of the problem, water pollution may continue to be a major issue well into the future. The development of effective wastewater treatment plants will take several years and the complete elimination of industrial pollution will require an increase in enforcement budgets and industrial cooperation. Runoff into inland waterways has caused some concern that these waterways may never reach an acceptable water quality level. However, there are a considerable number of precautions which could be taken to alleviate adverse effects of surface runoff pollution. Studies are available to indicate the source of these pollutants. Such studies point to the eutrophication problems attributed to surface runoff.[2] Inland water bodies, particularly the residential lakes resulting from dredge and fill, may be particularly susceptible to the adverse effects of urban runoff. Traditional design, which encourages the direct drainage of runoff into these water bodies, has excluded the use of retention basins which could improve the quality of water percolating through the soil and into the aquifer. Solutions to the surface runoff problem are intricately tied, therefore, to the water quality of the inland canals, the Biscayne Aquifer and Biscayne Bay. A comprehensive investigation into the polluting effect of storm water runoff, such as that proposed for Dade County,[3] is needed as a first step in the correction of problems caused by runoff.

Another source of water pollution which demands close scrutiny and additional analysis is septic tanks. The soils and high water table level in most of Dade County may not be conducive to this method of wastewater disposal. Studies are being conducted by the United States Geological Survey to determine the effect of septic tanks on water quality in the aquifer and in the inland canals. The study which is due to be completed in 1975, however, is not extensive enough to determine the effects of such disposal systems off the coastal ridge, nor is it expected that the results will be conclusive. It would be in the best interest of the County to take a conservative stand on permitting the use of septic tanks in view of the potential adverse effects on our drinking water supply.

Package treatment plants, even when designed to provide tertiary treatment, are another potential threat to the water quality if improperly managed. The proliferation of these plants, due partially to sewage moratoria in Dade County, demands that more restrictive controls be considered in the near future.

Agricultural pollution (phosphates and nitrates), which decreases the dissolved oxygen level and accelerates eutrophication of canals and other water bodies, may prove to be a more crucial problem as the soil suitability for agriculture decreases and the application of insecticides and fertilizers increases. The increasing incidence of fish kills and appearance of large numbers of diseased fish in Biscayne Bay between 1972 and 1973 is cause for great concern about the health of Dade County's estuarine waters. Thus, an effective water pollution abatement program will have to consider concurrently all aspects of the problem and must insure that the solution of one aspect of the water quality problem is not negated by the neglect of another.

Water Quantity

Protection of the supply of fresh water has become an important issue in Dade County and is a factor which shows the necessity of controlling future growth in the area. The primary source of potable water in Dade County at present is the Biscayne Aquifer, a sizable wedge-shaped underground water supply. The yield of the Aquifer is finite and is subjected to numerous hazards due to its proximity to the surface. This water supply's quality has been threatened by salt water intrusion, particularly during periods of drought, although salt intrusion dams have reduced significantly the problem of intrusion via waterways. Septic tanks may pose a threat to the water supply yet to be documented in detail.

The fresh water supply of Dade County faces the problem of increasing demand from an ever growing population, as well as reduced quality. This fact was evident during the water crisis faced by the County in 1971 when excessive pumpage of the aquifer resulted in salt water intrusion into the County's well fields. The rapidly growing county population is continually aggravating the problem. The growth of urban Dade County has greatly increased the consumption of water for individual, industrial, commercial, and personal service use, thus increasing the total demand. At the same time the drainage and filling of wetlands has reduced the recharge areas, thereby decreasing the available fresh water supply. Development which demands the pavement of large areas, and thus decreases the permeable surface area, continually decreases the recharge potential of the aquifer from rainfall. As the amount of paved area increases, surface runoff rates during intense thunderstorms increase, necessitating more frequent releases of canal water to tide during these short peaks. Parking lot designs should consider, as an alternative to present standards, greater proportions of grassed or other permeable surfaces to retard runoff rates. The problems of water quantity are intimately tied to those of water quality. The annual amount of water extracted from the aquifer should not exceed the quantity of rainfall that infiltrates underground in unpolluted zones.

Land Use

The immense environmental implications of rapid urban development and sprawl are not uncharacteristic of Dade County, which has increased in urban land area by 41% and in population by 36% during the 1960-1970 time period. The intense demand for land created by rapid growth has been partially responsible for the failure to consider environmental sensitivity. Overdevelopment of pinelands and hammocks has gone unchecked, although only vestiges of these native vegetation associations still remain. The draining of wetlands with respect to the part these areas play in local ecosystems has been largely ignored until recently. Additional stresses on the natural systems in the county have resulted from the demand for bayfront property, resulting in filling in parts of the bay and the destruction of shoreline mangroves -- both actions which have had serious impacts on water quality and the proper functioning of marine ecosystems.

In addition to the adverse impact of land use on specific environmentally sensitive areas, the general approval of land uses has not taken into account the suitability of areas for development based on the soil, vegetative, and hydrologic character. The direction of future land use to areas most suitable for urban development can serve a twofold purpose. First, it can aid in the location of more efficient growth patterns, in proximity to available urban services; and second, it can aid in the protection of aesthetically valuable, sensitive environmental areas by directing the growth to the areas suitable for urban use. Moreover, the achievement of protecting certain areas is more realistic because adequate land is available for projected county population growth well beyond the year 2,000 without endangering the viable natural areas.

Air Quality

Although the air pollution effects on the natural environment have not been documented in detail in Dade County, they have been recognized and recorded in other parts of the country. Potential impacts, which include effects on vegetation and water quality are not nearly as significant as the impacts of property damage and human health effects. The primary source of air pollution is presently the automobile. Other point sources include municipal incinerators and industrial sources. Power plant emissions could become a greater problem due to increasing shortages of low sulfur content fuel oil which could result in greater emissions of sulfur dioxide.

The air pollution problem could be aggravated by thermal inversions, characteristically found over tropical oceans, and common in Dade County, in addition to the occurrence of calm conditions (winds less than 6mph) more than 40 percent of the year. When associated with temperature and humidity factors, they often trap pollutants in the lower atmosphere and create potential health hazards.[4]

A combination of increased efforts to adopt effective pollution control devices for autos and a change in transportation modes from the individual cars to public mass mode will be necessary before these problems can be solved.

Beaches and Wetlands

Past development trends in Dade County have resulted in beach destruction and indiscriminate filling-in of wetlands. Beach destruction has been commonly attributed to building close to the shoreline as well as dredge and fill operations which have either filled over the beaches, or resulted in beach erosion following the cutting of inland channels. Wetlands, such as mangrove and salt marsh areas, have often been developed right up to, and often past, the high water marks, and, as beach development, without regard to scenic value or adverse natural forces such as wind and tide.

This situation, brought on by the increasing demand for bay front or ocean front property, is becoming more critical than ever. Miami Beach has practically no beach left due to the encroachment upon the beach by development. Plans are now being made to reconstruct a 200 foot wide public beach on the ocean side of Miami Beach.

This project could have been avoided, and must provide a lesson for those areas which still have natural beaches intact. The major public beaches in the County are presently on Key Biscayne, which is facing a critical traffic problem due to the beach's attraction.

Studies at the University of Miami have shown that mangrove areas along the South Dade shoreline are important in the maintenance of the Biscayne Bay ecosystem. These areas are rapidly falling to development and strict control over bayshore development is needed to save Biscayne Bay. The placement of the bulkhead line at or above the mean high water mark is crucial for the protection of Biscayne Bay. The restriction of land use in mangrove and salt marsh areas landward of mean high water is also essential.

Solid Waste

The major concerns related to the effect of solid waste pollution on the environment include the seepage of polluted water from dumps into the Biscayne Aquifer and the emission of air pollution to the air from fires often associated with these open dumps. Although some of these problems may be alleviated by the adoption of recently proposed technologically-advanced solid waste disposal facilities, care must be taken to minimize the effect of existing landfill operations, or those to be used until new facilities for disposal and recycling are constructed.

ENVIRONMENTAL SETTING

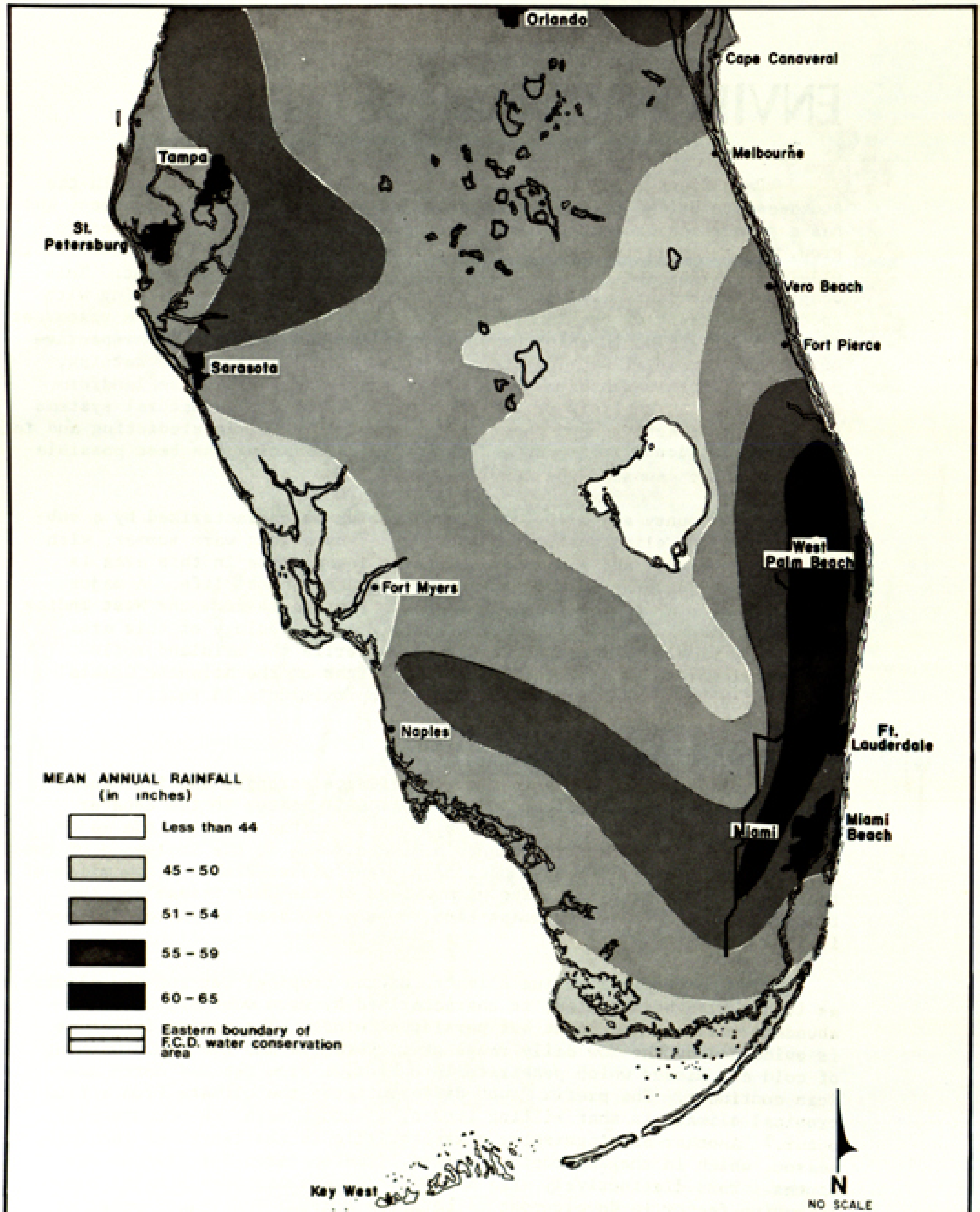
Dade County, one of the largest and most populous counties in the southeastern United States, encompasses an area of 2,200 square miles, and has a population exceeding 1.4 million. As the population continues to grow, it is imperative that certain environmental criteria be adhered to in order to prevent further deterioration of the natural environment. This chapter of the study will look at the natural environmental setting with specific emphasis on the landform, water, wildlife and vegetative resources of the county. The inventory process utilized will give us a perspective of the environmental setting, those systems which comprise the setting, and those forces which have been and are presently shaping the landform and ecology. An analysis of the present viability of the natural systems and the forces acting upon these systems can be useful in predicting and influencing successional trends,and useful in determining the best possible usage of these lands in the future.

Dade County and all of southern Florida is characterized by a subtropical marine climate and is distinguished by a long warm summer, with abundant rainfall, and a mild dry winter. The climate in this area is favorable to luxuriant plant growth and abundant animal life. A major portion of flora that is found in southern Florida is from the West Indies with a few tree species of temperate origin. The geology of this area is relatively simple. Limestone formations underlie the mainland soils. The major relief results from the topographic highs of the Atlantic Coastal Ridge which reach a maximum elevation of approximately 23 feet.

Climate

The climate of southern Florida reflects strongly the influences of its geographical location. South Florida is nearer to the equator than any other part of the continental United States. One of the major factors responsible for Dade County's mild climate is the influence of the Gulf Stream. This northbound oceanic current passes within a few miles of the Miami Beach shoreline. The warm waters of the Gulf Stream and the trade winds out of the southeast tend to warm the area in winter and cool it in summer.

The subtropical marine climate, or the tropical wet-and-dry climate, as it has also been called, is characterized by warm weather, usually abundant rainfall and light but persistent winds. The marine influence is evidenced by the low daily range of temperature and the rapid warming of cold air masses which penetrate into Florida from the mid North American continent. The prefix "sub" differentiates the climate from a true tropical climate in that killing frosts, although rare, do occasionally occur.[1] Another distinguishing characteristic is the length of the rainy season, which in the subtropical marine climate, lasts for five or six months. This distinctively mild and warm climate has been a major contributing factor in development of both the coastal and inland areas of southeastern Florida.



PRECIPITATION DISTRIBUTION

FIGURE 1

SOURCE:
University of Miami, Rosenstiel School of Marine and Atmospheric Science Technical Report ML 70111, 10/70

Each of the climatic elements of precipitation, temperature and wind have a distinct and direct influence on the hydrology and water resources of the area. Climate together with the geology has helped to mold the shape of the land, the drainage characteristics, and ultimately the activities of plants, animals and man.

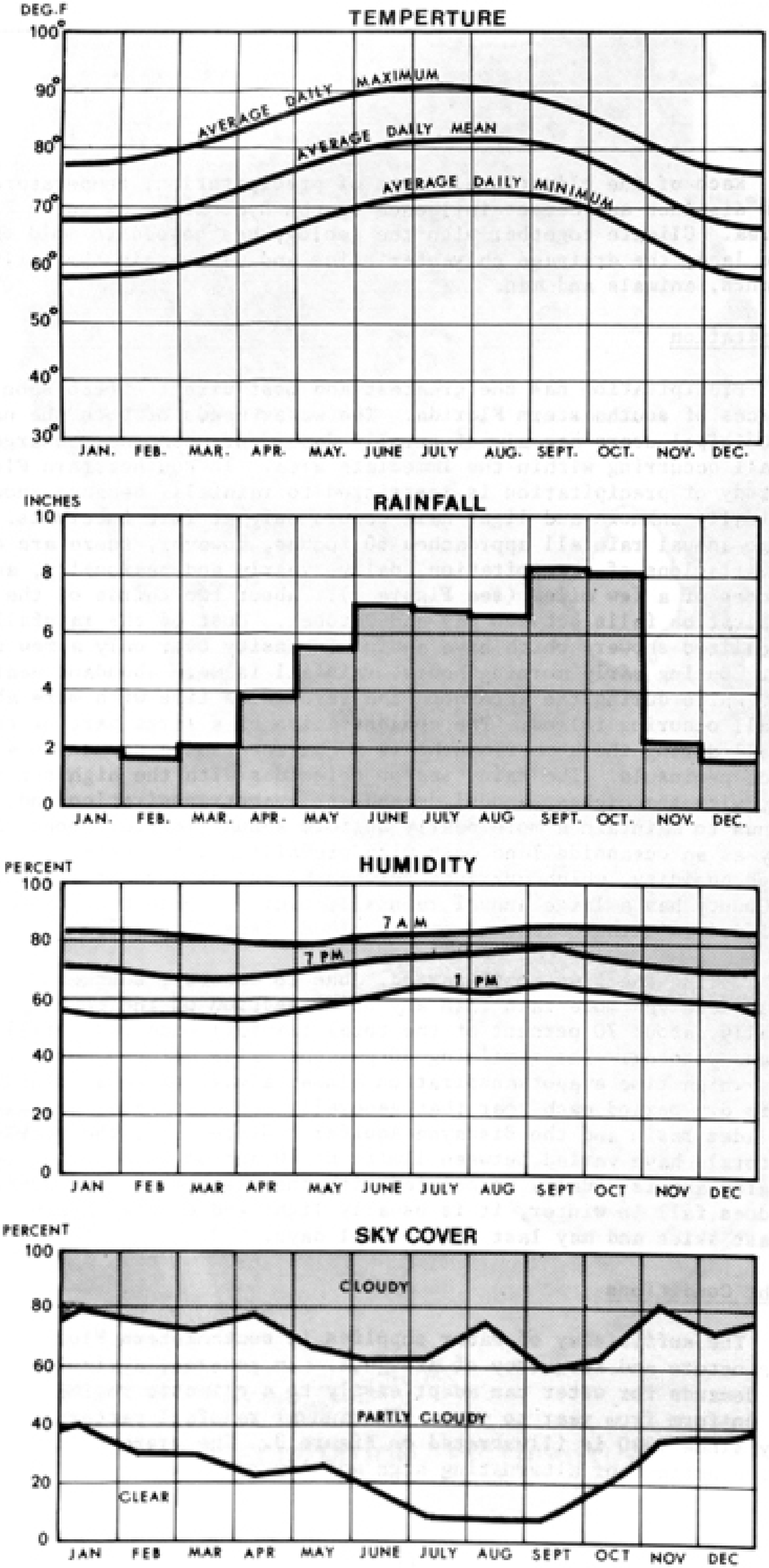
Precipitation

Precipitation has the greatest and most direct effect upon the water resources of southeastern Florida. The water needs of both the natural and municipal users are almost totally dependent upon the recharge from rainfall occurring within the immediate area. In southeastern Florida the study of precipitation is restricted to rainfall, because snow is practically unknown and light hail occurs only at rare intervals. The average annual rainfall approaches 60 inches, however, there are considerable variations of precipitation, daily, yearly and seasonally, and within distances of a few miles (see Figure 1). About two thirds of the annual precipitation falls between May and October. Most of the rainfall occurs as localized showers which have a high intensity over only a few square miles. During early morning hours, rainfall is more abundant near the ocean, while during the afternoon the reverse is true with more abundant rainfall occuring inland. The concentration of a large part of the annual rainfall during the summer months is a characteristic common to all of the Florida peninsula. The rainy season coincides with the high sun period, hence, with the highest annual demands of evapotranspiration and, therefore, it tends to maintain a more nearly uniform annual moisture condition. Dade County as an oceanside land mass with prevailing sea breezes, has a relatively high humidity, which averages between 60 and 85 percent. Even though Dade County has a large annual rainfall, over 60 percent of the days are classified as either clear or partly cloudy (see Figure 2).

During the five month period, June to October, southern Florida usually receives more rain than any other section of the country. Traditionally, about 70 percent of the total rainfall each year falls between June and October. The remaining 30 percent falls between November and May during which time evapotranspiration almost always exceeds rainfall. It is this dry period each year that generally depletes water storage in the Everglades Basin and the Biscayne Aquifer. Since 1940, the yearly rainfall totals have varied between limits of 40 and 85 inches. Winter rain is scarce and is usually associated with the passage of cold fronts. When rain does fall in winter, it is usually light and drizzly accompanied by overcast skies and may last for several days.

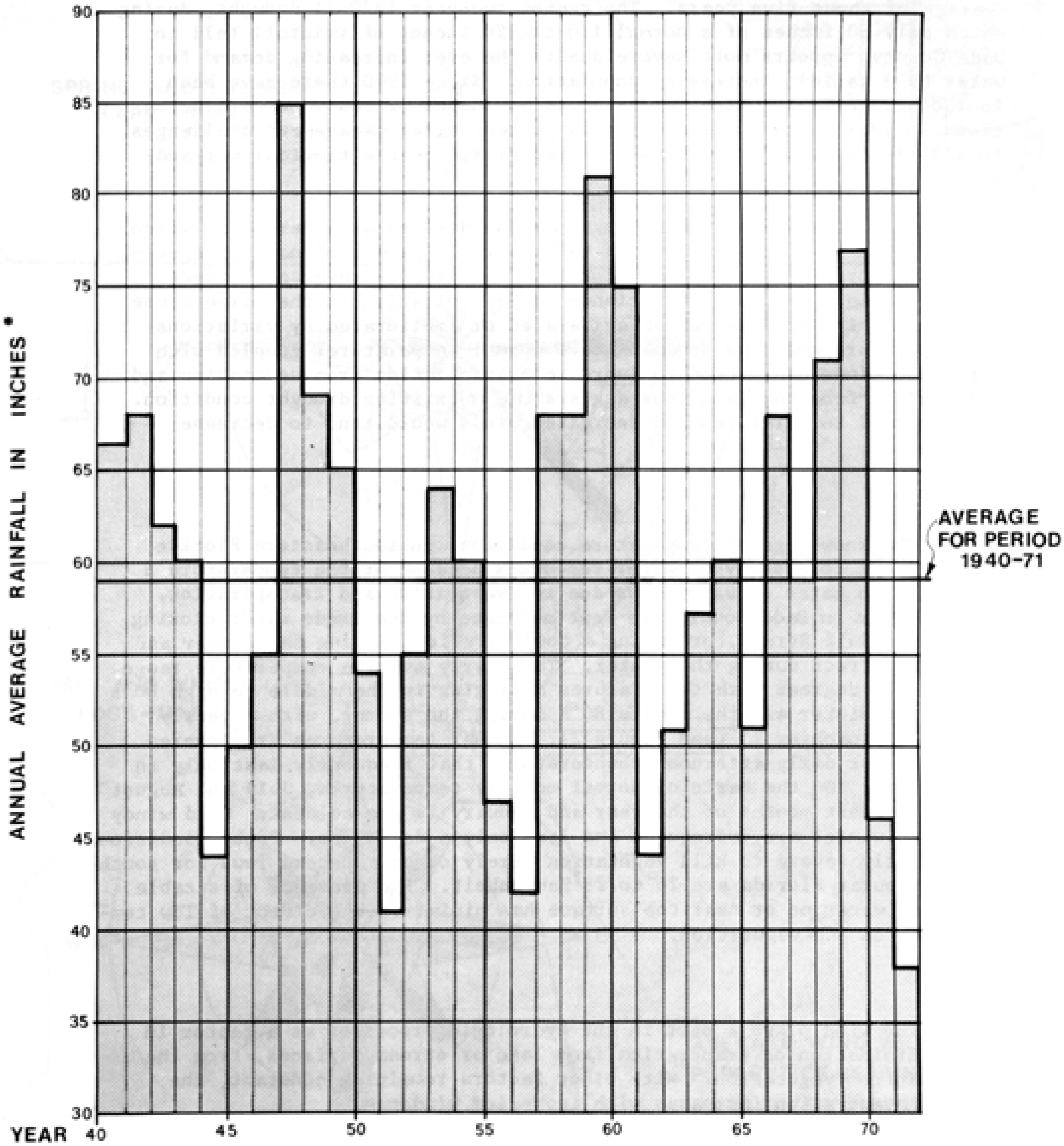
Drought Conditions

The sufficiency of water supplies in southeastern Florida depends on the nature and frequency of droughts. In general, agricultural or urban demands for water can adapt easily to a climatic regimen that remains uniform from year to year. The annual rainfall pattern for Dade County since 1940 is illustrated on Figure 3. The graph portrays a distinctive pattern of alternating high and low peaks with each lasting an



AVERAGE CLIMATICAL CONDITIONS

FIGURE 2



*FOR 3 REPRESENTATIVE STATIONS IN DADE COUNTY (HOMESTEAD, MIAMI AIRPORT, AND TAMIAMI CANAL AT 40 MILE BEND)

ANNUAL RAINFALL-DADE COUNTY FLORIDA FIGURE 3 average of about five years. The recent two-year 1970-71 drought, during which only 80 inches of a normal 110 to 120 inches of rainfall fell in Dade County, appears most severe due to the ever increasing demand for water by a rapidly increasing population. Since 1940 there have been four other years in which rainfall was 45 inches or less. Wide fluctuations in yearly precipitation totals present water management challenges to all of the earth's land areas characterized by the 'tropical wet-and-dry' climatic type.

In a general sense, a drought may be defined as a period in which rainfall has been so deficient as to hinder the growth of native vegetation and, more importantly, as it relates to man, to adversely affect water supplies. Although deficiency in precipitation is the prime cause of drought, its effects may be aggravated or ameliorated by variations in temperature and wind speed. Above normal temperatures coupled with increased winds would tend to increase transpiration from vegetation and evaporation from the land thus aggravating an existing drought condition. Below normal temperatures and decreased winds would tend to decrease evaporation.

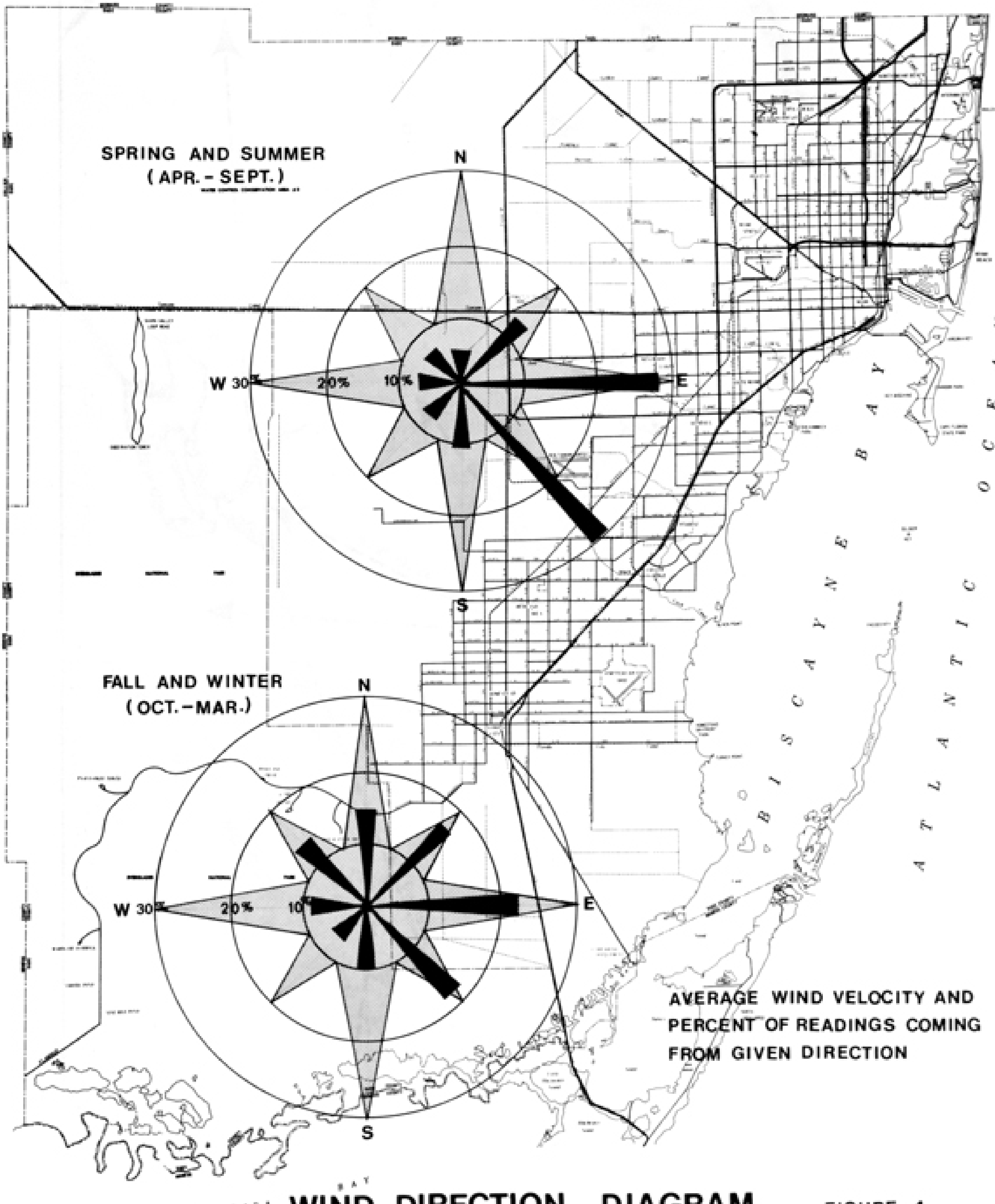
Temperature

The knowledge of temperature conditions in southeastern Florida is pertinent to a study of water resources because of the temperature's influence on rates of water loss due to evaporation and transpiration. Temperatures in Dade County are kept moderate by the trade winds blowing across the Gulf Stream, producing a cooling effect during the summer and a warming effect during the winter. The yearly average temperature range is about 20 degrees with temperatures averaging in the middle to high 60's during the winter and the middle 80's during the summer, with a yearly average approaching 75 (see Figure 2). Summer temperatures are lowered by the almost daily afternoon thunderstorms that frequently last only an hour or two. On the basis of normal monthly temperatures, July and August are the warmest months of the year and January is the coldest. Cold windy spells in winter are infrequent and last only a day or so. Frost conditions sufficiently severe to kill vegetation rarely occur. Record lows for southern peninsular Florida are 26° to 28° Fahrenheit. The presence of sizable bodies of water on or near the surface has minimized the effect of low temperatures on the vegetation.

Wind

The wind plays a part in the hydrologic processes as a factor in the determination of evaporation from lake or stream surfaces, from the soil and from vegetation. With other factors remaining constant, the rate of evaporation increases with increased windspeed.

The prevailing winds are easterly, especially during the summer and fall, however, they occasionally shift to the west (offshore breezes) at night. The direction of wind movement varies during the rest of the year. Sometimes when cold air masses invade the county during winter, the wind is from the north. Winds of high intensity which accompany



WIND DIRECTION DIAGRAM

FIGURE 4

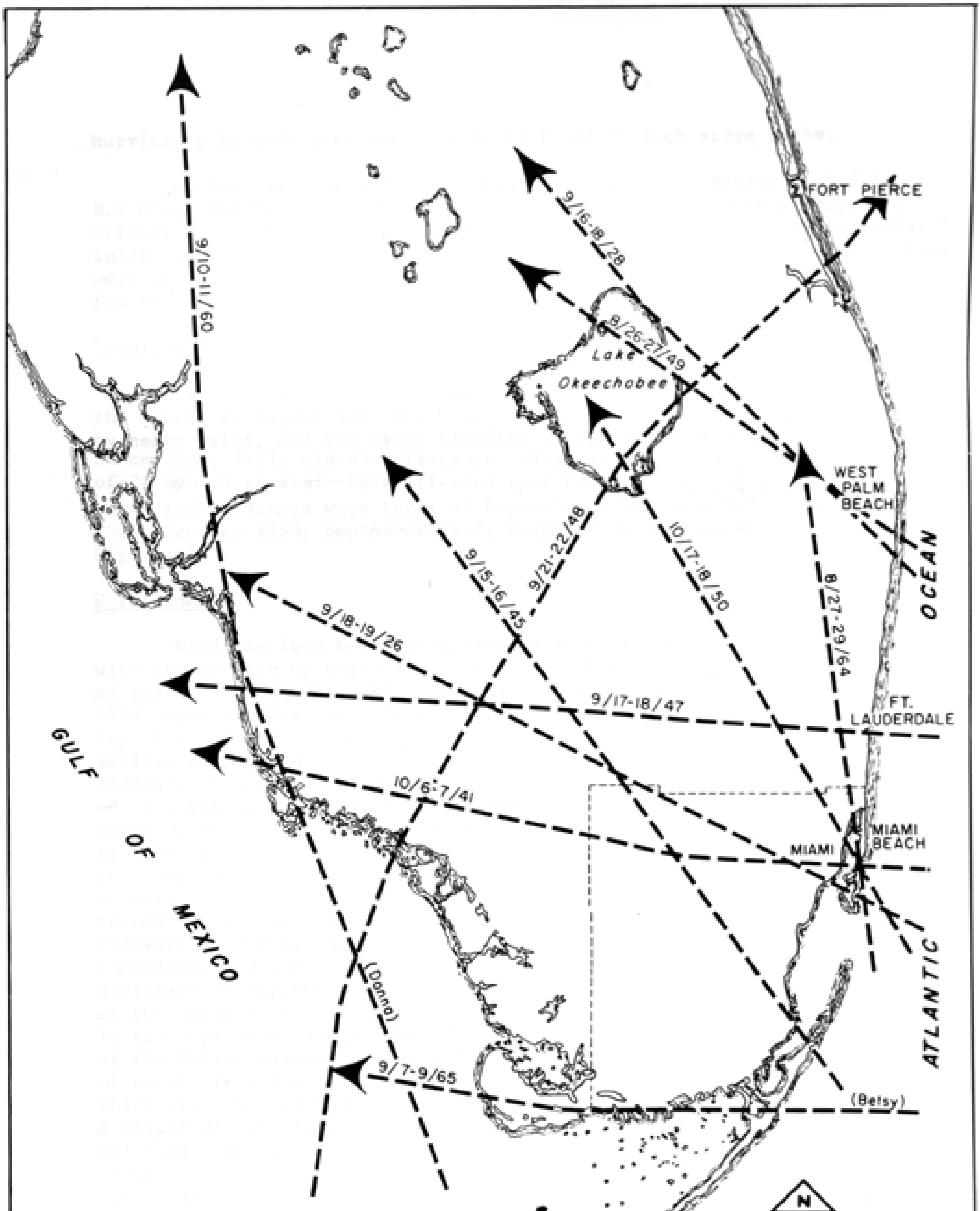


FIGURE 5

MAJOR HURRICANES AFFECTING SOUTH FLORIDA 1926-1972

SOURCE: JOHNSON, 1970

hurricanes in this area are usually confined to such storm paths.

On the basis of a 30 year record at Miami, air speeds varied from 8.1 miles per hour in July to 10.8 mph in November, with an average for October to March of 9.9 mph as compared to 8.8 mph for April to September.[2] Inland the average wind speeds can drop to half of those average velocities measured along the coast. See Figure 4, Rose diagrams of wind directions for Miami, Florida.

Tropical Storms

Tropical storms periodically pass over or near south Florida between the months of August and November. These storms are usually accompanied by heavy rains, and can cause flooding of low-lying areas of Dade County. Since June, 1911, eleven hurricanes--tropical storms with sustained winds of 74 mph or greater--have affected Dade County.[3] Storms which caused considerable damage were those of September 1926, November 1935, September 1945, October 1950, September 1960, August 1964 and September 1965 (see Figure 5).

Hurricanes

Wind has long been recognized as a major destructive force associated with the passage of hurricanes. The South Florida Building Code was designed and adopted in the wake of the massive damage wrought by the 1926 and 1928 Miami and West Palm Beach Hurricanes. Buildings erected in conformity with these codes have since been withstanding hurricane winds without serious damage. However, the major destructive force associated with the landfall of hurricanes, the hurricane tide, has been inadequately addressed in planning for Dade County's coastal areas. A storm of hurricane intensity, moving toward or crossing a coastline, will always be accompanied by tides above normal. The above-normal tide or storm tide results from the compounding of a storm surge with the astronomical tide. The volume of water pushed across a coastline as a storm surge is a function of the barometric pressure at the storm center, the storm center direction of foreward movement, the maximum sustained winds, the configuration of the coastline, and the configuration or slope of the sea bottom. The Miami Hurricane of September 18, 1926, was accompanied by a tide of 11.7 feet at the gauge at the mouth of the Miami River and 10.7 feet on Miami Beach. In the Keys Hurricane of September 2, 1935, it was reported that the tracks of the F.E.C. Railway were washed from the Long Key Viaduct at an elevation of thirty feet above mean low water. The hurricane of September 8, 1965, which was not a particularly severe one, brought a hurricane tide reaching a height of 9.82 feet above mean sea level at Homestead Bayfront Park. Existing flood criteria in the South Bay area are in the 6 to 6.8 foot range, which falls considerably short of even moderate hurricane flood potential. Levee 31 East, which was constructed in 1966 to prevent tidal flooding of a recurrence frequency of about once in ten years, is 7½ feet above mean sea level and can be topped by tides accompanying a moderate hurricane. Hurricane Donna, which passed 80 miles to the south, brought tides to Dade which were 6.5 feet above normal.

In recognition of the destructive potential of this natural phenonenon and that its local probability of occurrence is greater than anywhere else in the continental United States, future land use planning in Dade County must consider the destructive forces and the potential dangers to life and property posed by these storms.

Geology and Soils

Together the geology and soils constitute a major factor or element in the natural setting of Dade County. The underlying limestone sedimentary rocks provide the parent material from which the soils have developed. The limestone bedrock constitutes the most significant mineral resource and is used as a base material for roads, airport runways, as construction aggregate, and in the manufacture of cement. Perhaps the most important environmental factor of the limestone bedrock is its capability of holding and transmitting great quantities of water. The limestones near the surface are coarse grained shell rocks containing numerous cavities. These rocks make up the Biscayne Aquifer, which is as much as 120 feet thick under Miami but thins to a few feet in western Dade County. The importance of this aquifer can only be alluded to by the fact that all municipal water systems from Boca Raton southward are dependent upon the Biscayne Aquifer for their potable water supplies.

It is difficult to separate the importance of soil as an environmental factor from that of the geologic substratum. Soils consist of various sizes and types of mineral material (sand, silt, and clay) derived from the geologic substratum, organic matter from decaying plant and animal materials, water derived from precipitation, oxygen from the air, and infinite numbers of minute plants and animals. The soils are a physical biological system in themselves, as complex as the vegetation above and the geologic substratum beneath them.

Soils are the source and reservoir of mineral nutrients for the entire ecosystem. They provide a great storage reservoir for water and they further act as a medium or environment for numerous small plants and animals. Another important consideration is the value of soils as they influence water quality in South Florida. Recent research indicates the value of soils with high ion exchange capacities to concentrate nutrients, small organic components, and various elements and heavy minerals. The plants which grow on these soils mediate the release of nutrients and elements into the surface and ground-water so that concentrations rarely exceed ambient levels. Those areas which have maximum ion exchange capacities are peats and mucks. Such soils are usually found in association with sawgrass, cypress, mangroves, and blue-green algal mats associated with marls.[4]

Regional Geology

The peninsula of Florida is the emerged part of a much wider projection extending southward from the continental mass of North America. Geologists believe the core of the peninsula is composed of metamorphic and igneous rocks similar to those underlying the Piedmont region of the Eastern United States. The deep seated core of the Floridan Plateau is covered predominantly with limestone sediments ranging in thickness from about 4,000 feet in north central Florida to more than 15,000 feet in southeastern Florida.[5] The upper limestones were formed in shallow seas during a time in geologic history when continental glaciation resulted in world-wide fluctuations of sea level. During periods of glacial expansion sea level dropped as much as 200 feet as water was transferred from the oceans into the continental ice masses. This process was reversed during interglacials, periods of glacial thaw, when moisture was released by the glaciers, swelling sea levels to elevations as much as 100 to 200 feet above the present sea level.

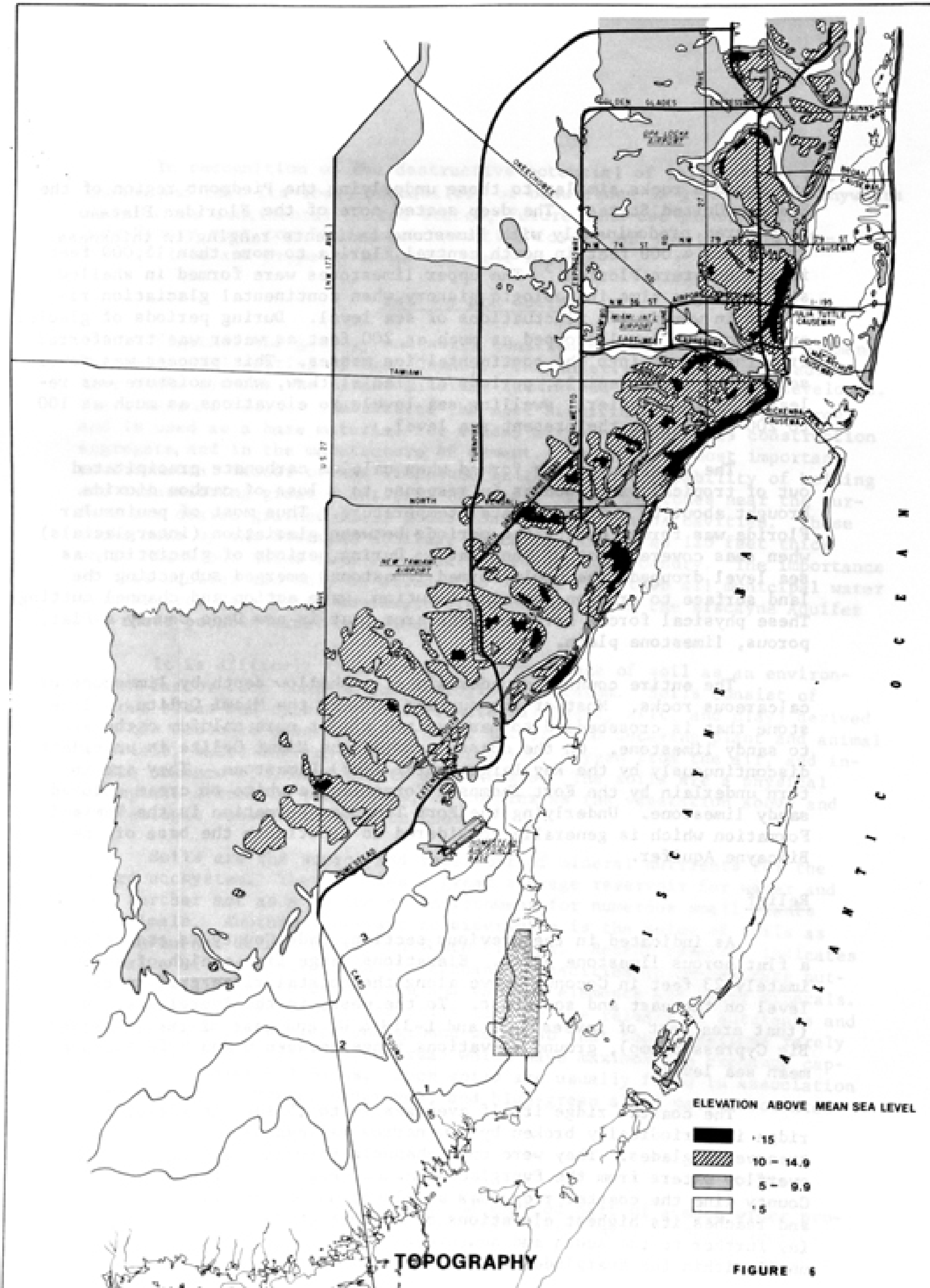
The limestones were formed when calcium carbonate precipitated out of tropical water bodies in response to a loss of carbon dioxide brought about by a rise in water temperature. Thus most of peninsular Florida was formed during the periods between glaciation (interglacials) when seas covered most of the state. During periods of glaciation, as sea level dropped, the newly formed limestones emerged subjecting the land surface to erosion by rain, solution, wave action and channel cutting. These physical forces have left the area that is now Dade County a flat, porous, limestone plain.

The entire county is underlain at a shallow depth by limestone or calcareous rocks. Most of the surface rock is the Miami Oolite, a limestone that is crossbedded to massive and almost pure calcium carbonate to sandy limestone. On the coastal ridge, the Miami Oolite is underlain discontinuously by the Key Largo (coral reef) Limestone. They are in turn underlain by the Fort Thompson Formation, a white to cream colored sandy limestone. Underlying the Fort Thompson Formation is the Tamiami Formation which is generally considered to constitute the base of the Biscayne Aquifer.

Relief

As indicated in the previous section, Dade County is essentially a flat porous limestone plain. Elevations range from a high of approximately 23 feet in Coconut Grove along the coastal ridge grading to sea level on the east and southeast. To the west, in the Everglades Basin (that area west of Levees L-30 and L-31N & W, and east of the so-called Big Cypress Swamp), ground elevations range between 0 and 9 feet above mean sea level.

The coastal ridge itself averages 10 to 15 feet in elevation. This ridge is periodically broken by low narrow valleys or channels called transverse glades. They were once channels through the ridge carrying overflow waters from the Everglades Basin. Beginning at the Dade-Broward County line the coastal ridge has an elevation of approximately 15 feet, and reaches its highest elevations of 23 feet at Coconut Grove. Extending further to the south and southwest it gradually decreases in elevation until within the Everglades National Park an elevation of approximately 2



TOPOGRAPHY

FIGURE 6

feet is reached at Mahogany Hammock (see Figure 6).

Biscayne Aquifer

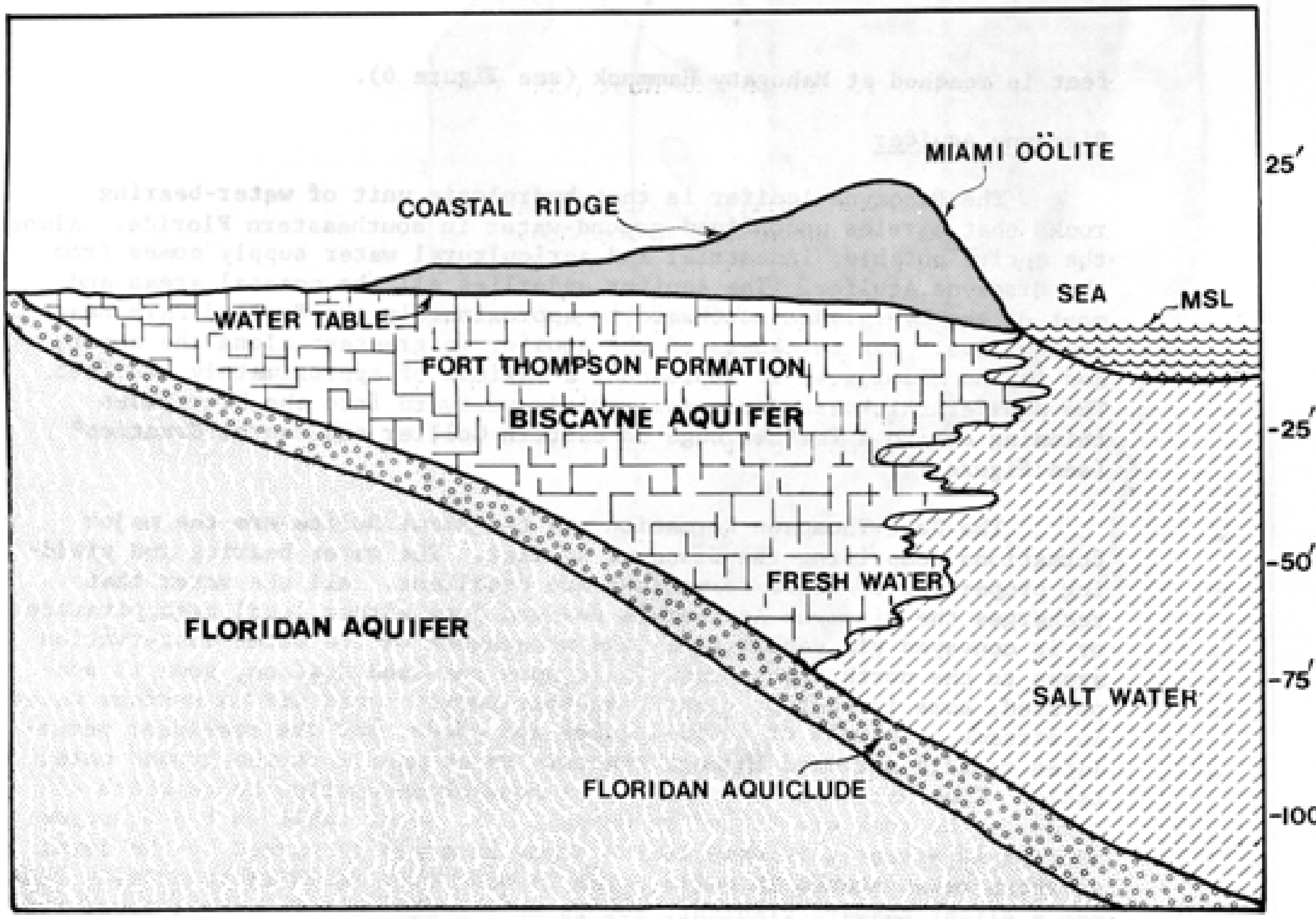
The Biscayne Aquifer is that hydrologic unit of water-bearing rocks that carries unconfined ground-water in southeastern Florida. Almost the entire potable, industrial and agricultural water supply comes from the Biscayne Aquifer. The Aquifer underlies all the coastal areas and most of the Everglades northward to approximately the Broward-Palm Beach County line. The thickness of the Aquifer is greatest along the coast, and in the Miami area it approaches a maximum of approximately 120 feet. The Aquifer thickness decreases rapidly westward into the Everglades thinning out to a feather edge in eastern Collier and Monroe Counties[6] (see Figure 7).

The Fort Thompson Formation and the Miami Oolite are the major formations comprising the Biscayne Aquifer. The water bearing and yielding properties of these formations are excellent. All the water that recharges the Biscayne Aquifer is derived from either local precipitation or is conveyed via canals from Lake Okeechobee or the water conservation areas to the north. When rain falls upon the land surface, some is evaporated, some is used by plants, another portion runs off as surface water in streams or canals or to fill lakes and ponds, and the remainder percolates rapidly downward through the thin sandy mantle to the ground water table. (The water table is the upper zone of saturation below which all voids in the rock are filled by water). The water table in the Biscayne Aquifer is essentially open to the atmosphere and is marked by the level at which water stands in wells. The ground-water table is relatively flat, has a slight seaward gradient, and is only a few feet above sea level (see figures 8, 9, & 10).

Normally in the Biscayne Aquifer the water table lies in the Miami Oolite, the Pamlico Sand or within the organic soils. The water table fluctuates in response to the variability of precipitation, evaporation and transportation demands, the effects of canalways, and aquifer pumpage. The entire natural or cultural environment of southeast Florida is dependent upon the Aquifer. Its importance is covered more thoroughly under the water resources section.

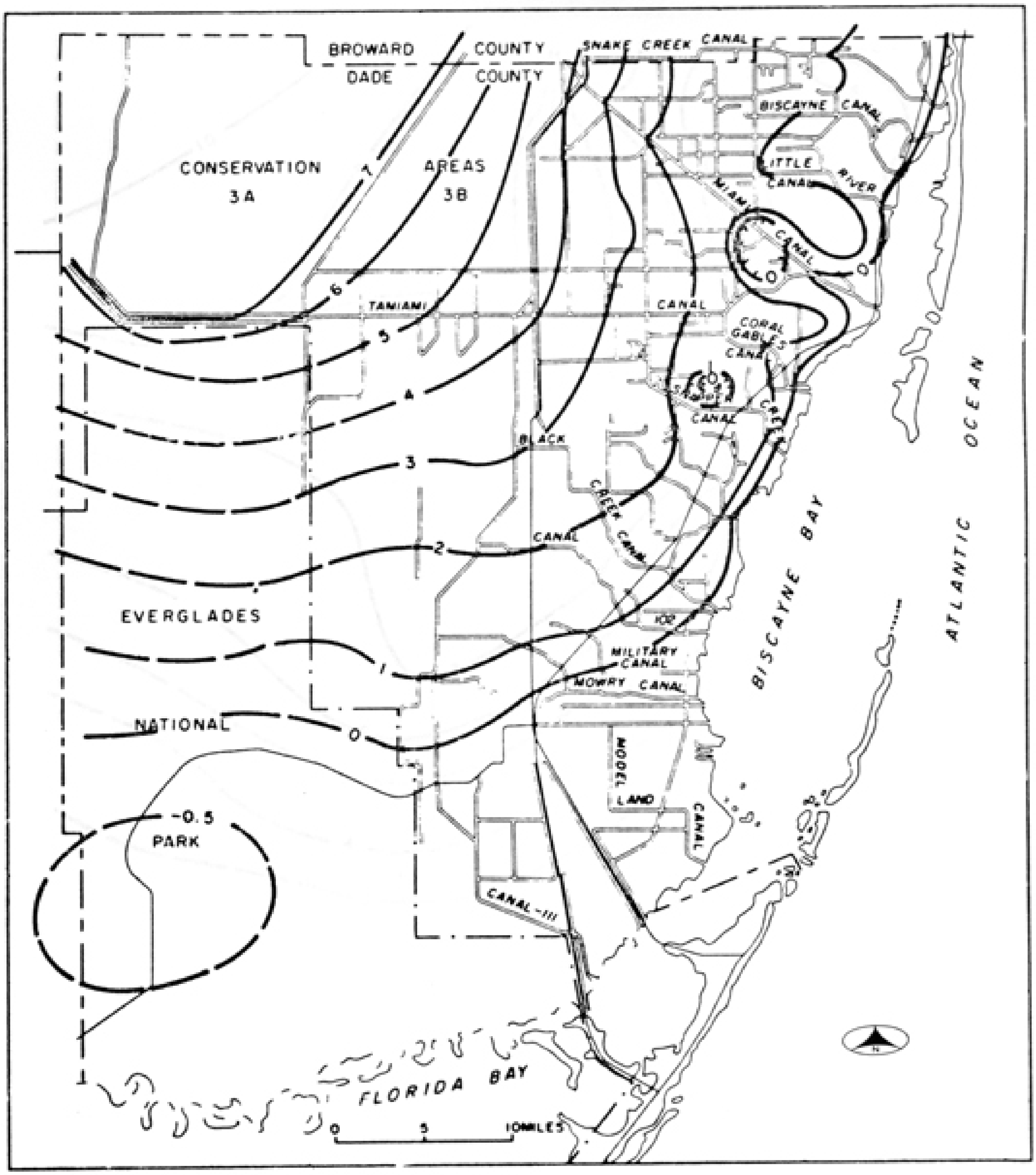
Soil Formation

Soil is a dynamic natural complex of organic and inorganic substances, and is a result of various kinds of physical and chemical weathering of rock or mineral material, acted upon subsequently, or added to and inhabited by living organisms. The characteristics of the soil at any given point are determined by: (1) the physical and mineralogical composition of the parent material; (2) the climate under which that soil material has accumulated; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the material.



GENERALIZED CROSS SECTION AND PLAN OF BISCAYNE AQUIFER IN DADE COUNTY

FIGURE 7

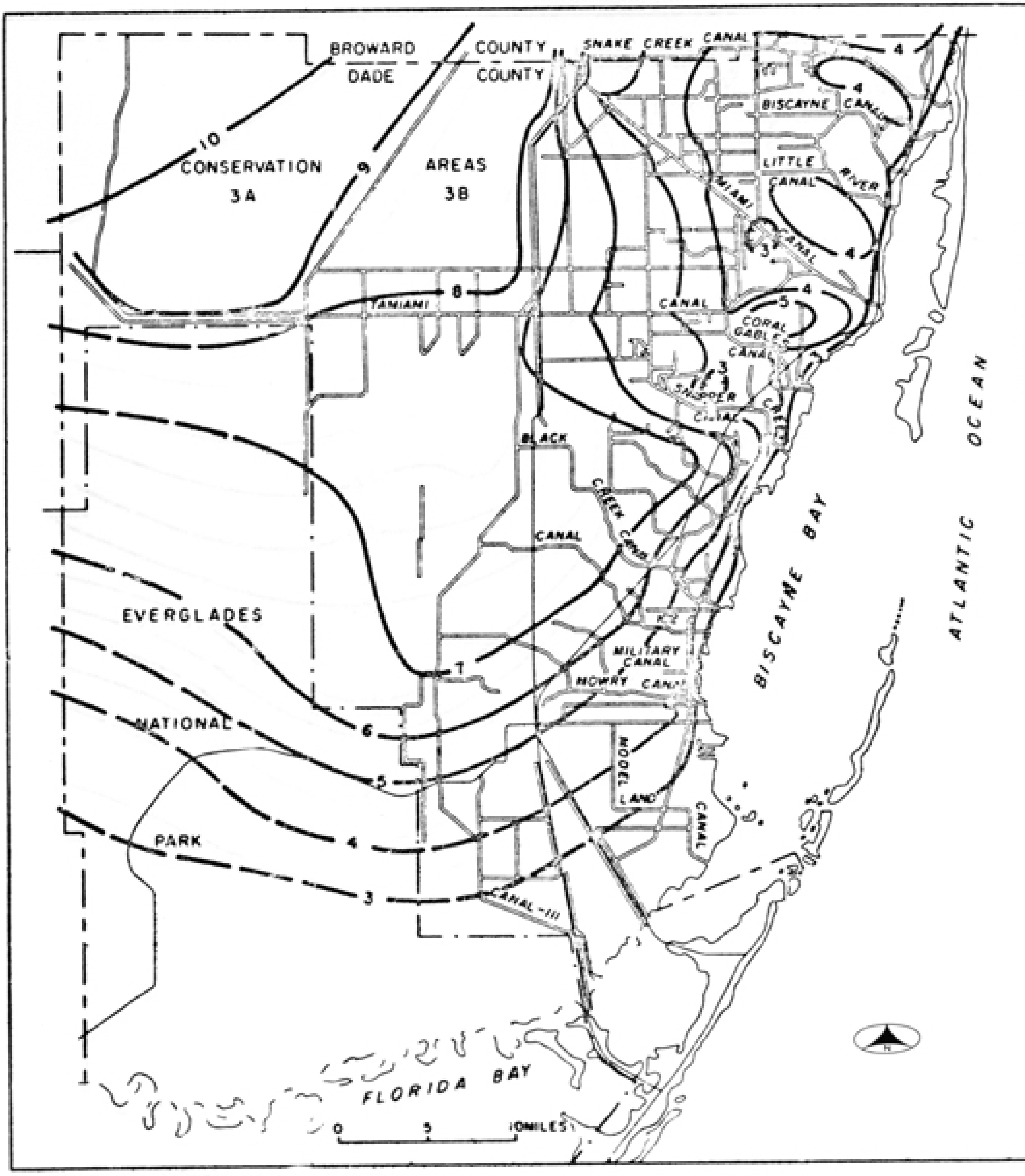


Source - Hull, U.S.G.S. 1971

AVERAGE LOWEST GROUND WATER LEVEL 1959-'69

(IN FEET ABOVE MSL)

FIGURE 8

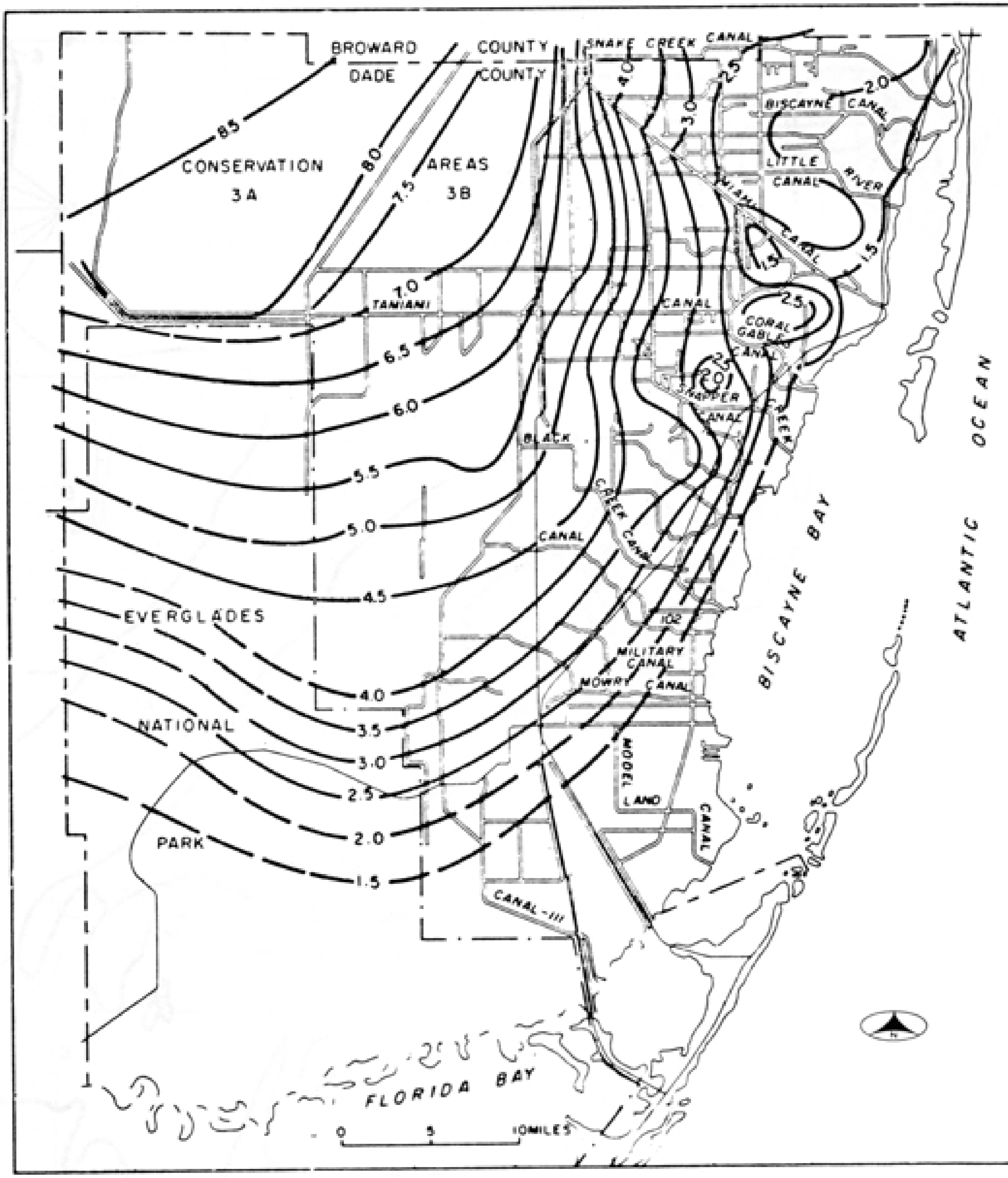


Source - Hull, U.S.G.S. 1971

AVERAGE HIGHEST GROUND WATER LEVEL 1959-'69

(IN FEET ABOVE MSL)

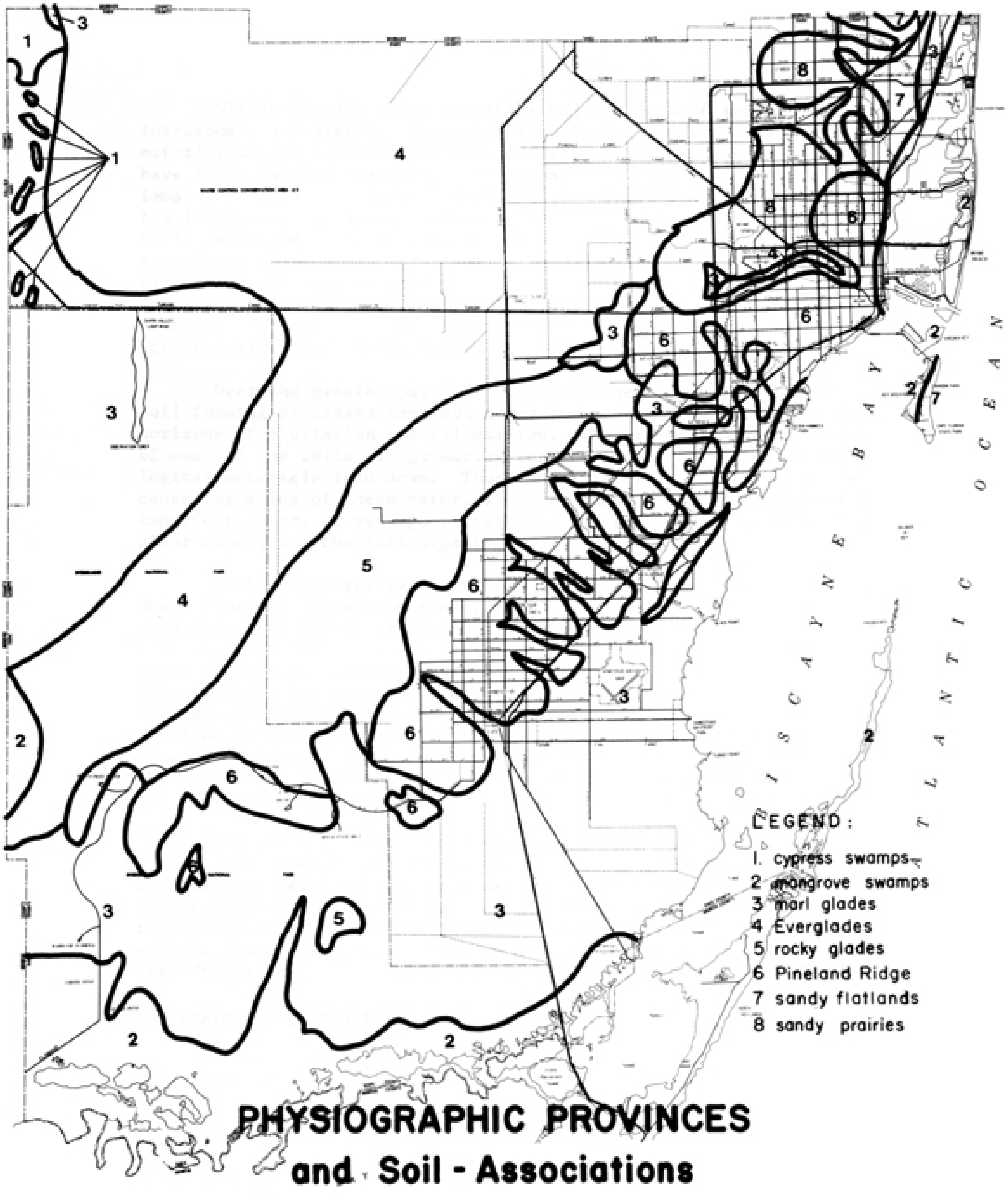
FIGURE 9



Source - Hull, U.S.G.S. 1971

AVERAGE GROUND WATER LEVEL 1959-'69
(IN FEET ABOVE MSL)

FIGURE 10



PHYSIOGRAPHIC PROVINCES and Soil - Associations

FIGURE 11

Within Florida there are three major orders of soils: zonal, intrazonal, and azonal. Basically these orders reflect the degree of maturity of the soils.[7] The zonal order represents those soils which have fully matured horizons. Intrazonal and azonal order soils are immature or less developed. South Florida soils consist principally of the intrazonal and azonal orders. The intrazonal soils are organic bog soils (muck and peat) which are very poorly drained. The azonal soils are mineral base soils (principally sands) which have not had sufficient time to develop mature profiles. The soils of the county have developed under the influence of a humid, subtropical climate. Owing to the warm climatic conditions and to the high rainfall, soil-forming processes are active during most of the year.

Over the greater part of the county the soils are young and the soil forming processes have not acted long enough to form noticeable horizons of eluviation and illuviation. The present characteristics of most of the soils are primarily results of the character of the geological materials laid down. Those characteristics are also partly caused by aging of these materials under the influences of excessive, imperfect, poor, or very poor drainage; the subtropical climate; the plant cover; and the soil organisms.

Soil scientists agree that there are four basic soil types in South Florida. These are sands, rocklands, marls, and organics. Sands were deposited on the parent rock by the ocean, but where this deposition did not take place or where erosion has occurred rockland is exposed. Marls are mineral precipitants laid down in either fresh or marine waters. Organic soils are accumulations of decomposing plants. The warm tropical climate and rainfall has continually leached the exposed sands, marls, and rockland so that they are low in fertility. The periodically inundated organic soils are somewhat of an exception. The loss of such soils through the process of oxidation has been curtailed and many feet of fertile muck and peat have accumulated.

The soils of Dade County are placed in 15 series and six miscellaneous land types.[8] The 15 series can also be aggregated into eight soil associations based on the characteristics of the soils, such as their parent material, mode of formation, depth to bedrock, drainage characteristics and other physical and chemical parameters. Each soil association will be discussed as it relates to a particular physiographic province. (see Figure 11).

Physiographic Provinces

Within Dade County eight physiographic provinces can be delineated. These provinces vary according to the underlying geology, their hydrologic conditions, their soils, and the natural vegetation associated with each province. In many cases an accurate delineation of the boundaries of each province is subjective due to the subtle differences that exist between them. In the extreme northwest corner of the county is the Big Cypress Swamp. Moving southeasterly across the county one passes through the

Everglades, Sandy Prairie, Flatlands, Rocky Glades, Atlantic Coastal Ridge, Southern Coastal Prairie and, finally, Biscayne Bay (see Figure 11).

Big Cypress Swamp. Approximately 35 square miles of the ill-defined Big Cypress Swamp lie within Dade County's extreme northwestern portion, north of the Tamiami Trail. The Big Cypress is bounded on the east and southeast by the Everglades physiographic province. To the north in Collier County it is adjoined by the Sandy Flatlands. To the southwest and south in Monroe County, the Big Cypress Swamp merges into the low lying coastal marshes and mangroves.

The Big Cypress Swamp is an area of alternating swamplands and hammocks with the former prevailing. The differences in the heights of aerated ground above the water table cause a marked diversification in the distribution of plants. The higher areas support bunch grasses, palmettos and pines, whereas the lower areas are covered with cypress, willow, bay heads, sedges, and other marsh plants. In general there is no natural marked demarcation between the Big Cypress and Everglades as they merge into each other.

The only source of water for the Big Cypress is rain and during the wet season most of the area is covered by a shallow layer of slowly moving water termed sheet flow. Rainfall is seasonal and is retained on the surface thus maintaining the natural hydroperiod which is essential to the ecology of the Big Cypress and of the coastal estuaries. The surface retention is due to the flat topography and poor drainage characteristics of the soils and underlying rock.

Within short distances the soils vary in the character of the materials, color, texture, consistence and thickness of the various layers. In places the soils consist of sands, marls, peats or a mixture of these materials.

The Everglades. The Everglades Basin occupies an irregularly defined area of about 4,000 square miles extending from an area slightly north of Lake Okeechobee to the salt water marshes and mangrove swamps which border on Florida Bay to the south. The Everglades extends south and southwestward from Lake Okeechobee in a vast arc about 40 miles wide and 100 miles long. The floor of the Everglades is comprised of rocks of the Fort Thompson Formation which is overlain in Dade County by the Miami Oolite.[9] Overlying these sedimentary rocks are several kinds of peat and muck. It is presumed that the Everglades existed originally as a shallow basin or series of hollows which have subsequently been filled in by peats and mucks.

Within Dade County, the Everglades occur in a broad area in the western and southern parts of the county. They have developed in the deepest parts of the trough formed by the rock floor. A peat mantle varies from 6 to 60 inches in thickness. Drainage is very poor. The excess surface water moves slowly through broad shallow sloughs interspersed with slight ridges. This ridge-slough area contains thousands of small oval-shaped islands interspersed with sloughs and small ponds or lakes. During much of the year, the sloughs are filled with water.

Aquatic plants grow profusely, especially the bladderworts, coontail moss, spider lily, bonnets, and a few grasses. Sawgrass usually grows along the slough borders. The islands are mostly of the bay head type. Their vegetation is mainly whitebay and sweetbay, wax myrtle, and dahoon holly, with an undergrowth of royal fern, cinnamon fern, and swamp fern. The organic soils of the peat marshes are members of the Everglades, Gandy and Loxahatchee series.

The Atlantic Coastal Ridge directs the flow of water southward. The nearly flat topography (as little as 3 inches change in elevation per mile) and dense vegetation causes the water to flow very slowly. Over time, decaying vegetation has formed extensive beds of peat and muck that act like sponges to soak up water during the rainy season. This water is then slowly released, providing water for the estuarine areas after the wet season has ended as well as supplying ground-water to the Biscayne Aquifer.

The original Everglades have been modified considerably as a result of drainage for urban and agricultural development and for flood control. In fact, the natural functioning of the Everglades has been almost totally interrupted so that the remaining functions are artificially managed. Figures 12 and 13 show a comparison between the historic area of the Everglades and the area that exists today. The vast majority of the remaining flooded muck soil areas are found in the F.C.D. Conservation Areas.

Soils which have been derived from the remains of aquatic and succulent plants and trees are the Everglades, Loxahatchee, and Gandy peats. They have formed mainly from sawgrass, lilies, and other water tolerant plants, and leaves and stems of woody plants. Peats within Dade County range from 6 to 90 inches in thickness. The very shallow phases are less than 36 inches in depth, the moderately deep 36 to 60 inches and deep phases generally exceeding 60 inches.

The Everglades peat has developed from the remains of sawgrass, lily, sedge, and myrtle. It is mostly a very dark brown or black surface layer. This peat is, under natural conditions, very poorly drained and may be covered with water during many months of the year. The Everglades series consist of shallow phase peat over either marl or shallow to deep sands, and deep phase peat over shallow marl or limestone.

Loxahatchee peat occurs in the central part of the Everglades basin in the western half of the county. Native vegetation is lily, pickerelweed and other aquatic plants. This series also has shallow and deep phases of very spongy fibrous material and is characteristically covered with water during the greater part of the year.

Gandy peat is on the bay, laurel, and myrtle islands within the Everglades basin. They stand 1 to 3 feet higher than the surrounding marsh. On some of the islands the upper 12 to 24 inches of the Gandy peat may be moderately well drained but the lower profile may be saturated with water.

In the western sections of the Everglades Basin and the extreme southern area marls occur. The Ochopee marls contain a considerable amount of fine sand mixed with the finely divided calcareous material. It is very poorly drained and may be inundated by water during many months of the year. Native vegetation is prairie, marsh, or forest. Most of this series is presently within the western boundaries of Everglades National Park and is used as feeding and breeding areas for birds and other wildlife.[10] The Flamingo marl occurs in the extreme southwestern part of the county. The Flamingo marl is very poorly drained and may be covered by brackish or salt water during high tides.

The Sandy Flatland. The Sandy Flatlands floor most of the lowlands along the Atlantic coast and extend west around the north side of Lake Okeechobee. They continue south beyond Naples where the coastal marsh begins. Along the Atlantic coast they are limited on the east by the narrow coastal ridge with its dunes, and on the southwest and west by the eastern border of the Everglades. This province continues southward between the Everglades and the coastal ridge to Coral Gables in the Miami area, with an occasional break through the ridge north of Miami where they form the floor of old drainageways.

Within Dade County, the Sandy Flatlands form a belt four to six miles wide just inland from the eastern shore in the northeastern part of the county. Similar soils also occur on Key Biscayne. The rock floor is approximately three to five feet above sea level. A mantle of sand ranging from six to seventy-two inches in thickness overlies the Miami Oolite. Soils on the Sandy Flatland are composed of the Broward, Dade, Palm Beach, St. Lucie, Arzell and Davie series. To the south they abut the Atlantic Coast Ridge of oolitic limestone and to the west they are overlapped by Everglades soils. Native vegetation consists mostly of slash pine, saw palmetto, short grasses, and scattered hammocks to the east with tall grasses dominating the lower western elevations.

These soils consist of thin to thick beds of fine sands ranging from 12 inches thick in the Broward and Dade soils to upwards of 96 inches in the St. Lucie soil. They exhibit rapid to very rapid internal drainage. The shrink-swell potential of these sandy soils is generally low and their presumptive bearing values are good ranging from 6,000 to 9,000 pounds per square foot after compaction. Thus they have few physical limitations for development.[11]

The Sandy Prairie. The Sandy Prairie physiographic province is a strip of land two to six miles wide west of the Flatlands. In northern Dade County they occur as a transition province between the Flatlands and the Everglades. They extend southward from the County line to Coral Gables. The Sandy Prairie soils are poorly drained fine sands consisting of the Arzell, and Davie fine sands. These soils have developed from very thin beds of fine marine sands over limestone. Generally the marl or limestone bedrock is at a depth between 18 and 48 inches. They exhibit medium to rapid internal drainage when free of the high water table. Originally, native vegetation consisted of tall grasses; however, drainage has resulted in a growth of slash pine. The shrink-swell potential of these soils is generally low and the presumptive bearing values range from 6000 to 9000 pounds per square foot. The major limitation of these soils for development is that they are naturally poorly drained. Generally when relieved of the high water table these soils exhibit similar physical characteristics as do the soils in the Sandy Flatlands.

The Rocky Glades. The Rocky Glades occur in an area south of the prairie provinces between the higher lying pinelands or coastal ridge on the east and south and the lower lying peat marshes or Everglades on the north and west. Elevations of the Rocky Glades range from approximately five to ten feet above mean sea level. This province is characterized by its rough, rocky outcroppings of limestone eroded into pinnacle rock in many locations. The surface of the Rocky Glades is covered with outcroppings of oolitic limestone almost devoid of soil. It differs from the Everglades province in its scarcity of peat or other organic soils. Soils within this province consist principally of the Rockland series that comprise extensive areas of Miami Oolite or Tamiami Limestone that have a very thin covering of unconsolidated soil material.

Vegetation is mainly sawgrass, switchgrass, beardgrass, sedges, and rushes, with some slash pine, cypress, bayheads and hammocks interspersed throughout. Hammocks and pinelands are slightly above water most of the year. Bayheads and swamp plants exist in the sloughs and on the lower elevations. There is considerable palmetto on the marl soils of the eastern portions. These once flooded areas are rapidly being cleared for cultivation or construction east of L-31 N. West of the canal system, agriculture on small tracts is proceeding without adequate drainage or flood protection.

Atlantic Coastal Ridge. Often referred to as the Pineland or Rockland Ridge, this province consists of outcroppings of Miami Oolite that form the eastern ridge impounding the Everglades for some fifty miles. North of Miami this province grades into the Sandy Flatlands which in themselves compose part of the ridge but are covered with a mantle of sand. The maximum elevation of 23 feet in the vicinity of Coconut Grove gradually lowers to 8 to 9 feet as the ridge extends southwest through Homestead and on some twenty miles to Mahogany Hammock in Everglades National Park, where it is 1.5 to 2.0 feet above mean sea level. This rock land has an extremely rough, pitted, irregular surface, much of it so eroded that it is called pinnacle rock. It is perforated with numerous solution holes, basins, and caves and is crossed by several sloughs (transverse glades) that before the advent of drainage canals carried the overflow of water from the Everglades eastward into Biscayne Bay.

A thick, porous block of limestone composed of two facies underlies this province; the upper is an oolitic limestone of Pleistocene age which is broken by many solution holes, caves, and fissures. The lower is a

Bryozoan Limestone of the Sangamon period.[12] Together they form the Miami Oolitic Limestone. The upper formation is extensively used for winter agriculture or is being rapidly developed for urban area.

Formerly a contiguous stand of Dade County pine spotted with tropical hardwood hammocks formed the arborescent flora. Shrubby and herbaceous species formed an understory of tropical hardwoods, and nearly 100 shrubby or herbaceous endemics were kept under control by periodic fires. The transverse glades and larger solution holes typically supported swamp plants, grasses, sedges, and swamp hardwoods.

Not only the pineland but, most of the plant communities within Dade County are represented by small patches or keys within this province. Five of the most important communities, namely pinelands, tropical hardwood hammocks, pineland sloughs, scrub buttonwood, and glades are present. Most of the plants of Dade County can be found in the pineland if one includes the microenvironments of the glades, swamps, hammocks, and solution holes. Even red mangrove and the coastal halophytes (salt tolerant plants) intermingled at one time with pine along the coast.

Soils which have developed on this province consist of the Rockdale series, a limestone complex. This group of well-drained rocky soils consists principally of various phases of fine sand and fine sandy loam. They occur on nearly level to gently undulating terrain. There are numerous places where the porous limestone (pinnacle rock) is exposed. Many small cavities or solution holes are filled with a mixture of light gray fine sand and brown claylike limestone residuum.

There is little or no external surface drainage because of the rapid infiltration. The depth to bedrock is in most cases dependent upon the depth of the soils within solution holes and can often exceed 24 inches. The soils also exhibit a low shrink-swell potential and have a presumptive bearing value between 6000 and 9000 pounds per square foot when compacted.[13] The ground-water table fluctuates between one and ten feet below the surface; however, during extended rains low areas may become flooded for several days. Most of this land has been cleared for either farming or urban development. Heavy equipment was used to remove the pine trees and to break up the limestone. The denuding and scarification process has resulted in a soil mixture composed of fine angular gravel-like limestone.

Soils within the transverse glades consist of marls 2 to 72 inches thick underlain by the Miami Oolite. The glades lie at a slightly higher elevation than the marshlands to the west. Hammocks within the glades are from 6 to 18 inches higher than the surrounding glades and support a variety of hardwood species.

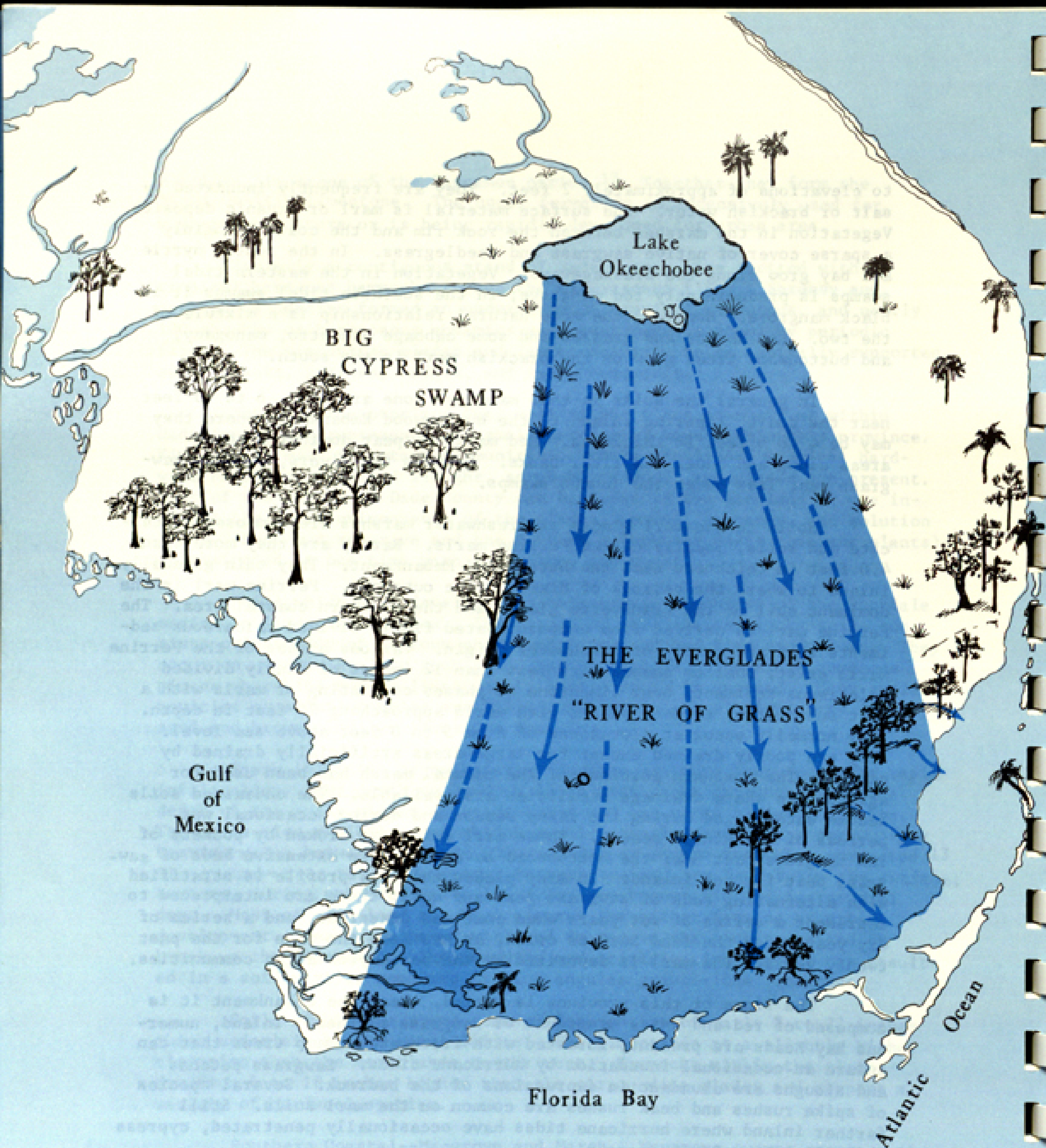
Southern Coastal--Mangrove and Marsh. Mangrove swamps occur on the eastern and southern coasts of Dade County. In the northeast they formed a belt just inland from the barrier beaches and only relics of these mangroves exist today. To the south they broaden into a band 8 to 10 miles wide. These areas range in elevation from slightly below mean sea level to elevations of approximately 2 feet. They are frequently inundated by salt or brackish water. The surface material is marl or organic deposits. Vegetation in the marshes between the rock rim and the coast is mainly a sparse cover of native sawgrass and needlegrass. In the south, myrtle and bay grow along the drainageways. Vegetation in the eastern tidal swamps is predominantly red mangrove; in the southern tidal swamps it is black mangrove. However, the more natural relationship is a mixture of the two. Low shrubs and grasses and some cabbage palmetto, mahogany, and buttonwood trees grow on the brackish marl in the south.

In general the soils in this mangrove zone are deep, 6 to 15 feet near the coast, tapering inland to the Buttonwood Embankment where they may be 4 to 6 feet in thickness. Red mangrove peat dominates those areas along and under the river banks. Between the rivers, muck or sawgrass peat lies under the juncus swamps.

Soils in the marl glades or freshwater marshes are composed of calcite mud soils, locally called Perrine marls. Rarely are they more than 4.0 feet in thickness near the Buttonwood Embankment. They thin gradually inland to where the bedrock of Miami Oolite outcrops. Perrine marl is the dominant soil of the transverse glades and the southern coastal area. The Perrine marl is derived from unconsolidated finely divided calcareous sediments that are mainly of freshwater origin. Various phases of the Perrine marls exist; shallow phases with less than 12 inches of finely divided calcareous sediments over limestone to phases consisting of marls with a peat substratum, to deep phases with marls approaching 20 feet in depth. They normally occur at elevations of from 5 to 8 feet above sea level. They are poorly drained except for large areas artificially drained by canals. The northern portions of the coastal marsh has been used for agriculture where drainage facilities are available. The undrained soils become waterlogged during the rainy season and during occasional wet periods of the winter season. These marl soils are broken by pockets of red mangrove peat near the Buttonwood Levee and more extensive beds of sawgrass peat farther inland. In many places the soil profile is stratified with alternating beds of sawgrass peat and marl; these are interpreted to represent a series of wet years when peat was preserved, and a series of dry years when the land surface dried, as has been the case for the past twenty years. The marl is deposited by the periphyton algae communities.

The flora of this province is varied. Near the embankment it is composed of red and white mangroves or sawgrass marshes. Inland, numerous bay heads are present, forested with freshwater swamp trees that can endure an occasional inundation by hurricane tides. Sawgrass patches and sloughs are abundant in depressions of the bedrock. Several species of spike rushes and beak rushes are common on the marl soils. Still farther inland where hurricane tides have occasionally penetrated, cypress and willow heads are numerous.

Biscayne Bay. Biscayne Bay is a shallow elongated subtropical lagoon about 35 miles long, as much as 10 miles wide and 12 feet deep. It is bound on the west by mangrove swamp of the mainland, on the north



HISTORIC
DRAINAGE PATTERNS IN SOUTH FLORIDA
(Everglades Waterway)

FIGURE 12

EXISTING DRAINAGE PATTERNS IN SOUTH FLORIDA

FIGURE 13

by Dumbfoundling Bay, on the south by Card Sound and on the east by the barrier islands and the Atlantic Ocean. The coastal ridge provides nearly complete separation of Biscayne Bay from the broad, low expanse of the Everglades Basin to the west. The seaward boundary of Biscayne Bay is a ridge of coral limestone. To the south this fossil coral ridge forms an emergent string of islands--the northern Florida Keys. The longest, Elliot Key, isolates southern Biscayne Bay from the more seaward reef dotted shelf bordering the Straits of Florida. To the north the coral limestone ridge is submerged but capped by the sand island barrier beaches of Fisher Island, Virginia Key, Key Biscayne, and Miami Beach. These islands, separated by natural and artificial channel cuts, isolate northern Biscayne Bay from the narrow offshore shelf. Grass covered flats of lime and sand close the gap between the sandy island barriers to the north and the coral limestone keys to the south. The numerous tidal channels cutting across these flats provide the prime source of tidal exchange with offshore waters but protect central Biscayne Bay from ocean storm waves.

Water Resources

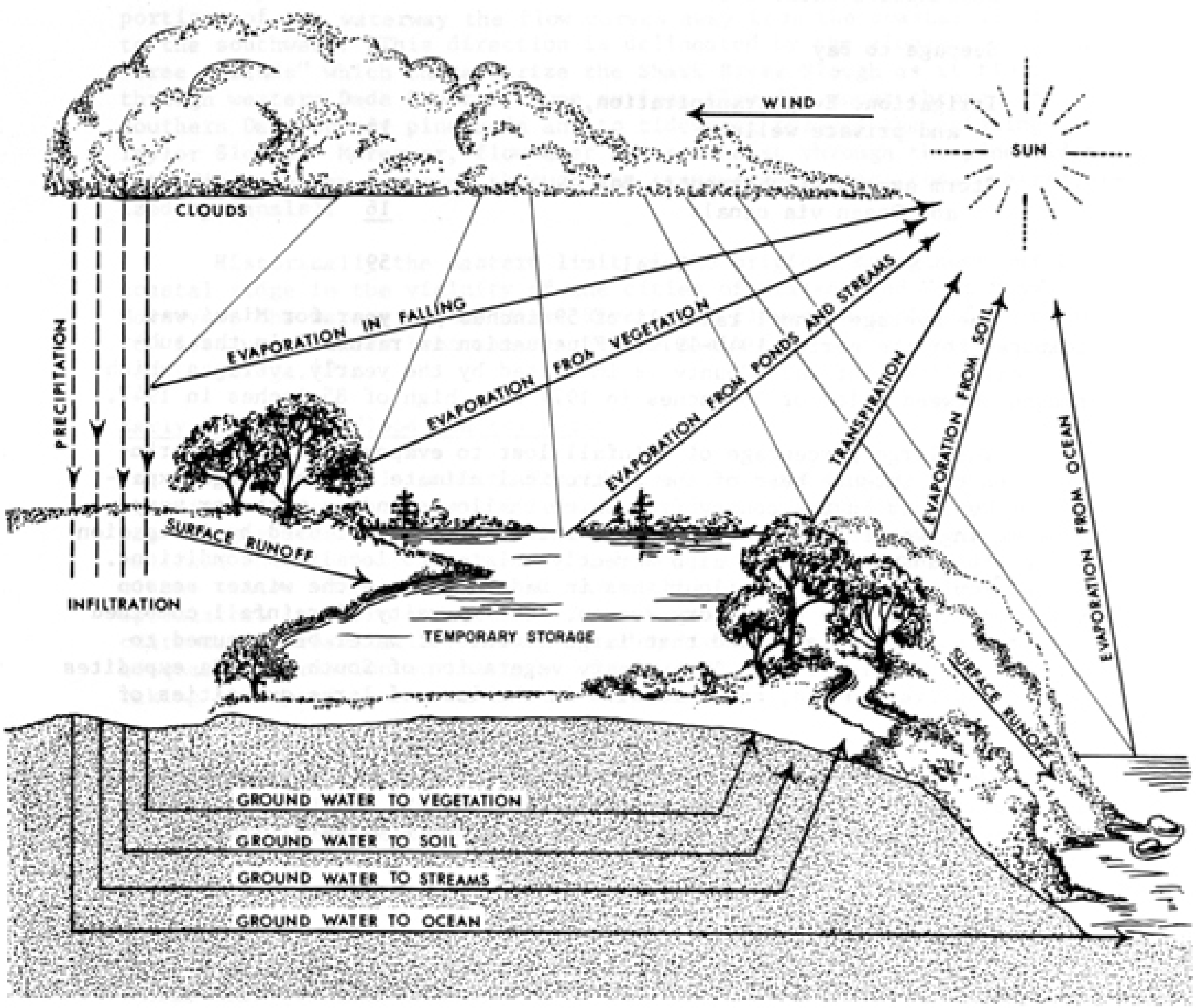
A general overview of the hydrologic character of Dade County is essential to understanding the functional interrelationships between vegetation, soils and water. The information provided in this chapter should provide the basis for understanding the specific nature of hydrologic issues related to small area analysis provided later in this study (see Figures 12 and 13; source: National Geographic Magazine).

Rainfall and the Hydrologic Cycle

An understanding of the complexity and nature of water conservation problems demands our examination of the hydrologic cycle, particularly as it applies to Dade County and South Florida. Simply, the cycle is the process through which water moves from the ocean, to atmosphere, to land, and back to the oceans (see Figure 14).

The source of most of the rain that falls on the land ultimately is the ocean. This occurs as air masses lying over the ocean gain large quantities of moisture through evaporation. When these air masses move inward over the warm land surfaces the air rises, the moisture condenses, clouds develop, and much of the water falls as precipitation.

Rainfall, after reaching the earth, is disposed of in two manners. First, the processes of evaporation and transpiration return a major part to the atmosphere. The water may return to the air as a result of evaporation from vegetation, streams, ponds, soils, and ocean; it may also return to the air as a result of evaporation while falling, or through transpiration from vegetation. The remaining rainfall which does not run off directly to the sea or to streams percolates downward to the ground-water table. Ground-water also is eventually carried through the cycle and thus returned to the sea and the air. This may occur as the ground-water passes to vegetation, to the soil from which it evaporates, to streams, or directly to the ocean. Evaporation and drainage from the land are continuous processes, although they are variable in rate and amount. There is an endless sequence of additive and subtractive factors, which over a long



THE HYDROLOGIC CYCLE

FIGURE 14

period of time, must balance; that is, total inflow of rainfall must equal total outflow of water through evapotranspiration and runoff.

Characteristics of the hydrologic cycle also vary from region to region depending on climate, topography, soil types and vegetation. Rainfall disposition is as follows in Dade County:[14]

Rainfall Disposition	Inches/year
Surface Evaporation	19
Consumptive Water Use	3
Seepage to Bay	5
Irrigation, Evapotranspiration, and private wells	16
Storm excess discharged to Bay and Ocean via canals	16
Total	59

The average annual rainfall of 59 inches per year for Miami was computed for the period 1940-1972. Fluctuation in rainfall in the sub-tropical climate of Dade County is indicated by the yearly averages which ranged between a low of 38 inches in 1971 to a high of 85 inches in 1947.

The large percentage of rainfall lost to evaporation is due primarily to the intense heat of the subtropical climate and the large expanses of wetlands in the county from which shallow standing water or very slow moving waters evaporate. The 16 inches of rainfall used by irrigation and evapotranspiration are also directly related to localized conditions. The agricultural business flourishes in Dade County in the winter season corresponding to the normal dry season. The sparsity of rainfall combined with the porous soils demand that large amounts of water be consumed to support winter crops. The lush, leafy vegetation of South Florida expedites evapotranspiration and, thus, results in the loss of large quantities of ground-water.

Man induced problems such as the construction of drainage canals and the use of vast impervious surfaces for roadways and parking lots has resulted in the diversion of tremendous amounts of water through surface runoff.

Everglades Waterway

Practically all life in the South Florida ecosystem is dependent upon a direct fresh water supply --which is derived directly from rainfall and is retained in what naturalists call the "Everglades Waterway" -- the area of the Kissimmee-Okeechobee-Everglades basin.

In its natural state, flow in the Everglades Waterway began in the lakes of the upper Kissimmee River and slowly meandered southward through the river's floodplain into Lake Okeechobee. In wet years the lake overflowed its southern rim and drained southward through the sawgrass Everglades, adding to the Everglades shallow sheet flow produced by rainfall. However, much rainfall and sheet flow was and still is lost to seepage and evapotranspiration. Historically the only significant surface flow to tidewater from this sytem occurred at the southern tip of Florida, now within Everglades National Park.

The coastal pine ridge running from the northeast to southwest in Dade County forms the eastern boundary of the waterway. In the lower portions of the waterway the flow curves away from the coastal ridge to the southwest. This direction is delineated by the elongation of the "tree islands" which characterize the Shark River Slough as it flows through western Dade County. Some surface flow did occur through the southern Dade County pinelands and to tidewater through the existing Taylor Slough. Moreover, flow east and southeast through the pine ridge into Biscayne Bay occurred through the transverse glades (today characterized by canals).

Historically the eastern limit of the original Everglades was the coastal ridge in the vicinity of the cities of Hialeah and West Miami. Moreover, the waters of the Miami River once flowed as rapids for perhaps 200 feet where water from the Everglades Basin flowed over the Atlantic Coastal Ridge.[15]

Early History of Flood Control Works

Flood control in south Florida can be traced back to the 1880's when the first drainage canals and levees were built around Lake Okeechobee. It was further accelerated in southeast Florida by the construction of the railroad which helped south Florida develop at a rate faster than the rest of the state. Once the railroad was established efforts were made by land speculators to drain and reclaim inland areas for agriculture and to accomodate rapid urbanization. Due to inadequate engineering practices, inadequate information on the hydrologic conditions, and the enormous undertaking attempted, these early efforts failed.

The Everglades Drainage District was created by the 1905 Florida Legislature to expedite the "reclamation" program. The efforts of the Everglades Drainage District for the most part failed. The more than 400 miles of canal excavated during the 18 years after 1913 overdrained the land during dry seasons while they were inadequate to furnish flood protection during wet seasons. The inadequacy of the Everglades Drainage District was further evidenced by the destruction of its levees along the south shore of Lake Okeechobee in the 1928 hurricane which resulted in a loss of more than 2,000 lives. This hurricane prompted a major effort by the Corps of Engineers to provide flood protection from Lake Okeechobee. These works were completed about 1937. Meanwhile the effort of draining wetlands for development continued, often to the benefit of land speculators, and without concern for the water needs of the new Everglades National

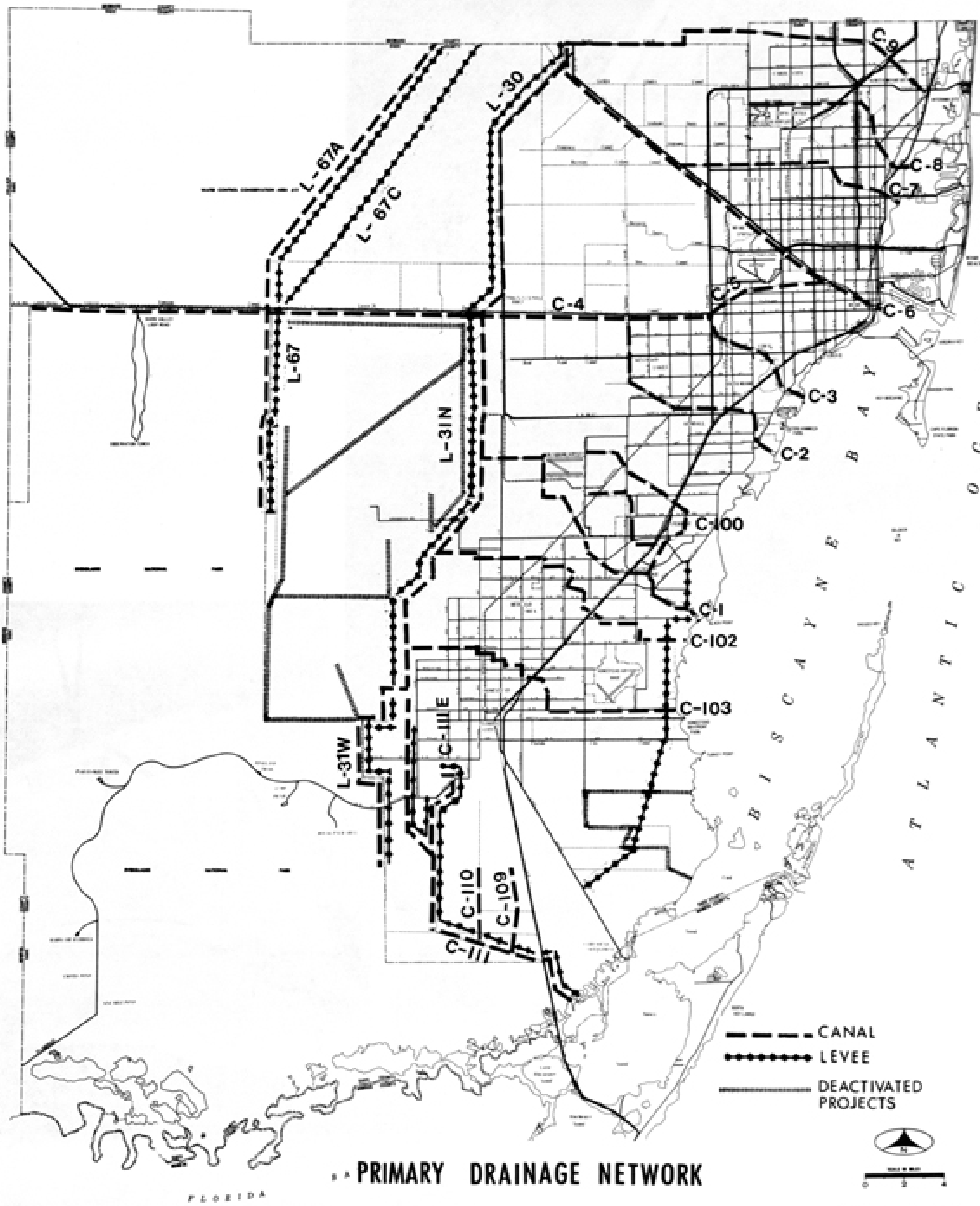
Park which was authorized by U.S. Congress in 1934.

The hydrology of southeastern Florida was affected significantly before 1945, when land drainage and reclamation were the principal objectives. The prime effect was a lowering of water levels along the coastal ridge and in the interior as a result of: (1) completion of coastal drainage canals along the urbanizing coastal ridge to provide dry land for housing developments; (2) completion of the West Palm Beach, the Hillsboro, the North New River and the Miami Canals which intercepted or diverted water from the Everglades to the ocean; (3) construction of the levee on the south shore of Lake Okeechobee, which prevented southward spillage from the lake during hurricane season. Estimates indicate that water levels were lowered considerably, perhaps as much as 5 or 6 feet throughout southeastern Florida as a result of uncontrolled drainage.

Following the extensive flooding of South Florida and the east coast in 1947 and 1948 the Corps of Engineers received authorization to proceed with a yet more extensive system of canals and levees, with the Corp's primary concern being flood control, agricultural irrigation, and the provision of water for growing urban areas. In the planning of the Federal Project the needs of the eastern coastal area and those of Everglades National Park were again overlooked.

In partial response to congressional authorization the Central and Southern Florida Flood Control District was established in 1949. This agency with the cooperation of the Corps of Engineers oversaw, beginning in 1952 the development of a massive system of drainage canals and levees. In 1949 the Corps began construction of three conservation areas south of Lake Okeechobee and north and west of Miami. These areas were to be used for water surplus for agricultural needs south of Lake Okeechobee. Stored water would then be used during periods of rainfall deficiency. In addition to agricultural usage the stored water would provide recharge for the municipal well fields along the east coast and the maintenance of a freshwater head for protection against salt water encroachment into the Biscayne Aquifer (see Figure 15).

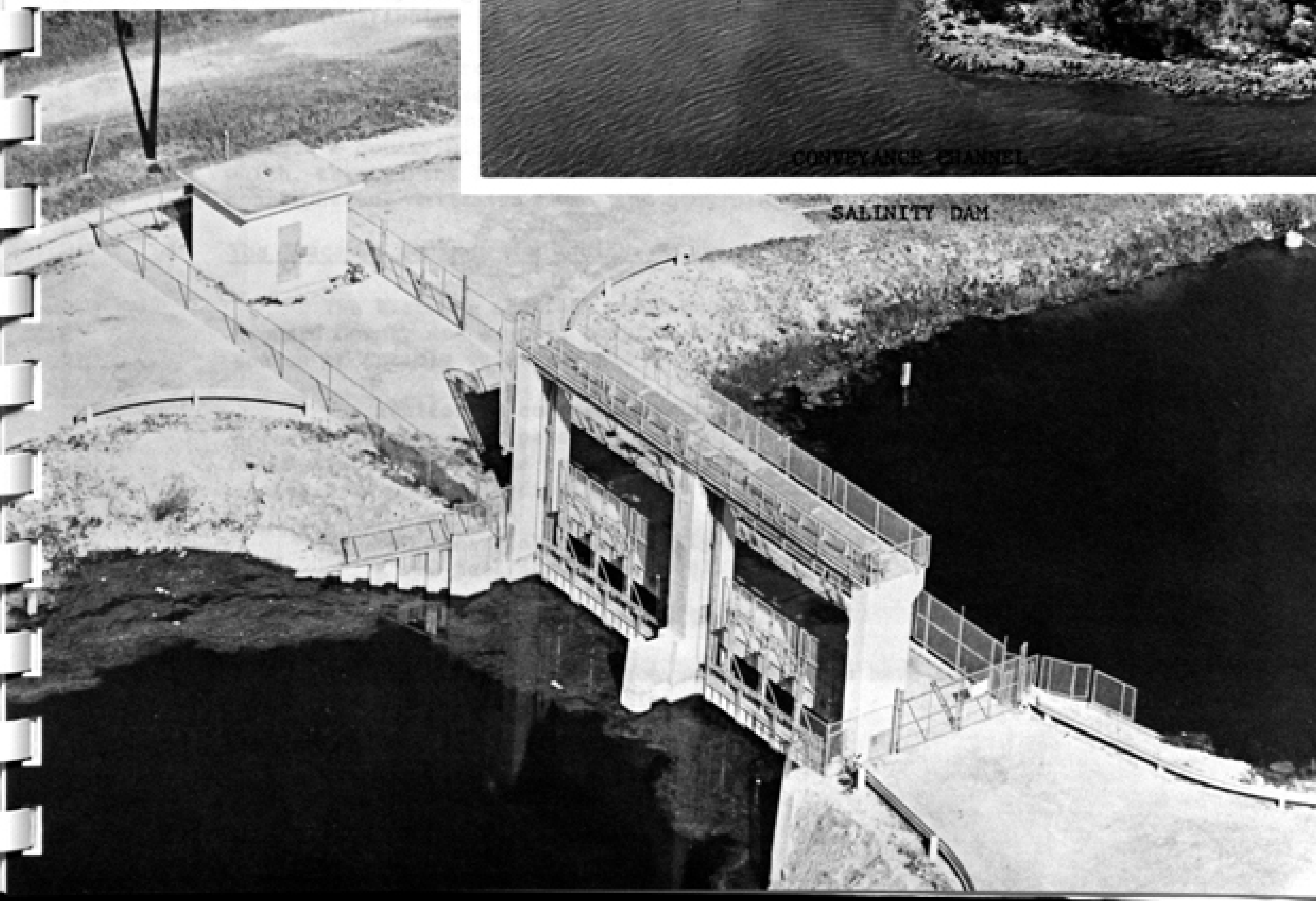
Spillway structures were provided at the south end of Conservation Area 3 so that flood waters could be released to Everglades National Park. With the completion of Levee 29 along the north Park boundary and closure of the Structure 12 gates in 1962, surface flow to the remaining Everglades area still tributary to the Park was regulated. The Conservation area remained below flood stage until 1966 and no Everglades water flowed to the Park between 1962 and November of 1965 with the exception of minor releases which were made to the Park in April 1964. This together with deficient rainfall in the period resulted in extreme stress upon the Everglades National Parks ecology. These droughts and the realization that the water needs of Everglades National Park were not being met caused Congress to authorize a restudy of the Flood Control Project by the Corps of Engineers "with particular reference to recommendations as to the expansions and improvement of the authorized project to provide for the supply, distribution and conservation of water for or on the Everglades National Park, Florida".



PRIMARY DRAINAGE NETWORK

FIGURE 15

CONVEYANCE CHANNEL



SALINITY DAM

Upon completion of the study in 1968 the Corps of Engineers recommended that the provision of water to the park be made a "project purpose" and a minimum of 315,000 acre-feet be annually delivered. Tentative agreement was reached between the National Park Service, the State of Florida and the Corps of Engineers; and in 1970 by enactment of Public Law 91-282. The park is to receive from the Flood Control Project "not less than 315,000 acre-feet annually". In addition, Public Law 91-282, authorizes the Corps to implement a plan which would alleviate most future water problems of south Dade County and the southeastern part of the Park. Under this plan water will be conveyed to these areas via L-31 N canal from Conservation Area 3. Deliveries to the park will be made in accordance with historical seasonality.

The period from 1946 to 1962 has been one of water control as well as flood control. The water control practices were an attempt to prevent further damage to water resources caused by the earlier uncontrolled drainage, during which flood control was of higher priority because urban areas were expanding inland and drainage systems required improvements.[16]

The recent policies of the F.C.D. indicate a change towards a water conservation agency and away from a strict flood control and land reclamation agency. The drastic effects of completed projects demand that close scrutiny be given to all future projects with the maintenance of viable functioning ecosystems being the item of highest priority.

Related to the F.C.D. is the Water Conservation District in Dade County which consists of secondary canals which feed into the primary canals of the F.C.D. which in turn empty into Biscayne Bay. The secondary canals constitute a county-wide drainage district under the jurisdiction of the County, which, through its Public Works Department, controls their design and construction, maintains them, and controls discharges into them.

The Biscayne Aquifer and Aquifer Recharge

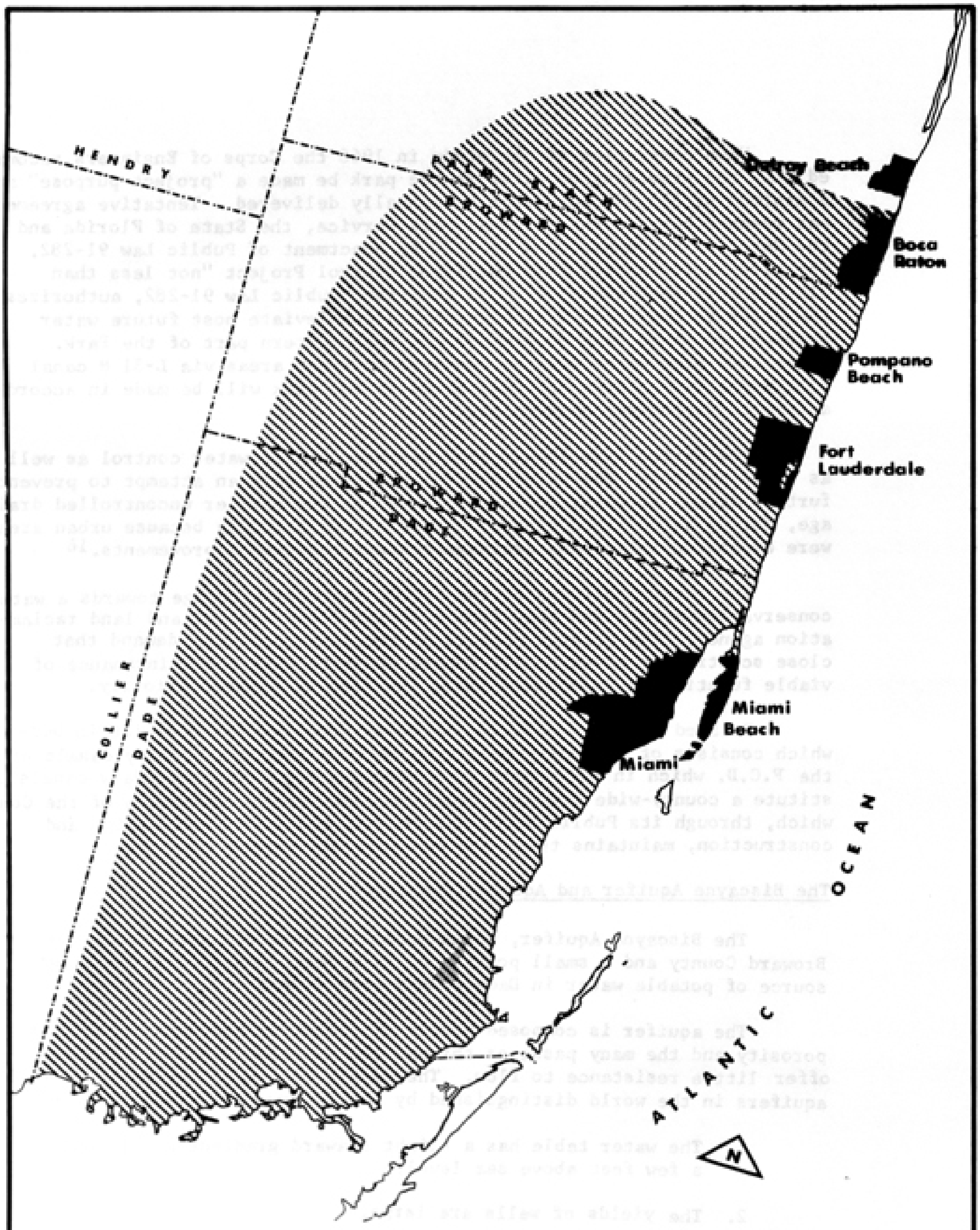
The Biscayne Aquifer, which underlies most of Dade County, much of Broward County and a small portion of Palm Beach County, is the major source of potable water in Dade County (see Figure 16).

The aquifer is composed mostly of limestone and sand. The high porosity and the many passages through the solution riddled limestone offer little resistance to flow. The result is one of the most permeable aquifers in the world distinguished by the following characteristics:

1. The water table has a slight seaward gradient and is only a few feet above sea level.

2. The yields of wells are large.

3. The ground and surface water regimens have an uncommonly high interrelationship.



AREAL EXTENT OF BISCAYNE AQUIFER

FIGURE 16

4. The water table reacts quickly to rainfall. There is a high rate of rainfall penetration and surface water infiltration and, although large, there is relatively little surface runoff compared to other locations.

5. The coastal areas are susceptible to saltwater intrusion.

Figure 7 shows a generalized cross-section of the Biscayne Aquifer, typical for the area along the Tamiami Trail. The depth of the wedge-shaped aquifer varies from zero feet on the western border of the county to approximately 120 feet along Biscayne Bay.

Water in the Biscayne Aquifer is not level everywhere for movement is continually taking place. The lateral movement within the aquifer results from water seeking its own level by flowing from higher to lower elevations. Within Dade County the local water movement trend in the aquifer is a few feet a day in a northwest to southeast direction.

A quantitative account of ground-water in Dade County is made difficult by the great variation in hydrologic factors. The areas contributing to runoff of streams and canals cannot be determined with any degree of exactness. It is also difficult to accurately outline areas of natural ground-water discharge because those areas are constantly changing in size according to the distribution, intensity, and duration of rainfall, the stage of the water table, the stage in the canals, and tidal and periodic changes in sea level.

Evapotranspiration is another factor which complicates the issue of water quantity in the aquifer. Since the water table is on or near surface in much of southeast Florida it is within easy reach of the root systems of plants. The quantity of water lost through evapotranspiration, thus, varies widely with location, depth to water table, vegetation type, and weather conditions.

The Biscayne Aquifer is recharged over its entire surface by rainfall. Flow from Lake Okeechobee and the Conservation Areas south to Dade County via Flood Control District canals aids in the maintenance of a high water table in the vicinity of the wellfields and at the coast.

During the dry season some recharging of the aquifer from drainage canals occurs as the water seeps from these exposed areas of the aquifer, i.e., the canals, outward to the relatively lower water table. This canal to aquifer water exchange is opposite to that of the wet season when ground-water flows laterally into the canal and is carried off to tide during times of peak canal water levels.

The recharge characteristics vary from area to area in Dade County. Miami Oolite underlies the surface of the Atlantic Coastal Ridge from Broward County to Homestead. The oolite has a high vertical permeability; thus rain falling on the oolite surface rapidly percolates downward to the water table. A rapid rise in the water table occurs within a few hours after the rain begins if the rainfall is of sufficient intensity and duration to saturate the soil and rock above the water table.

Rain falling in the Everglades recharges the aquifer until the water table reaches the surface or ground elevations. Additional rainfall floods the glades, and, as the flood stage increases, the flow into the canals and overland to the south, and through the canals to the east also increases.

The key factor in Dade County with respect to ground-water resources is the perennial yield of the aquifer. The aquifer is known to be permeable enough to yield copious amounts of water without withdrawals becoming excessive. It must be remembered that the yield of the Biscayne Aquifer is presently dependent upon the well locations and the ability to convey water to the well field locations during times of drought. Otherwise the excessive lowering of the water table can result in salt water encroachment into the wellfields.

Surface Waters and Surface Runoff

The surface waters in Dade County are most easily classified by the terms saline and fresh waters. The inland surface waters are basically composed of the canals; many of which are channelizations of former natural streams or drainage areas,and inland lakes or former borrow pits. The transverse glades which historically crossed the Rockland Ridge to Biscayne Bay are presently the location of many of these canals.

The major inland waterways in Dade County are canals which connect the Everglades and Conservation Areas 3A and 3B in the western part of the county with the urban and agricultural areas located on the coastal highlands adjacent to Biscayne Bay. Flow in these canals is controlled by structures operated by the Central and Southern Florida Flood Control District. These canals are operated to prevent floods by draining developed areas during the rainy season, and to recharge ground-water supplies near wellfields and prevent salt water intrusion during dry seasons. The canals are all equipped with salinity dams which allow freshwater to flow to tide but prevent saltwater from moving inland via the canals.

The most significant waterways with respect to hydrology in Dade County are Snake Creek, Miami River, Snapper Creek, Tamiami, Black Creek, Princeton and Mowry Canals, C-111 and the Taylor Slough.

The combined flow from these waterways during the period 1960 to 1968 was 75 percent of the total tideward runoff from all Dade County.[17] Of the previously mentioned waterways only the Taylor Slough acts as a functioning natural drainage basin, and even this characteristic has been partially negated by the construction of L-31 N.

The recreational use of most of these waterways is somewhat limited, particularly in the urban areas, due to poor water quality. High coliform counts resulting from the discharge of untreated wastewater and from surface runoff have rendered most of these waterways unfit for any human contact. However, some of these waterways are used for fishing and boat access to the Bay. The problems and the causal factors associated with these problems have been discussed in other sections on water quality.

Other inland freshwater bodies include rock quarries and lakes in residential areas formed from borrow pits as the limestone rock was quarried for fill. These water bodies offer excellent potential for recreational use if proper water quality can be maintained. The deeper rock pits represent additions to the storage area of our aquifer, therefore, they function as water reservoirs by reducing the rate of water table recession during periods of peak well pumpage in their vicinity.

Included in the saline waters to be discussed are Coastal Zone Waters, i.e., the waters of Biscayne and Florida Bays and the Atlantic Ocean. Biscayne Bay waters are generally the most sensitive and perhaps the most threatened of the saline waters which support substantial recreation, tourist, and fishing industries. Although the estuaries and the bays are interdependent and do function similarly, they will be discussed separately.

The estuaries are the areas where the salt water from the bay or ocean mix with the fresh water which has drained from the land. These areas are highly productive biological areas; moreover, the mangroves and associated vegetation of the estuaries bear the brunt of storms and thus protect the coast from excessive erosion. The brackish waters of the estuaries are laden with decaying leaf matter or detritus which flows with the tide into the coastal waters offshore where other marine species feed on the protein rich detritus and decomposers which flow out of the estuaries. Thus the mangrove estuary zone of the coast is vital to the continuing existence of the fisheries. It provides spawning grounds for some marine species; however, its greatest value is the tremendous quantities of detrital materials which it provides to the low end of the food chain. Such estuarine environments are by and large rigorous environments due to the constant variations and extremes. Relatively few species can successfully adapt to it and those that do tend to produce large populations characterized by equally large seasonal variations in numbers.

The intricate relationship in the functions of the estuaries and the bays suggests that the bays be considered an extension of the estuaries. As the marine life within the estuary matures it moves into the shallow water of bays where growth continues. The bays also provide a feeding ground for fish from the deeper waters.

Biscayne Bay is a shallow lagoon 35 miles long, up to 10 miles wide, and 12 feet deep. Mangroves and urban development border the bay on the west and barrier islands form the eastern border. Along the western shore of the south Bay, peat, mud, and organic debris are several feet thick. The bay bottom in the northern part from the Broward County line south to the northern tip of the Elliot Key has a cover of sediment rich in organic matter. This mud-like material has covered much of the Bay between the shoreline and the barrier islands and has been carried to the bay from the inland waterways. Origination of the mud is believed to be the pollution laden urban runoff and the improperly treated domestic waste which had long been discharged into inland waters, if not directly into the Bay. Much of the bay bottom north of Black Creek Canal was originally hard sand covered intermittently with grasses. Poor quality water in north Biscayne Bay and destruction of a habitable bay bottom has resulted also from extensive dredge and fill, from bulkheading, and from the impediment of the natural flushing process due to the damming effect of a half dozen inadequately trestled causeways crossing the bay.

The southern portion of the bay is still relatively intact south of Black Creek Canal. The eastern portion of the Bay south of Key Biscayne is still covered with grass beds. Hard sands, grass beds, sponge and coral beds, algae covered rock bottom, and good water quality still characterize south Biscayne Bay. However, the deposition of muck at the mouth of Black Creek Canal, apparently as a result of sediments carried from inland, is presently taking place. The preservation of south Biscayne Bay and of Biscayne National Monument will necessarily depend on the regulation of effluents and perhaps surface runoff entering the canals discharging water into south Biscayne Bay. Already, sedimentation of the bay bottom is smothering the coral, sponges, and turtle grass communities in portions of the National Monument.

Florida Bay is the largest bay in South Florida. The tidal marshes around the Keys and the mainland estuaries make this bay one of the richest in marine life. One of the primary threats to Florida Bay at this time is the dredging and filling occurring in the Keys of Monroe County.

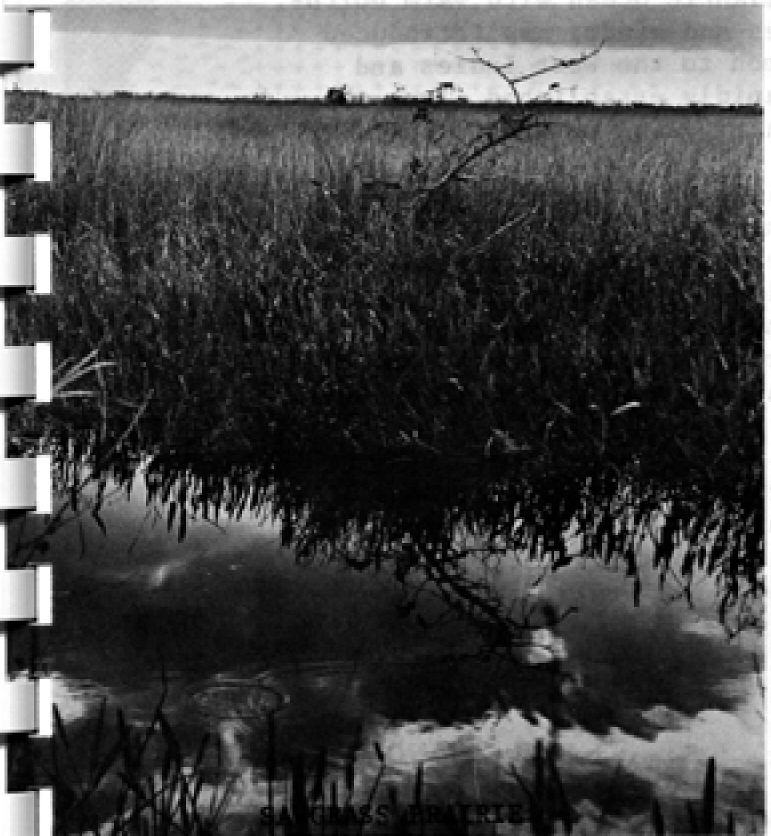
As it has been alluded to previously, surface runoff under natural conditions performs many useful functions although runoff in urban areas is becoming a major problem associated with both water quality and water quantity.

Runoff, a term applied in general to the surface outflow from an area, has complex characteristics in the natural state of the Everglades. There is an almost constant flow of water into and out of storage in the rock (from the canals) and to a more limited extent in the muck. Moreover, the flow through the canals is subject to considerable regulation to provide for irrigation and drainage. The control structures at some points are only partially effective due to leakage through highly permeable rocks making measurement of runoff indeterminable.

Vegetation and Wildlife

South Florida exhibits unique associations of flora and fauna, characteristic of the only subtropical area in the United States. Seasonal precipitation and drought, a low variation in mean monthly temperature, high humidity, flat terrain, infertile soils, and the rare occurence of killing frosts have encouraged the establishment of "tropical savannah" flora. The area is characterized by broad expanses of heavy grasses and sedges, with scattered forests of deciduous and evergreen arborescent (tree-like) vegetation.

HARDWOOD HAMMOCK



SAWGRASS PRAIRIE

PINE-PALMETTO

MANGROVE

The high, well-drained limestone ridge paralleling South Florida's east coast, has allowed the invasion of hardwood and coniferous trees from both the temporate and tropical zones. The Atlantic Ocean with warm northbound Gulf Stream currents, and hurricane tides and winds, has introduced into the region numerous tropical species common to the West Indies and the Yucatan Peninsula. These invaders have rapidly established along the coastal ridge and into sections of the freshwater grass communities.

Vegetation in Dade County can be classified into eight major vegetation types or associations. These are: mangrove, salt grasses, pine, freshwater grasses, hammocks, tree islands, cypress, and exotics. Each vegetation type or association will be summarized in terms of its distribution, site requirements, function, succession, and major natural and man-caused factors affecting it. The need for this information becomes apparent in subsequent chapters on natural systems, zone descriptions, and environmental criteria.

Figures 17 and 18 illustrate the historic and present locations of the major vegetation provinces within Dade County. It should be added that salt grasses are found within the Southern Coastal Marsh Prairie and the freshwater grasses are within the Marsh Prairies, Wet Prairies, and the Sawgrass Swamps.

Mangroves

Three types of mangroves, red, black, and white, inhabit the low, tidal coasts along eastern and southern Dade County. In northern Biscayne Bay there was a band of mangroves which probably extended several hundred yards in width historically along the low contours of the Dade County coast; to the south they broadened to 8-10 miles wide on the north shore of Florida Bay (see Historic Vegetation Map, Figure 17). Figure 18, a map of the presently existing vegetation provinces, shows that the northern half of Biscayne Bay has only scattered remnants in the vicinities of East Greynolds Park, the Interama site, Coral Gables Waterway, Snapper Creek Canal, and Matheson Hammock. South of Black Point, the band of mangroves continues, interrupted only by the Turkey Point power plant, and a few smaller developments.

While generally considered a salt tolerant, coastal tree, mangrove can be found far inland along the banks of tidal creeks extending into the freshwater zone. Hurricane floods have been known to carry mangroves 20 miles or more inland depositing them in the deep, organic filled solution holes of the freshwater grasslands.

Red mangrove, a primary invader of barren flats, functions as a coastal land builder. Large quantities of leaf matter decay and form a tough deposit of peat. Red mangroves then migrate seaward, repeating the landbuilding process. Black mangroves often establish on the newly created red mangrove deposits and add to the buildup of organic material, until they in turn are succeeded by the white mangroves on slightly higher and dryer land (see Figure 19).

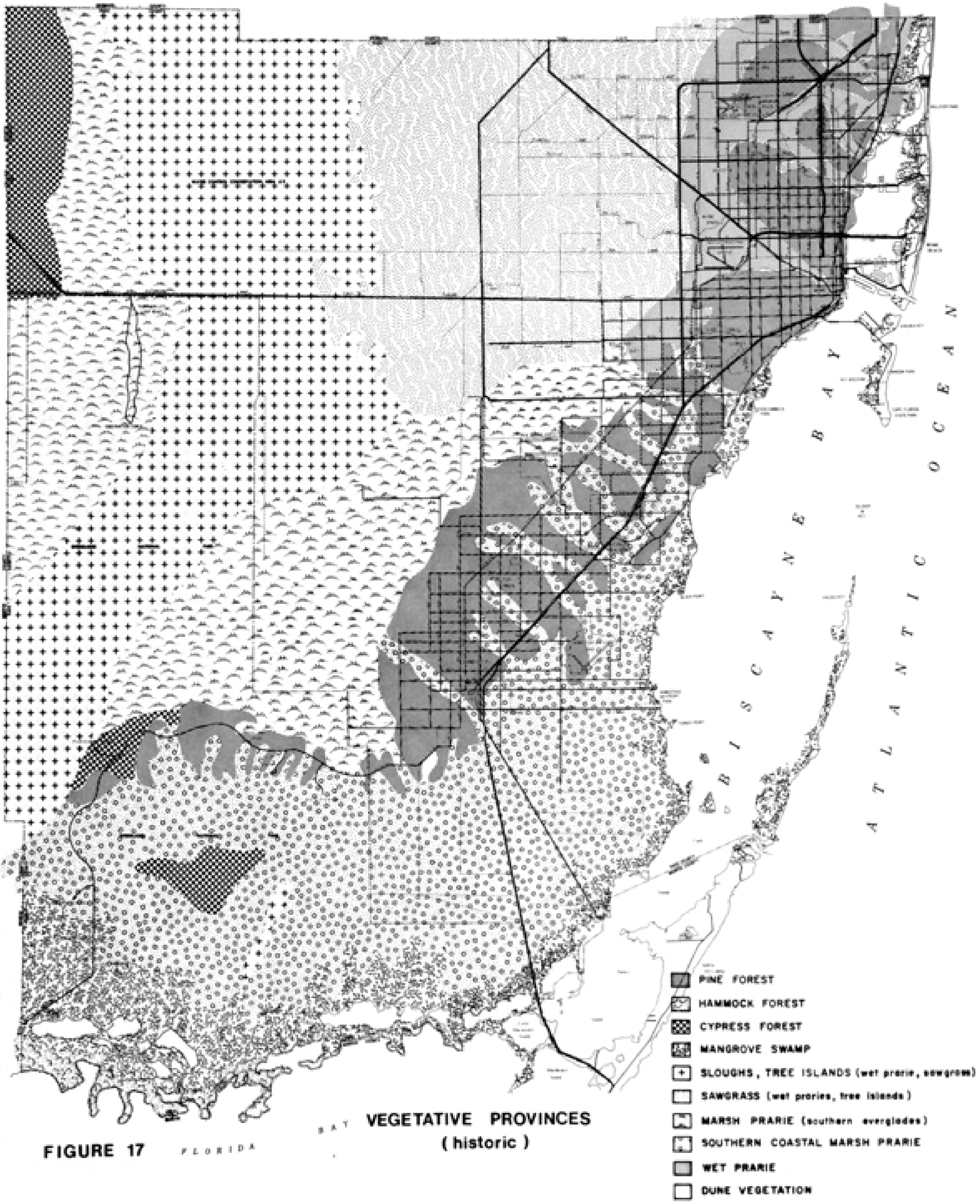
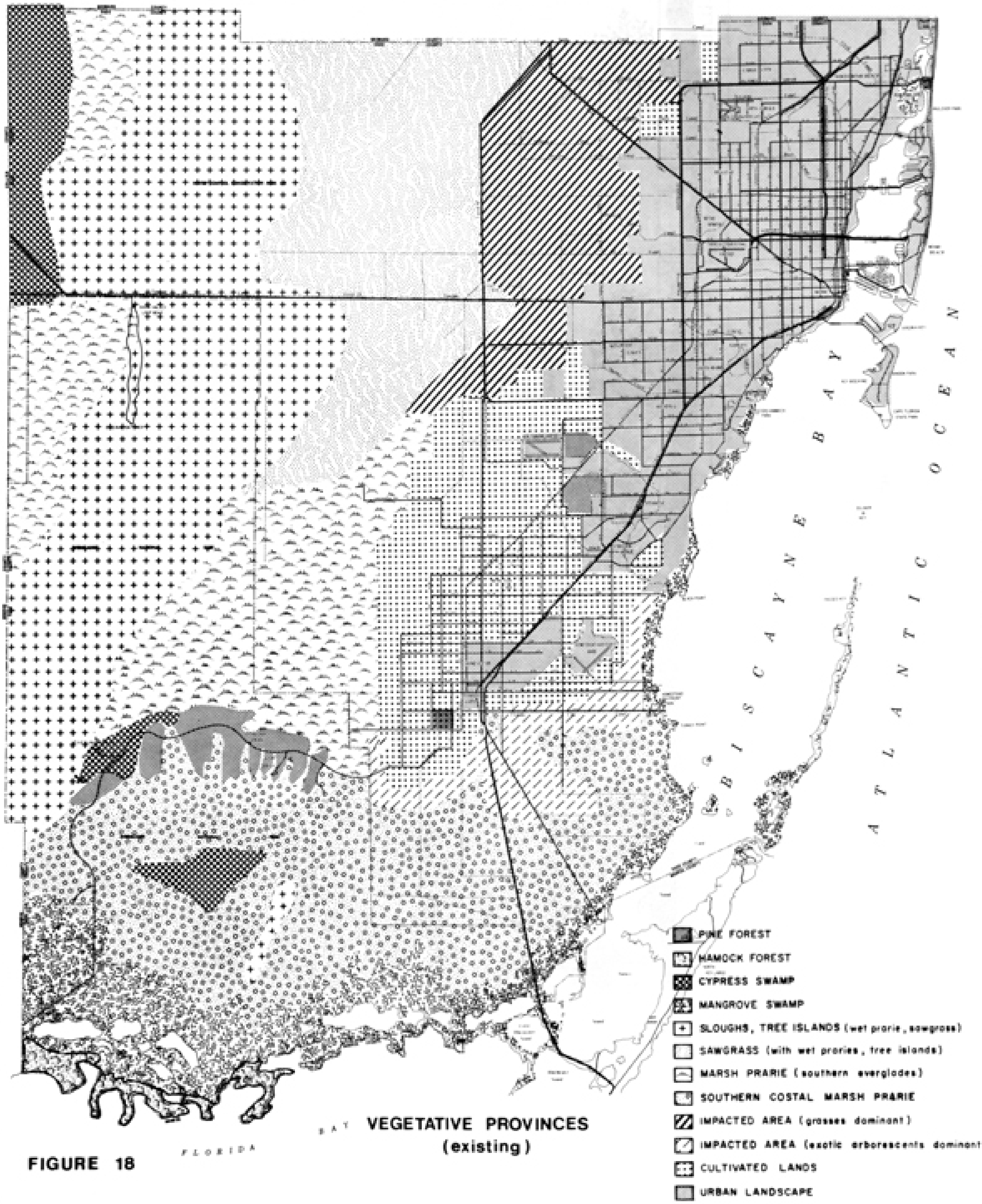
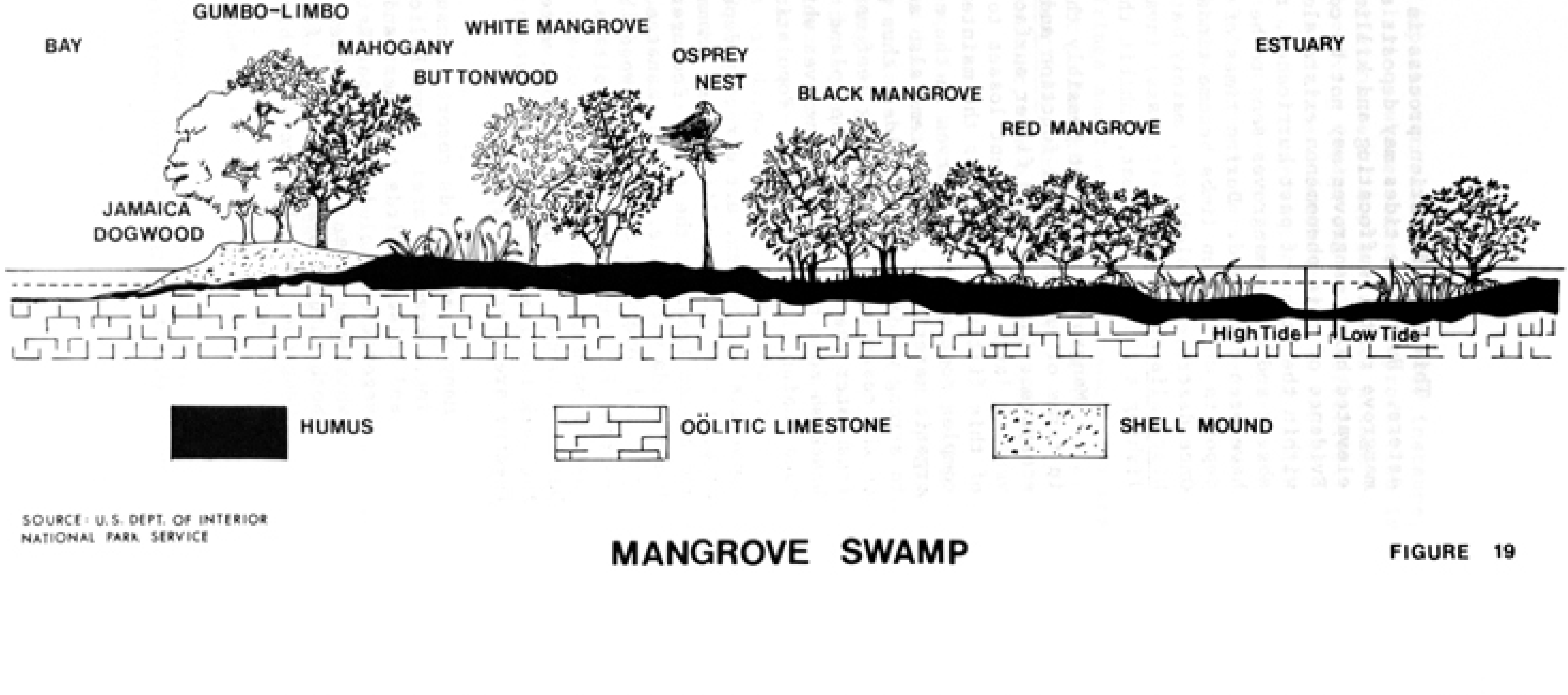


FIGURE 17 VEGETATIVE PROVINCES (historic)



VEGETATIVE PROVINCES (existing)

FIGURE 18



SOURCE: U.S. DEPT. OF INTERIOR
NATIONAL PARK SERVICE

MANGROVE SWAMP

FIGURE 19

This land formation process is often interrupted by natural disasters. Hurricane tides may deposit silt-like marl muds over the red mangrove roots, suffocating and killing the trees. The slightly elevated black mangroves may not be covered, and generally survive. Evidence of this phenomenon exists along the southern coasts where, within the paths of past hurricanes, red mangroves are generally absent and white mangroves seem to be the new colonizers where reds have been destroyed. During times of extended drought, organic deposits and fallen limbs become tinder dry and susceptible to fire. Once destroyed, halophytes, mainly batis and salicornia as well as <u>Distichlis spicata</u> (a salt grass) invade the site, and by establishing a thick grassy mat, inhibit the regeneration of mangroves.

Mangroves represent possibly the most dynamic biotic community in terms of environmental function and productivity. "Mangrove ecosystems intercept and filter surface water run-off, thereby preventing large scale nutrient losses to the open sea; a by-product of this filtering action is the maintenance of water quality. Their complex root structure serves in the accumulation of organic and inorganic materials. The systems also act as mechanical energy buffers to strong winds and storm tides, thus preventing periodic devastations of the coastline."[18] Decaying leaf matter or detritus suspended in freshwater sheet flow from the upland marshes form a highly productive brackish zone beneath the mangroves which act as a basis of aquatic food chains along the coast. Populations of crabs, tarpon, snook, grouper, and other species, which are actively sought by sport and commercial fishermen, are directly dependent upon the mangrove swamps at some time in their life cycle. Mammals such as raccoon, squirrel, and bobcat frequent the area. Endangered wildlife species such as the Florida crocodile, Florida manatee, southern bald eagle, roseate spoonbill, American osprey, and wood ibis depend on the area for seasonal feeding and breeding habitats. The dependency that these species have upon the mangrove forests is exemplified by wood ibis. During November and December, when water levels are too high within the Park for feeding, the southeastern coast is the primary alternate feeding area for this species.

> Many aquatic birds resort to mangroves for roosting or nesting. Examples are: Brown Pelicans; Cormorants; most herons and ibises. Birds that nest and live mainly within mangrove vegetation include: Clapper Rail; Mangrove Cuckoo; Black-whiskered Vireo; Yellow Warbler; and Prairie Warbler. If both natural beaches and mud flats, interspersed among the mangrove, are also included, birds such as the Laughing Gull; Least Tern; Killdeer; Wilson's Plover; Black-necked Stilt, and Common Nighthawk can be added to the list.[19]

Inland drainage and development requiring dredge and fill pose a severe threat to the mangrove ecosystem. Drainage of upland areas by canals eliminates seasonal sheet flow of freshwater into the estuaries, resulting in higher salinity gradients with little or no seasonal variation. Serious impacts can result within, for instance, the endangered crocodile population, whose successful reproduction is dependent upon the seasonal maintenance of low salinities within tidal creeks. Development, involving dredge and fill, effectively destroys or isolates mangrove from inland freshwater flow and or tidal flushing. The interior of the mangrove communities in south Dade County will not function as efficient particulate exporters unless large widespread flows of freshwater are available seasonally to sweep accumulated material seaward.

Salt Marsh Plants

Between the mangrove fringe and the freshwater communities are communities of halophytes, salt to brackish water plants, typified by Batis maritima, Juncus roemerianus, and Spartina spp. Also to be found in this area are grasswort, sea blite, sea purslane and sea-side daisy.

The location of these species is generally a response to soil conditions. Batis is found on low marl soils, 7-10 feet deep, which are periodically inundated by saline water. Juncus occurs in swamps between the main rivers crossing the saline zone, and on old sawgrass peat beds mixed with freshwater muds, 6-12 feet deep, which have been inundated by the rising sea. Spartina grows on slightly elevated areas often landward of Juncus in a brackish water environment.

The successional trend of mangrove to batis has previously been mentioned. In the case of juncus and spartina, the major stimulus for their expansion is the rising sea level. South Florida's flat coastal topography allows minimal increases in sea levels to expand broadly those areas subject to tidal inundation. Within a few decades, rising sea levels can change a fresh-water marsh to a juncus marsh.

Function of the salt-marsh plants is similar to that of mangrove. Intercepting freshwater sheet flow, absorbing nutrients functioning as habitat for life forms on the lower end of the marine food chain, and adding detrital matter to the waters.

Pine

South Florida slash pine (Pinus elliotti var. densa) is locally known as "Dade County Pine". Pines once extended along the coastal ridge from North Miami, south to Mahogany Hammock, a total distance of approximately 55 miles. It is commonly found in association with Saw Palmetto and over 100 species of endemic, fire adapted plants.

The Rockland coastal ridge, because of its freedom from inundation, and its well drained sandy and rocky soils, is the most suitable habitat for the pine-palmetto association in Dade County. West of the ridge, the higher outcrops of oolitic limestone within the rocky glades, are dotted with patches of pine intermingled with hardwood hammocks (see Figure 20).

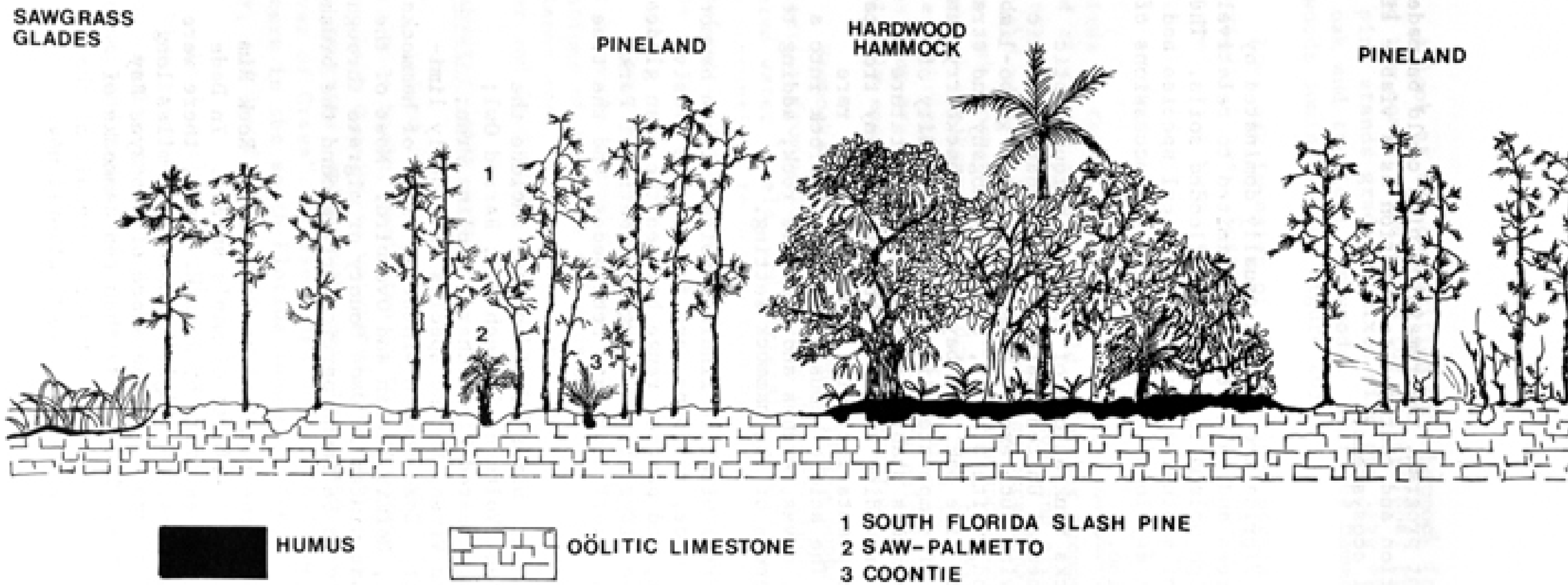
Succession on the ridge is from pine forests to hardwood hammock. Periodic fires act to reduce competition from invading hardwoods less tolerant of fire than pine. Fires also benefit the pines by reducing dangerous accumulations of litter or dry fuels, by restoring nutrients captured by plants to the soil, and by exposing mineral soils for pine seed germination. Hammocks are found along the ridge adjacent to or within the transverse glades (former drainage channels) where protection from fires was naturally provided by high water levels and humid conditions.

Pineland, dotted with hammock, provides the habitat diversity needed by many species of wildlife. Pure pine and mixed stands of pine and hardwoods support populations of resident and migratory birds and mammals with large numbers of seed and berry-bearing plants, such as pacoma, quail berry, and poisonwood.20

Many local breeding birds are largely limited to pinelands. Some of these (marked below with asterisk) have disappeared or become very rare as nesting species in Dade County with the destruction of the pine. Some characteristic nesting birds of pinelands are: Swallow-tailed Kite*; Red-tailed Hawk*; Sparrow-Hawk*; Bobwhite; Great Horned Owl*; Common Nighthawk; Pileated Woodpecker; Downy Woodpecker; Hairy Woodpecker*; Red-cockaded Woodpecker*; Eastern Kingbird*; Scrub Jay*; Blue Jay; Brown-headed Nuthatch*; Eastern Bluebird*; Loggerhead Shrike; Pine Warbler*; Common Grackle; and Summer Tanager*. Some typical winter birds are: Yellow-bellied Sapsucker; Eastern Phoeve; Blue-gray Gnatcatcher; Black-and-white Parula, Yellow-throated, Palm Prairie, and Myrtle Warblers; Grasshopper Sparrow; and American Goldfinch.* 21

Dade County's pinelands lie within the flight pattern of many migratory bird species making their way from Canada and the northern United States to Cuba, the West Indies and the Yucatan peninsula. So intense is this use that the Redlands area has been declared a bird sanctuary. The protective cover offered by the underbrush encourages utilization by opposum, rabbits, raccoons, and even bobcats, during times of stress.

Virgin stands of Dade County pine were slow growing forests over 60 feet tall, with trunk diameters reaching up to 24 inches. Early agricultural practices and intense lumbering during the first half of this century reduced these forests to the second-growth forests seen today. Development and exclusion of fire are the primary factors contributing to the further decline of the species; some loss from insect damage, a secondary factor, is occurring in the south Dade area. With proper design criteria, regulations, and possibly



PINE AND HAMMOCK RIDGE

SOURCE: U.S. DEPT. OF INTERIOR, NATIONAL PARK SERVICE

FIGURE 20

a suburban fire management program, the remaining pine could be made compatible with urbanization and continue to function as a viable link in the local and regional ecosystems.

Hammocks

Hammocks of south Florida are forests usually dominated by broad-leaved evergreen trees and palms that are limited to relatively small areas growing on high upland to seasonally flooded soils. They contain a great variety of south-temperate to tropical species and represent a climax forest developed after a series of successions of other species of vegetation.

Dade County hammocks rank as one of the most unique biotic communities in the continental United States. Trees characteristic of the West Indies, carrying such exotic nomenclature as, gumbo-limbo, lysiloma, Jamaican dogwood, white stopper, Madeira mahogany and strangler fig, intermingle with live oak, red bay mulberry, hackberry, and many hardwood species typical of temperate climates. The humidity of the interiors of these hammocks stabilizes seasonal temperature variations within, thus providing suitable habitat for many tropical terrestrial and epiphytic plants including many species of rare bromeliads and orchids. The acidic humus erodes the bedrock into a myriad of solution holes, caves, arches and pinnacle rock, adding tc the complexity and uniqueness of the hammock setting.

Species of terrestrial wildlife finding habitat within hammocks include opossum, rabbits, mice, raccoons, and foxes. The elusive white tailed deer, bobcat, and panther range between the open glades and the forested limestone ridge within Everglades National Park. Multitudes of insect life, small reptiles, centipedes, and the tree snail Liguus spp. abound.

> Many nesting, resident birds are found and include the Turkey Vulture; Black Vulture; Screech Owl; Barred Owl; Chuck-will's Widow; Crested Flycatcher; Carolina Wren; and Black-whiskered Vireo, but no species is closely limited to this habitat. Some common wintering birds of hammocks are Whip-porr-will, Hermit Thrush and Ovenbird. Most of the small landbirds that winter in Dade County or migrate through the area are likely to be found particularly around the brushy edges of hammocks.22

"Like the pine woods, the tropical hammock of the Rock Rim (coastal ridge) show the tragic effects of man's spread. In Dade County alone, according to an estimate by John K. Small, there were once over 500 separate hammocks. A single hammock five miles long and half-a-mile wide used to run along the shore of Biscayne Bay where Miami now stands...." 23 Today less than ten hammocks of greater than thirty acres exist along the ridge, a result of the intense competition for land for urban and agricultural use.

A look at the composition of a hammock from its exterior toward the center, indicates the successional trend of the area. Pure pine stands grade to mixed pine and live oak, changing to mixed live oak and tropical hardwoods. Near the hammock center tropical hardwoods dominate (see Figure 20).

Live oak invasion of the pineland occurs in areas unscathed by periodic fires. Locating adjacent to potholes and sinks, where collected water humidifies the surroundings, the oaks find a slight degree of fire protection. A layer of fire resistant leaves is deposited. When decayed, these preserve soil moisture, increase the acidity of soil water, and promote softening of the bedrock. Carried by birds or the wind, seeds of tropical hardwoods rest upon the altered site and gain a foothold. Further accumulations of humus, and erosion of the limestone into caves and arches continues until only the massive Ficus aurea, with an occasional myrsine, pigeon plum, and dense mats of lichens, mosses and ferns remain in the center of the hammock. The dominance of the Ficus aurea, commonly called "strangler fig" may be attributed to its peculiar habit of depositing seeds upon the bark of its neighbors. Roots and branches completely encircle the host tree, eventually choking it to death.

Hammocks have long served wildlife populations with forage and protection from wildfires during drought-ridden years. Today, with lowered water levels, and decreasing humidity, hammocks are rendered more susceptible to destruction by fire. These areas still serve as refuge for wildlife isolated from the natural and undisturbed lands to the west.

Conversations with long-time residents of South Dade indicate that hammocks played a vital role for wildlife during the 1971 drought. Sightings of the rare and endangered Florida panther occurred in the Redlands area, and probably resulted from increased competition for water and food within the Everglades. 24

Freshwater Grasslands

Inland from the tidal areas and west of the ridge lies the Everglades basin, dominated by the freshwater flow from the Kissimmee River/Lake Okeechobee watershed, southward, to the coastal estuaries. Here sawgrass, spike rush, beak rush, and maidencane comprise the "River of Grass". These sedge and grass communities are the dominant feature in the south Florida landscape due to their vastness, monotony, and low flat profile.

Marl soils, underlying all of the sedges, result from the green and blue green algae known as periphyton, which inhabit the freshwater area. Acting upon the calcium laden water, these algae remove the calcium, and convert it to marl which precipitates upon the bedrock.

The distribution of "grasses" is in response to the depth of the marl and water levels. Sawgrass, the most common species, is usually found on marl deposits 2-4 feet deep and overlaid by a thick mat of sawgrass peat. The area is inundated by approximately 1.5 feet of water in the rainy season, and is dry during the winter months. Spike rush, beak rush, and maidencane typically locate on thinner marls, 2-3 feet deep and overlaid by little organic material. Constituting the "wet prairie", these sedges lie between the sawgrass and the deeper sloughs and rivers, and remain inundated for a longer period than does the sawgrass.

The presence of the dense growth of grasses acts to retard the southward movement of water to an imperceivable creep. The layers of organic soil, acting like a huge sponge, allow the gradual infiltration of ground water into the porous aquifer below. Remaining surface water carries in solution dissolved nutrient from the decaying vegetation, and moves toward the coastal estuaries, where it becomes the basis for the aquatic food chains.

The periphyton mat is a complex community of not only green and blue-green algae, but over 100 different organisms that form a basis of the Everglades web of life. Mosquito larvae, tadpoles, salamanders and other free-swimming creatures feed upon microscopic flora and fauna. In turn these are food for small fish, reptiles, and mammals, which are food sources for game fish, wading birds, large mammals and reptiles. 25

High productivity of the grass communities, coupled with their expansiveness, allow a broad diversity of wildlife.

> A number of local bird species seem to require extensive wilderness areas and seldom appear in the settled parts of Dade County even where relatively suitable habitat occurs. Examples are:
> Anhinga; Wood Stork; Roseate Spoonbill; Everglades Kite; Short-tailed Hawk; Limpkin; Sandhill Crane; and Common Crow. In these cases, the missing ingredient appears to be freedom from disturbance, rather than any specific habitat factor. 26

Mammals of particular mention are the round-tailed muskrat, and the Everglades mink, both of which are listed as rare and endangered wildlife of the United States. 27

Sawgrass communities accumulate layers of peat, until such layers become thick enough to lead to the decline of the species. Upon this decline, hardwood species, specifically willow, cocoplum, sweet bay, red bay and swamp holly, invade the higher site and add their own accumulations of organic material until a "bay-head" is formed.

Periodic fires historically swept the grass communities, and limited the hardwood invasion. Prior to the extensive water management control seen today, seasonal inundation kept the organic soils moist even during the dry season. Hence, fires destroyed only the tops of the sedges, and the root systems were protected. Regeneration by root-sprouting allowed the grasses to re-establish themselves.

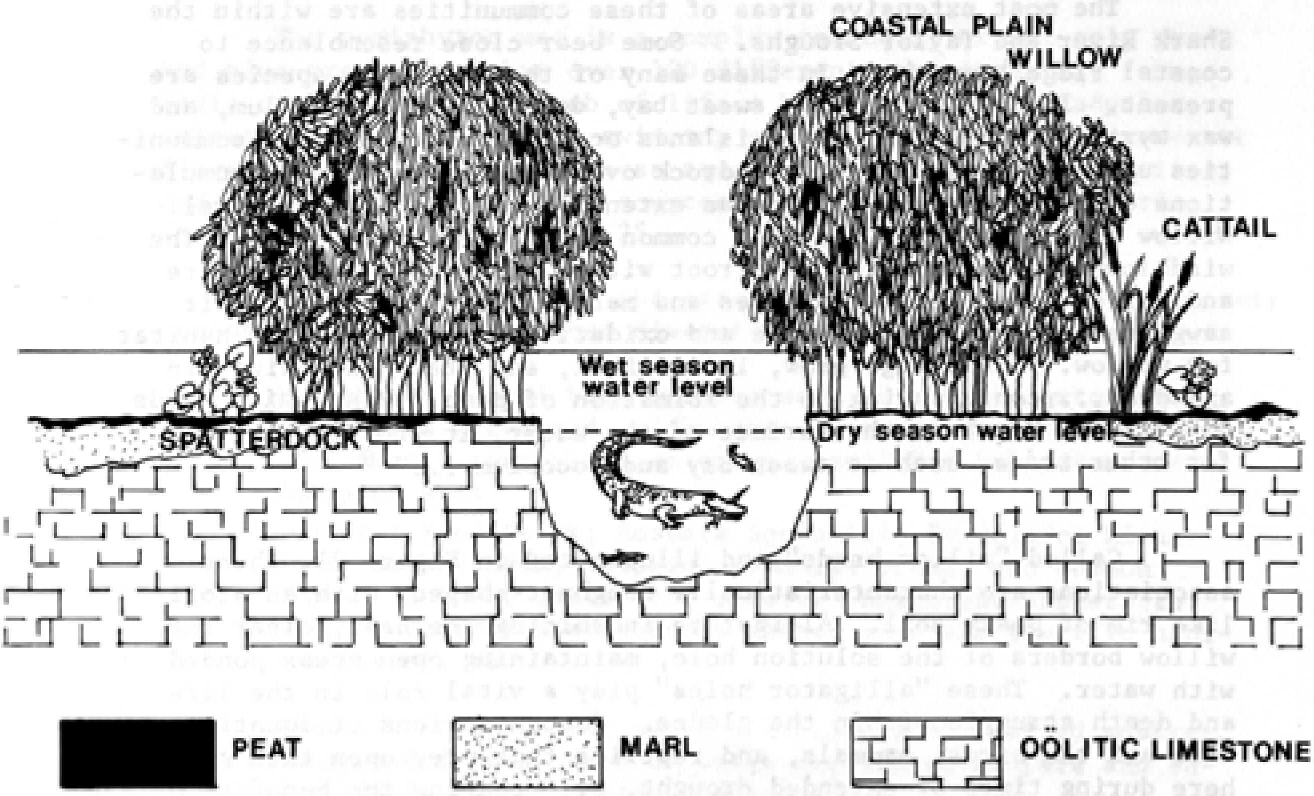
Drainage and extensive water management works have shortened the hydroperiod, or period of inundation, within the Everglades. The organic layer, dry for a longer period during the winter, is now subject to extensive sub-surface fires commonly called "muck fires".[28] These fires destroy the sawgrass root system preventing its reproduction, thus encouraging invasion by those species characteristic of the wet prairies, such as sedges and rushes. Where muck fires have destroyed the grass root systems and the organic soils, a successional trend to hardwoods can often result.

<u>Tree Islands (Everglades Hammocks)</u>

The most extensive areas of these communities are within the Shark River and Taylor Sloughs. Some bear close resemblance to coastal ridge hammocks. In these many of the same tree species are present. In others, willow, sweet bay, dahoon holly, cocoplum, and wax myrtle predominate. Tree islands occur within the grass communities upon depressions in the bedrock overlain by extensive accumulations of peat, or upon rock mesas extending above the water level. Willow heads are among the most common Everglades tree island. The windblown seeds of willow take root within areas disturbed by fire and agriculture. Solution holes and marl soils relieved of their sawgrass peat covering by fire and oxidation provide suitable habitat for willow. "Seedlings grow, leaves fall, and stems and twigs die and drop....contributing to the formation of peat. When this builds up close to or above the surface of the water, it provides habitat for other trees, such as sweet bay and cocoplum...."[29]

Called "willow heads" and illustrated in Figure 21, these associations are characteristically doughnut-shaped, with an atoll-like rim of peaty soil. Alligators inhabiting the head, clear the willow borders of the solution hole, maintaining open areas ponded with water. These "alligator holes" play a vital role in the life and death struggle within the glades. Concentrations of aquatic life and the birds, mammals, and reptiles that prey upon them gather here during times of extended drought, all reaping the benefits of the alligator's activities. When alligators are absent, solution holes fill with muck and the vegetation takes on a dome-like, brushy appearance.

When peat accumulates in depths of one to four feet above bedrock, red bay, sweet bay, wax myrtle, cocoplum and dahoon holly invade the willow head turning it into a "bay head". The decaying vegetation increases the acidity of surrounding waters and dissolves



WILLOW HEAD—ALLIGATOR HOLE

SOURCE: U. S. DEPT. OF INTERIOR,
NATIONAL PARK SERVICE

FIGURE 21

the limestone perimeter of the bay head oftentimes creating a moat 10' to 20' wide. Here alligators ply their trade as in a willow head, creating shelter and concentrations of food for other animal species. The moat offers fire protection to the interior vegetation. Bay heads may also occur just inside the brackish zone, and may be seen with a ring of red mangrove and paurotis palms inhabiting the inner edges of the moat.

The final type of tree island is the tropical hardwood hammock. Similar in species composition to the hammocks found along the coastal ridge, these tree islands differ in their origin. As bay heads continue to accumulate peat, and remain unscathed by fire, elevations of from one to four feet above water levels are created. Hammock species, intolerant to long periods of inundation, and requiring aerated soils, find suitable habitat on the upstream ends of the lenticular bay heads. More often, hammock species are found upon limestone outcrops. Ficus spp., poisonwood, and gumbo limbo, the primary invaders, rapidly pave the way for additional hardwoods.

Moats are sometimes found around these tree island hammocks, offering fire protection and wildlife habitat. Since they are the highest elevations in the Everglades region, they also offer refuge to animals during times of extreme high water. If droughts or flooding become too severe, the hammock itself may succumb as well as the wildlife.

Cypress

Bald cypress, Taxodium distichum, has a limited distribution within Dade County. The major stands are southeast of Shark River Slough near Pa-Hay-Okee Overlook (Everglades National Park) and in the northwestern corner of Dade County.

Cypress is a deciduous conifer with an affinity for deep water and organic or clay soils. Its best habitat is within depressions in the limestone bedrock, which remain wet during most of the dry season. Seasonal flooding is important for the initial establishment or regeneration of the species. For proper seed germination, abundant moisture is required for one to three months after seed-fall, allowing the seed coat to soften and swell. After the water recedes, the seedling sprouts, but its growth must be quick enough to stay above the next seasonal flood.

Growth in soft, mucky soils has given cypress a characteristic form and pattern. The wide buttressed base and characteristic "knees" projecting above the water line, are thought to be adaptations to increase vertical stability. The "knee" has been the subject of much speculation, as many people feel it functions in root respiration. The dome profile of many cypress stands is a function of the deep water and organic deposits near the center of the solution hole, and increasing shallowness of the same as one moves away from the center.

With the decay of fallen needles, organic acids erode the limestone, allowing the cypress to expand its habitat both vertically and horizontally.

A most unusual form of cypress, is found in northwestern Dade County. Dwarf or "hat-rack" cypress respond to drastically fluctuating water levels, and poor soils, and become established on low, broken limestone outcrops. Here, winding their roots through cracks in the bedrock in search of water and pockets of organic matter, these trees seldom attain heights over ten or twelve feet.

Cypress are normally not affected by fire, due to their principle habitation of low, wet areas. However, during extended droughts, fire can burn away accumulations of peat and destroy root systems. Dwarf cypress are somewhat less susceptible to fire damage, due to limited accumulations of fuel on the bare limestone, and by the fact that roots reach deep into rock fractures. Decreasing water levels, make cypress domes more susceptible to invasion by willow and wax myrtle and eventually other tropical hardwood species.

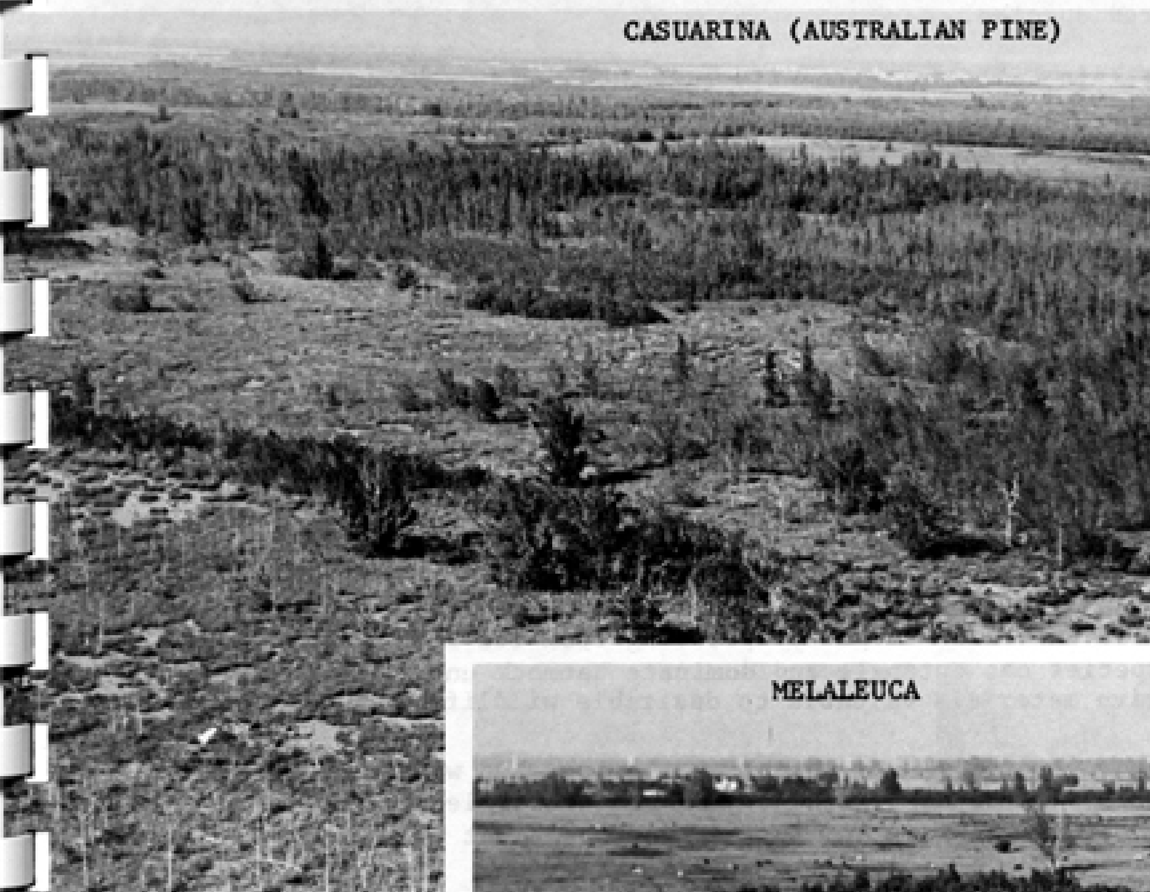
Cypress domes and forests provide watery haunts for many species of wildlife. Numerous bromeliads support populations of insects, snails, salamanders and snakes which are food for several insectivorous and carnivorous bird species. "Alligator holes" are found within cypress heads, and draw herons, egrets, wood storks, bald eagles, raccoons, bobcats, panther and black bear to feed upon the abundant aquatic life.

Exotics

Exotic vegetation are those plants which have been introduced either accidentally or intentionally into South Florida from foreign lands. When controlled and cultivated, they have served useful landscaping and agricultural purposes. However, lacking biological controls such as insects and disease, and finding a favorable ecological niche, several species have escaped cultivation and are rapidly becoming a threat to native vegetation. These plants out-compete native vegetation, furnish only limited support to desirable wildlife populations, and can very rapidly dominate the regional landscape.

The most common, due mostly to their aggressiveness, are Australian pine (Casuarina spp.), cajeput (Melaleuca quinquenervia) and Brazilian pepper (Schinus terebinthfolius). Posing an equally serious threat, but not as common in Dade County are guava Psidium guajava, Colubrina asiatica, Ardisia solanacea, Hydrilla verticillatia, and water hyacinth (Eichhornia crassipes). These plants produce large quantities of seeds readily dispersed by wind, water, or wildlife. All are adept at invading disturbed lands, such as abandoned agricultural fields, spoil banks, and lands impacted by fire or drainage. Once established, these exotic species maintain control by out-competing and excluding native vegetation from the understory. Pure

SHINUS (FLORIDA HOLLY)



CASUARINA (AUSTRALIAN PINE)

MELALEUCA

stands of exotic, once formed, generally insure that reclamation by native vegetation is impossible.

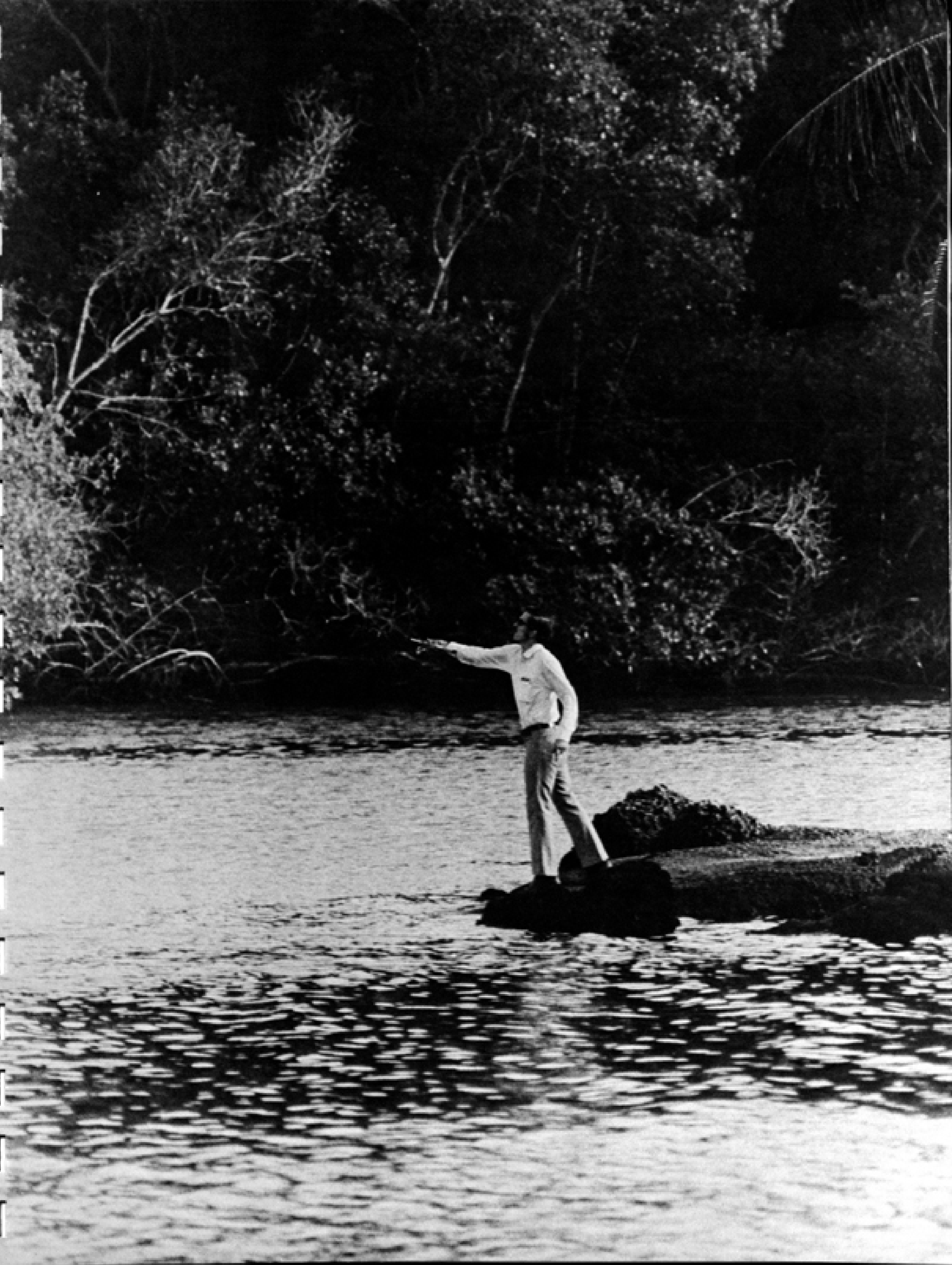
Australian pine, introduced during the early 1900's were and still are widely used for roadside plantings and windbreaks. A light demanding tree, it readily spreads its winged seeds onto the marl soils of the drying glades, abandoned agricultural lands, and along hurricane disturbed beaches where it grows prolifically. Although susceptible to fire, frost and fungus disease, it forms dense stands under which little understory grows. In southeast Dade, the roots of Australian pines have provided physical barriers to the breeding of loggerhead turtles and the Florida crocodile, both of which are rare and endangered species.

Cajeput (melaleuca), simultaneously introduced with Australian pine, is an Asiatic relative of eucalyptus and is characterized by its thick papery peeling bark. Copiously seeding when stressed by fire, frost or mechanical damage, cajeput forms dense thickets devoid of wildlife. It also sprouts from the root system of a fallen or cut tree trunk. Local naturalists claim that alligators move when cajeput invades the vicinity of a gator hole. Cases of human respiratory problems have been attributed to the species when planted within an urban area. Highly resistant to flood and fire, cajeput readily invades cypress domes and tree islands, often taking on the dome-shape of the former. At present, no economical control exists for cajeput, making it nearly impossible to eradicate once established.

Brazilian pepper, also called Florida holly is a shade-tolerant species that easily invades native understories. Wintering robins, rapidly attracted to the plants red fruit, spread undigested seed throughout the countryside. A vigorous grower, Brazilian pepper, easily survives fire and cold damage by sprouting from its roots. Given time, the species can entangle and dominate hammock understory, out-competing native materials valuable to desirable wildlife species.

Populations of exotic plants appear on the increase within Dade County. Increased drainage, wildfire, and careless clearing of lands, provide additional habitat and further encouragement for population explosions of these plants.

Native plant materials are an integral part of the cyclic process of the local ecosystem, supporting and supported by water, wildlife, and soils. Exotic plants interrupt the cycles, creating dead-end biological communities that take much and return little. Encouraged by anthropogenic change, these plants are yet another factor compounding the biological degradation of South Florida.



NATURAL SYSTEMS

Despite his present position of dominance on earth, man is still dependent upon other living organisms for his sustenance. Isolated within the urban areas and segregated from nature, some people lose this realization. It is very important that people are aware that their life support system is dependent upon the biosphere of the earth. As all other animals, man is dependent upon the ecological interrelationships within the biosphere--that thin layer of the earth's surface in which land, air, and water intermingle, and life exists.

People must seek to understand that they constitute a biotic factor, affecting and affected by the plant and animal communities around them. Only through the understanding of natural processes may people intelligently manage the environment and be a long term recipient of its wealth.

Living organisms do not exist independently of one another. Every plant and animal is a member of a living community and every member is supported by, and lends support to, the other members of that community. The lone pine tree on the coastal ridge is alone only in being separated from the other pines. Below it, on the ground or in the soil, are a variety of organisms without whose presence the pine could not continue to grow. Similarly, the pine provides a source of nutrients and energy upon which other organisms depend. A forest of pines should not be considered solely for its aesthetic appeal, but also for its value as an interacting complex of vegetation and animal life. Such a complex is referred to as a biotic community. If the definition of the complex is expanded to also include non-living resources, such as water, soil, sunlight, and atmosphere, the unit being considered can be referred to as an ecosystem.

Concepts of Ecosystems

Basic to comprehending the relationship of man to an ecosystem is a thorough understanding of concepts that govern the function and processes of an ecosystem. In this age of environmental crises, it is possible to trace current problems back to a disregard for the basic precepts under which ecosystems operate. The previous paragraphs have alluded to an interdependence of the various elements comprising an ecosystem. Several concepts and principles of ecosystems will be discussed to provide the necessary background information to understand the interdependence of the various resource elements. Those concepts to be discussed initially are interrelatedness, complexity and stability, resilience, and carrying capacity.

Interrelatedness

An inescapable characteristic of ecosystems is the interrelatedness of the various parts. The use of one resource affects all the others. The lowering of water levels in a sawgrass marsh exposes the organic soils to the air and leads to destruction of the soils through oxidation. The reduction of organic soils will cause subsequent invasion by other vegetative species more adapted to the new soil conditions, and will greatly reduce the natural filtration that surface waters will receive as they percolate into the aquifer. The absence of standing water destroys the value such waters once held as a feeding habitat for wading birds. These birds forced to compete for food in other areas often overtax these limited resources of food.

In a similar vein, the destruction of an insect population through the use of insecticides can prevent the pollination of desirable plants, pollute surface and ground-water supplies, and create health hazards for man and beast. It is, therefore, imperative to recognize that all living resources are in balance with their physical environment, and changes exerted upon ecosystems must be evaluated for more than their face value. Their interrelated parts and functions must be understood.

Complexity and Stability

Ecosystems are by nature complex. Climate and geology determine the soils that occur within an ecosystem. Soils and climate likewise determine the types of vegetation. Vegetation, through a feedback function, can alter soils and micro-climate in a given area and pave the way for new forms of vegetation. In response to all these factors, the habitability of an area for wildlife is controlled; with wildlife exerting some control over vegetation through feeding.

Between all plant and animal species there is competition for growing space and energy, predation of one species upon another, parasitic relationships and mutually supporting relationships. These act as checks and balances to regulate the numbers and quality of each species and prevent a single species from increasing or decreasing greatly. An ecosystem working under these relationships, with no external change, can be referred to as stable.

Resilience

Although the sensitivity of ecosystems does vary, ecosystems are not necessarily delicately balanced in a strict sense of the word. Change is a common characteristic of ecosystems. Through time, ecosystems have been subjected to numerous traumas: storms, fire, flood, freeze or geophysical upheaval. Some ecosystems have adapted and survived, others have succumbed and disappeared, but always destruction has been followed by the replacement with another biological community and ecosystem more adapted to the altered conditions.

The ecosystems that have survived are those that have exhibited the ability to adjust and adapt to change. This ability of ecosystems is defined as resilience, and includes the ability to adjust to sudden shocks or accumulative incremental changes. However, any ecosystem is limited in its ability to adjust. The "dust bowl" phenomenon of the 1930's in the western United States is an example of a natural ecosystem (prairie) succumbing to the cumulative effects of incremental change (agriculture). The resilience of the system was exceeded and dramatic unexpected signals of change occurred.

Of considerable consequence to planning is the resilience factor in ecosystems. Planning operates under the philosophy that incremental change will soon indicate the effect of intervening actions. At that point the cost-benefit ratio of the action can be evaluated, and new policies and actions developed to rectify any problem areas. However, when tampering with ecosystems, actions do not produce immediate signals of change and a series of actions may occur before their effects can be detected, let alone evaluated. Due to this time lag the resilience of an ecosystem can be overburdened and severe environment degradation can occur long before remedial actions are instituted.

<u>Carrying Capacity</u>

Within every ecosystem there are limited amounts of food, shelter, water and growing space. Every organism has a specific set of minimum requirements for its own growth and reproductive capacities. Organisms compete with organisms for a sufficient supply of necessary resources. When numbers of organisms are low and the necessities of life are abundant, competition is insignificant and growth rapid. However, as numbers increase, the supply of food, shelter, water, and space for each individual decreases and the competition intensifies. Various density dependent factors act to reduce the total number of organisms as demand outstrips supply. The final number of organisms to which an ecosystem can provide the necessities for individual well-being is termed the carrying capacity of that ecosystem.

Processes of Ecosystems

The relationships within an ecological system are never static. Life and death, growth and decline, change and replacement, go on continuously. Energy pours down from the sun, sunlight is captured by green plants, and energy is transformed, used, and stored. Chemicals and elements in the soil flow through complex pathways, from soil, to plants, to animals and back to the soil. Water also follows an intricate cycle through the ecosystem, starting from and returning to the atmosphere.

<u>Energy Flow</u>

An ecosystem is driven by an inflow of energy provided by sunlight. Green plants capture the energy quanta with their leaves, and through the process of photosynthesis, convert carbon dioxide from the air, and water from the soil, into glucose. Later, combining glucose with simple chemical compounds obtained from the soil, plants build more complex carbohydrates and proteins required by the animal world. Herbivores, carnivores, parasites, decay bacteria, fungi, and other organisms depend directly or indirectly upon plants to maintain their own living processes.

The amount of energy available in sunlight is large in relation to that which is captured and used by a biotic community. Only a small percentage of the sunlight striking plant leaves is retained in chemical compounds, the remainder being radiated as heat or reflected from leaves. Despite their inefficiency, plants are the only effective converters of sunlight energy into forms useful to animals and man, and presently are the only means of storing energy in large quantities.

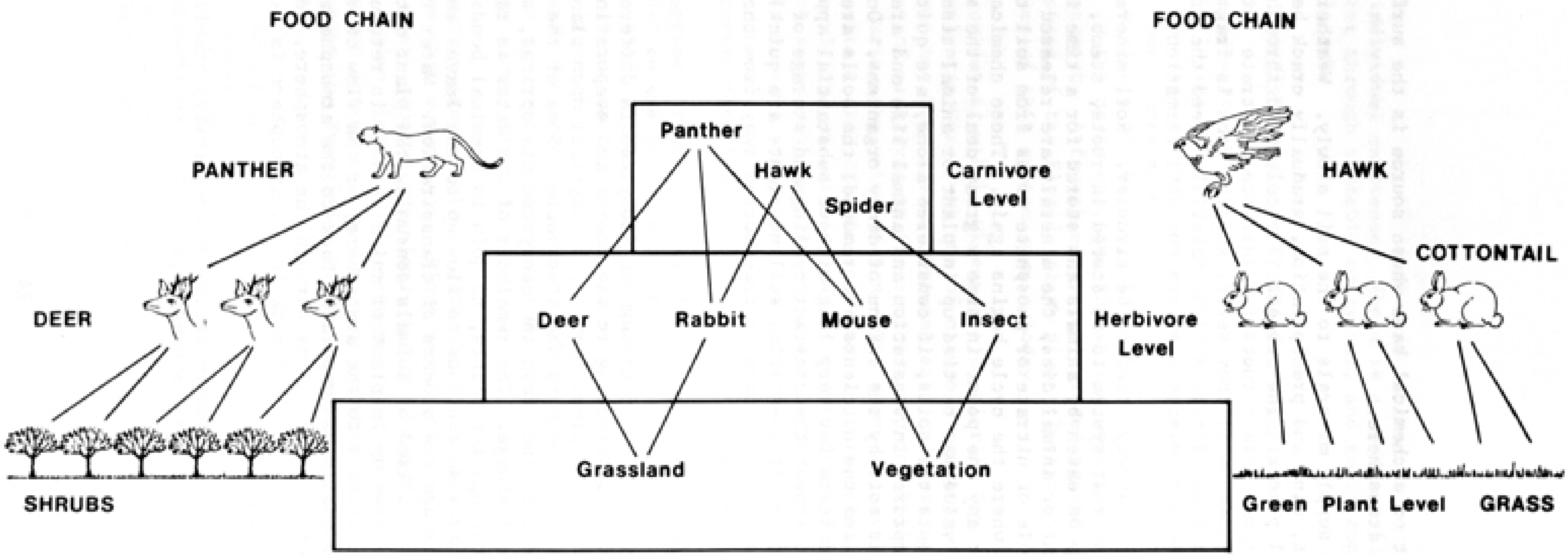
Between each energy transfer, some energy is lost. This is in response to a basic natural law, the "Second Law of Thermodynamics". It states that during any energy transfer from one form to another, some energy escapes the system, usually as heat. No transfer is 100 percent efficient. To compensate for this inefficiency, the number of green plants must be larger than the herbivores that feed upon them, and likewise the numbers of herbivores must exceed those of carnivores. Much of the energy stored in plant carbohydrates and proteins is not converted to an equal quantity of animal tissue. As chemical conversions occur during digestion and animal metabolism, energy is lost.

Because of these energy relationships, it is possible to portray the distribution of living organisms in an ecosystem in terms of a biotic pyramid, as shown in Figure 22. The broad base corresponds to the green plants, which have a high caloric value and the largest total mass of the organisms. The second layer represents the herbivores, and the third layer the carnivores. The diminishing size of each level of the pyramid corresponds to decreasing amount of stored energy and total masses of organisms.

The pathways over which energy flows through a biotic community are called food chains. A simple food chain is also illustrated by Figure 22. Grass captures energy from the sun and stores it in seeds, buds, and roots. These are consumed by rabbits, and energy not lost in digestion or metabolism is stored in animal tissues. Rabbits are then fed upon by hawks, and energy is transferred with some loss, into hawk tissue. The food chain ends, for no predators feed upon hawks. However, the hawk may support a variety of parasities, and upon its death will provide food for numerous organisms of decay. The rabbit population will simultaneously be fed upon by panthers, and the grassland by other herbivores. Thus, food chains become interlaced into complicated food webs, and pathways of energy become difficult to trace.

Mineral Pathways

Ecosystems must not only have a source of energy, but a source of chemical building blocks from which organisms can be constructed. Biotic



BIOTIC PYRAMID SHOWING PORTION OF A GRASSLAND FOOD WEB

FIGURE 22

pyramids rest on a chemical base whose source is the surface or subsurface rock and the atmosphere.

Rocks supply minerals to the soil slowly. Weathering, the action of cold, heat, wind and precipitation, gradually crack bedrock shattering it into small pieces. The process is accelerated through the action of living organisms. Plant roots for instance penetrate into cracks between rocks, widen them until they split, and the rock is fragmented. Acids formed by water and decaying plant materials speed the process of rock disintegration and release elements for soil formation.

Mineral pathways tend to be circular. Soil minerals enter green plants via the root system to be stored in roots, stems, leaves, or fruits. Here they may be eaten by animals and stored for a time in their tissues. When the plant or animal dies, the minerals are released back to the soil. Thus a molecule of nitrate or phosphate moves from soil to plant to animal, back to soil where the cycle begins again. These chemicals are in constant motion and at any one point in time a great deal of the soils fertility and nutrient value may be tied up in plant or animal tissues. In some tropical forests the soils, if considered alone, are quite sterile. Nutrients are captured in vegetation and animal life and are returned only briefly to the soil by the action of decay organisms. Once the forest is destroyed and the nutrients are removed; the soils are seldom able to support agriculture for very long without substantial applications of fertilizer. Without the constant cycling and storage of minerals within the natural community, existing soil nutrients are quickly leached deep into the ground by rain or transported away from the ecosystem, as in the removal of crops.

The Hydrologic Cycle

The cycle of water through an ecosystem is different than that of other minerals. Originating in the oceans and evaporating into the atmosphere and falling as precipitation, it may fall upon plants or soil and be evaporated directly back to the atmosphere. Some of the precipitation may remain in the soil and leave the ecosystem via springs, surface waterways or subsurface drainage. The remainder of the water is taken up by roots, transported through the plants, to join in chemical bonds forming plant tissue. It may also continue to flow up to the leaves and be lost to the atmosphere through the process of transpiration. Water retained in the plants may be utilized by animals consuming the plant material. Eventually all the water tied up in plant or animal tissue is returned to the soil and continues its travels to the atmosphere, or the flow of streams to the ocean, to eventually be evaporated back to the atmosphere. This complex cycle of water from the oceans through the atmosphere, soils, vegetation, animals, streams, ocean, and back to the atmosphere is termed the hydrologic cycle (see Figure 14).

Ecosystems are characterized by complexity, stability, and the degrees to which they can absorb change. In a pristine state, organisms control and are controlled by other organisms and processes functioning within the ecosystem. They are limited in numbers, distribution and the quality of their individual existence. There is a constant flow of energy, chemicals, and water through a stable ecosystem, and so it continues with inputs balancing losses.

Functioning of the Everglades Ecosystem

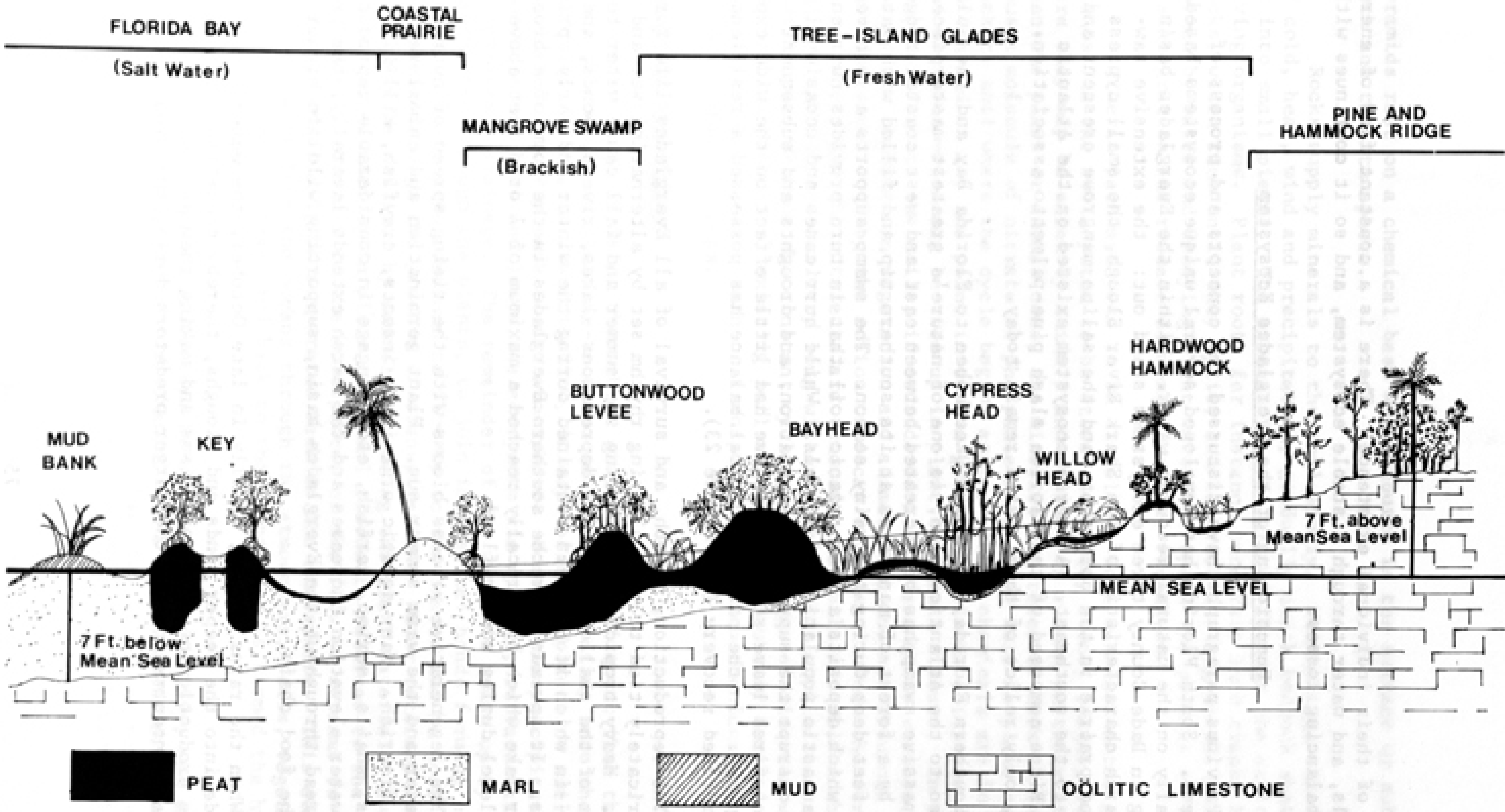
Previous paragraphs have discussed the concepts and process of ecosystems. South Florida has developed several unique ecosystems based principally on the natural resource water. Within the Everglades basin existing in Dade County three ecosystems stand out: the extensive sawgrass marsh characteristic of the Shark River Slough, the small cypress swamp and prairie in the northwest, and the saline mangrove crescent and prairie to the southeast. A fourth ecosystem existed on the Atlantic Coastal Ridge composed of the Florida slash pine-palmetto association, however, only relics of this system remain today.

Southern Florida, from Lake Okeechobee to Florida Bay and the Gulf of Mexico to the Atlantic Ocean, is one of nature's greatest masterpieces. Here a massive swamp has been created between east and west coastal ridges plugged by a forest of mangroves at its southern tip and filled with water several feet deep during the rainy season. The swamp supports a lush vegetation which deposits a rich organic soil that in turn provides nutrients for a fantastic population of animals. While hurricanes and occasional freezes disrupt the supporting vegetation, and droughts and subsequent lightning fires leave scars, they have had little effect on the wide expanse of swampland. In the past the natural balance has possessed a resilience that permitted recovery (see Figure 23).

The reproduction, growth, and survival of all Everglades life forms are intricately tied to the pulsating rhythm set by alternating wet and dry seasons. Heavy tropical rains during the summer and fall cause water to rise out of the shallow scattered depressions--lakes, rivers, ponds, and sloughs--in which it has been contained during the winter and early spring droughts. It spreads over the southern Everglades in the form of a broad marsh or lake which historically reached a maximum of 7 or 8 feet above ground level during summer flood.

The regenerative process blooms with the rising spread of nutrient laden water and the warm summer sun. Plant germination and animal reproduction flourish. Many aquatic organisms--insects, crayfish, killifish, reptiles, snails, shrimp, garfish, etc.--engage in considerable reproduction. As the water elevation increases and the marsh extends laterally, the progeny spread throughout the Everglades basin, supporting wildlife higher up on the food chain.

When the rains let up, usually in late October, the water begins to recede into the deeper ponds and sloughs, thereby concentrating the summer's production of small organisms and making them available in essential concentrations to the larger predators during the drought season.



PLANT COMMUNITIES OF EVERGLADES NATIONAL PARK

SOURCE: U.S. DEPT. OF INTERIOR, NATIONAL PARK SERVICE

FIGURE 23

These ponds in many cases have been created by crayfish or alligators. They dig their own watery holes which come to be occupied by a great variety of refugees attempting to escape drought conditions elsewhere. These "gator holes" turn into microcosms of the Everglades ecosystem. Turtles lay their eggs, wading birds come to feed. Many of the plants and organisms die or are eaten by other predators. With the reoccurrence of rains in early summer the cyclic reproduction and distribution of life begins again.

Careful study of the estuarine area indicates that this interphase of fresh and salt water is essential to the environment of numerous fish that require the proper salinity gradients to feed or reproduce. Although it is an extremely difficult environment in which to survive due to the rapidly changing conditions, fish move back and forth from fresh to estuarine water staying where the salt water gradient meets their specific environmental needs. The interference with the normal sheetflow of fresh water from the interior has already resulted in periods of super salinity in some estuarine areas due to the loss of freshwater sheetflow. Salinity of 70 parts per thousand, twice that of seawater, are already encountered in Florida Bay. Although such can occur naturally, these salinities are lethal to the eggs and young of menhaden, the black mullet, the spotted sea trout, snook, tarpon, blue crabs, stone crabs, oysters, and pink shrimp. Collectively these are worth millions of dollars each year commercially to Florida, and are one of the major drawing cards of the local tourist industry.

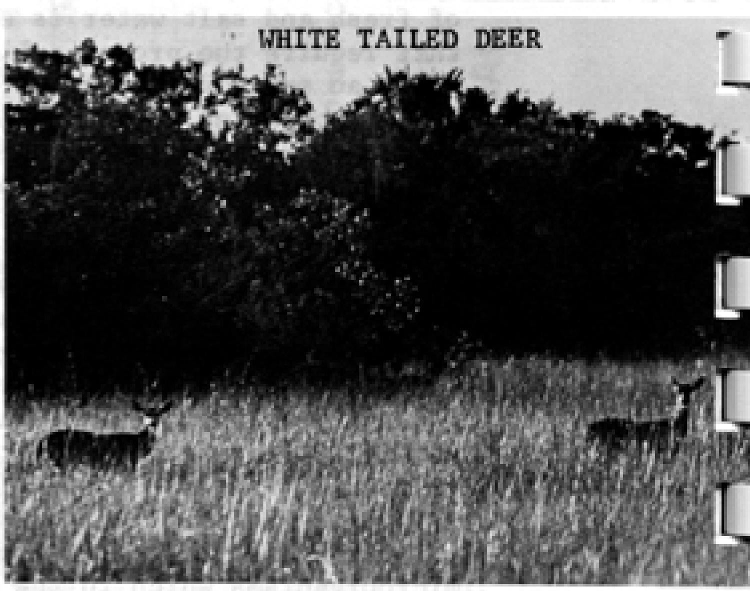
Natural freshwater bodies within the Everglades ecosystem contain microorganisms which in the presence of oxygen break down organic animal wastes into inorganic substances. Aquatic plants, through photosynthesis, convert these inorganic substances back into organic materials. These become tied up within the plants, and are recycled back to the animal life of the system. As long as inputs balance losses, the system remains stable, and life flourishes.

Runoff containing sewage, fertilizers, pesticides, and industrial wastes, provide the receiving waters with additional sources of organic and inorganic substances. Due to the resilience of the water body, a certain percentage of these can be assimilated. The system breaks down when excessive quantities of nitrates and phosphates are discharged, and the ability of the plants to assimilate these back to organic material, is exceeded. Such over-enrichment of the water-body, encourages a tremendous growth of algae which shade out more valuable plants, deplete oxygen, develop noxious odors, and in extreme cases cause the death of fish. Expensive procedures are then required to purify the water, remove algal growths, and restock the depleted wildlife. These costs stemming from environmental degradation are felt in one form or another by every citizen of Dade County.

The problems evolving from environmental degradation are not limited to the water-related components of the Everglades ecosystem. Improper use and destruction of terrestrial aspects generate equally complicated circumstances and costs. One only has to look at the destruction which has

GREAT BLUE HERON

WHITE TAILED DEER



FLORIDA ALLIGATOR

occurred to the beaches, estuarine areas, hammocks and pinelands to see the alterations which have occurred.

The environmental problems experienced today are based upon our previous disrespect for nature and the inviolability of the land. Natural processes perform considerable degrees of work for man, and the lack of recognition of this fact eventually leads to costs that must be paid by the violators.

The character of the south Florida ecosystem has changed drastically in this century. Early white settlers, seeking their fortunes, saw the area for the wealth that could be made quickly from use of the land. Delicate organic soils were drained and farmed, until their fertility was destroyed or the soils themselves disappeared through oxidation. Rivers were channelized to speed the drainage of marshlands to prevent the natural annual occurance of floods. Animals were slaughtered, birds for their plummage, alligators and crocodiles for their hides, mammals for their furs and meat, and predators for the sake of killing. Beaches and dunes gave way to resort areas and estuaries for residential developments. Those resources that had an immediate value were destroyed and even those that did not suffered equally due to their interrelations.

What future will the ecosystem within Dade County have? This is no longer a question for bird watchers or wilderness enthusiasts. The limits of our ecosystem and the stresses being placed upon it are involving all people and all interests, in shared problems and common goals. To insure that Dade County has a livable future, it is necessary to adopt land use concepts and land evaluations different than those under which the area was settled. A respect for the natural features of the area and a determination to live in harmony with them must be paramount. Features which are valued for their material function and the support they provide to urban populations must be conserved or wisely used. This can only be realized through proper land use controls and regulations or incentives.

METHODOLOGY

The design and selection of the methodology for this study had to be made relative to south Florida's unique environmental situation. The organization of the study process, from the initial direction provided by the Citizens Task Force to the development of environmental criteria, is delineated in the schematic shown on Figure 24.

Concurrent with the development of the proposed environmental protection policies by the Citizens Task Force, technical assistance was obtained from a Technical Coordinating Committee which consisted of individuals representing federal, state, and local agencies and organizations having environmental and technical expertise. The following list indicates those agencies and organizations that participated in the development of the Environmental Protection Guide as members of the Technical Coordinating Committee:

- Central and Southern Florida Flood Control District
- Dade County Cooperative Extension Department--Agricultural Division
- Dade County Park and Recreation Department
- Dade County Pollution Control Department
- Dade County Public Works Department
- Florida International University--Joint Center for Urban and Environmental Problems
- Greater Miami Chamber of Commerce--Environmental Quality Action Committee
- Izaak Walton League--Mangrove Chapter
- Miami-Dade Water and Sewer Authority
- South Florida Regional Planning Council
- State of Florida--Division of Forestry
- Tropical BioIndustries, Inc.
- United State Department of Interior
  South Florida Ecological Study
  National Park Service--Everglades National Park and Biscayne National Monument
- United States Geological Survey
- University of Miami
  Center for Urban Studies

The technical nature of the Environmental Protection Guide demanded assistance from hydrologists, biologists, soil scientists, engineers, and planners. Thus pertinent and necessary technical information on hydrology, soils, vegetation, land use, air and water quality, and in other areas of environmental concern was provided by the Technical Coordinating Committee.

The combination of input from the Citizens Task Force, staff, and Technical Coordinating Committee provided the basic information and data necessary for the determination of the environmental resource parameters

ENVIRONMENTAL PROTECTION GUIDE STUDY PROCESS

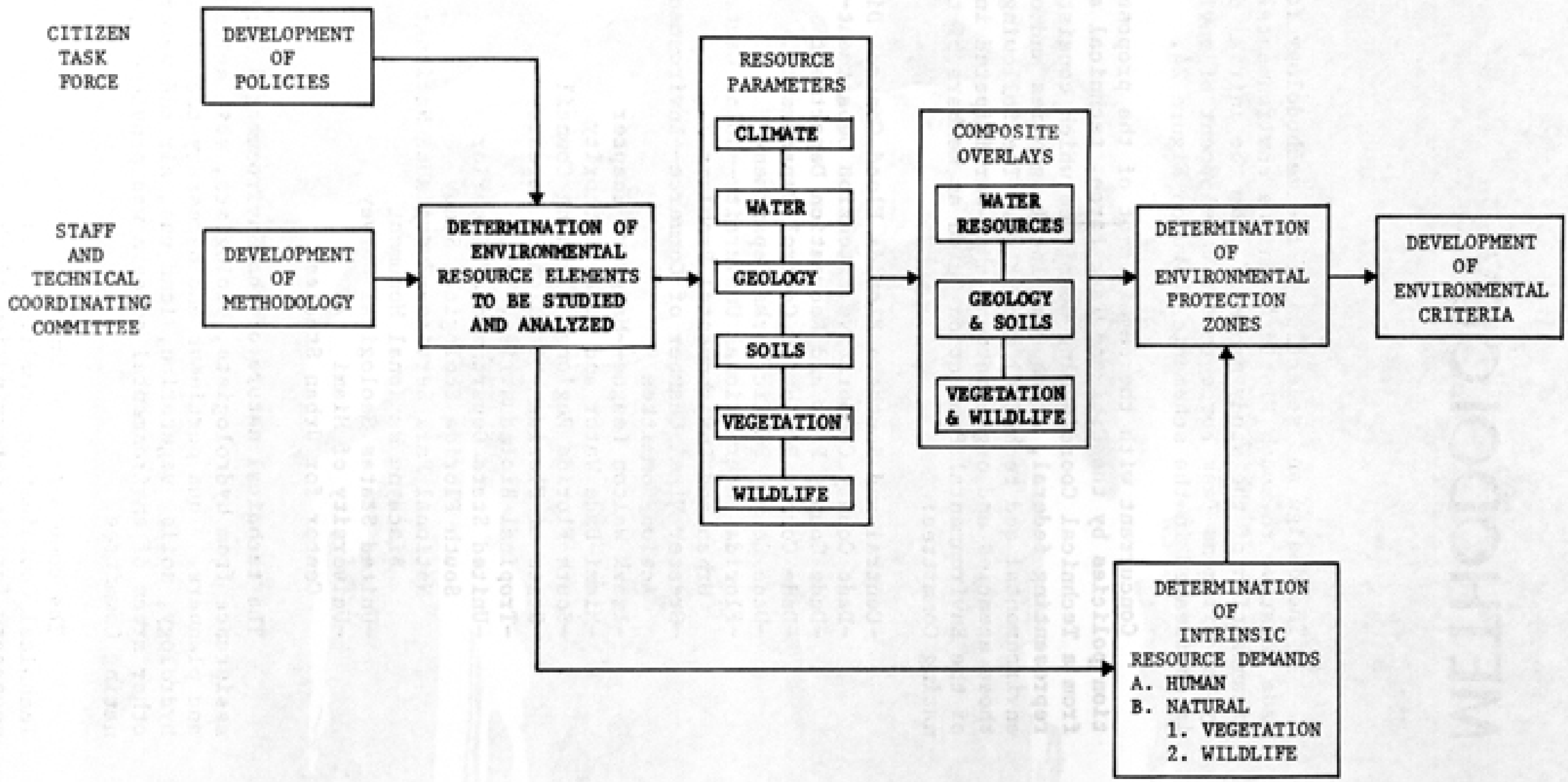


FIGURE 24

to be studied and analyzed. This determination is a reflection of the attitudes of the public towards protection of the Dade County environment, the magnitude and complexity of major local environmental problems, the character of the existing environment and the availability and form of existing data. The combination of the above factors provided the basis for determining the resource parameters for the study which are: climate, water, geology, soils, vegetation, and wildlife. The detailed information embodied in the identified six resource parameters formed the basic input for a map overlay process for use in this study. The map overlay process closely follows the process developed by Ian McHarg in his book Design With Nature. The map overlay process used in this study was developed in the following manner. The six natural resource parameters listed previously were grouped into three major study components: Hydrology, Geology, and Biology. The information pertinent to each study component was then displayed on three individual transparent overlay maps entitled Hydrology, Geology, and Biology Composite Maps. The purpose of these overlay maps was to permit an interpretation of the sum of the factors depicted on each individual composite map by superimposing the transparent maps upon one another to arrive at a summary or final Composite Map. The final Composite Map, therefore, reflects the environmental sensitivity or the development suitability of various geographic areas. The logical combination of areas with similar suitabilities and/or constraints resulted in the formation of an Environmental Protection Zone Map which reflected generally the input from the Composite Map Overlays.

Analysis of Major Study Components

Prior to a detailed description of the methodology certain environmental assumptions must be made. The environment represents one of the most complex systems known to man for it truly represents the complete set of resources, physical and geological, that exist on earth, as well as the infinite interactions that occur among this set of resources. Thus, an environmental evaluation system to be practical and effective, must greatly simplify the environment into a relatively small number of components and indicators that can be used to determine, for example, whether or not a proposed project will have a significant impact on the environment. Those three major study components considered to be vital to this project and based on the resource components previously identified are: hydrology, geology, and biology. All resource parameters to be described herein including water quality, soil and drainage characteristics, and wildlife habitats are all inherent in the analysis of these three components. The following descriptions discuss the resource parameters within each component and provide some rationale for the inclusion of each parameter.

It must be emphasized that each component (hydrology, geology, biology) discussed initially is analyzed independently and therefore reflects only those constraints which are dictated by the resource parameters directly related to that component. For example, a specific area delineated on the Geology Composite Map may appear to have no constraints to development. However, when the hydrologic and biologic components of that area are considered in the composite overlay process various development constraints may become evident.

Under the headings of the three following study components--Hydrologic, Geologic, and Biologic--there will be a discussion of the resource parameters. Following the explanation of the resource parameters will be a description of the delineated subzones of varying environmental sensitivity within each study component.

Hydrologic Constraints. Those resource parameters which took precedence over others within this study component include but may not be limited to the following: aquifer recharge, freshwater sheetflow, hurricane tidal inundation, flood protection, fill requirements and the related flood criteria, and drainage patterns. Each of these parameters vary in importance as they apply to the Hydrologic Constraints Map (Figure 25). For analytical purposes five zones: minor, slight, moderate, (hurricane tidal zone), severe and very severe were delineated and given a numerical ranking from one to five respectively. Those areas with minor hydrologic constraints were rated H_1. A similar procedure was used for those areas on the Geologic and Biologic Constraints Maps; the use of this ranking procedure aided in the identification of zones of varying character on the Environmental Protection Zone Map. Therefore, the zones potentially range from $H_1G_1B_1$ to $H_5G_3B_5$, with Hydrology, Geology, and Biology components having five, three and five categories respectively.

Basically, the Hydrologic Constraints categories may be characterized as follows. The H_1 or Minor Hydrologic Constraints category has few constraints to development. Where flood driteria are met (as established by the Dade County Public Works Department--Water Control Division or by the Central and Southern Florida Flood Control District) through fill requirements, protection from a ten year to a twenty-five year storm is provided (see Figure 26). Fill required within this category ranges generally from zero to two feet with the greater depths of fill needed either in the old transverse glades or where organic soils exist. Greater amounts of fill may be required in the extreme northwest and southeast portions of the H_1 area. The western boundary of the H_1 category is generally the line within which the Flood Control District can provide flood protection for a ten to twenty-five year storm. It must be recognized that the ability of these canals to drain freshwater to tide is a function of a number of factors including the level of tidal waters. Thus in the case of a hurricane when a rise in the tide prevents positive drainage through the Flood Control District canal system the 10 to 25 year flood protection will be nonexistent. Although the moderate hurricane (sustained winds of 125 mph) does not pose a serious tidal flood threat (see Figure 27) hurricanes of a more severe nature could potentially flood extensive portions of the H_1 category (see Figure 28).

The second Hydrologic Constraints category is the H_2 or slight constraints category. This area is outside that area offered 10 to 25 year flood protection by the Flood Control District but is east of Levee 31-N, thus providing the area with at least minimal flood protection when flood criteria are met. This area generally requires between zero and two feet of fill and is not subject to inundation from hurricane tidal flooding.

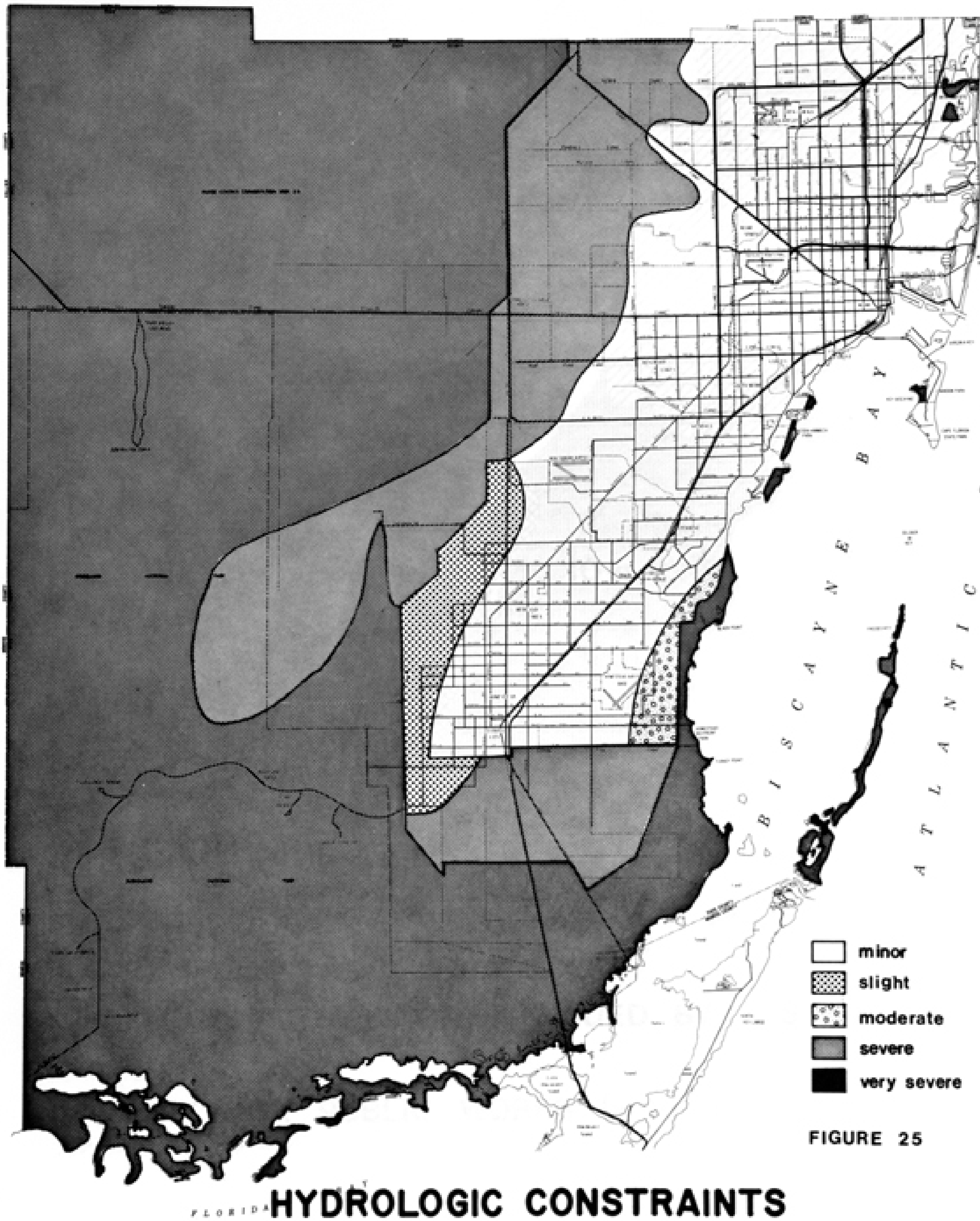
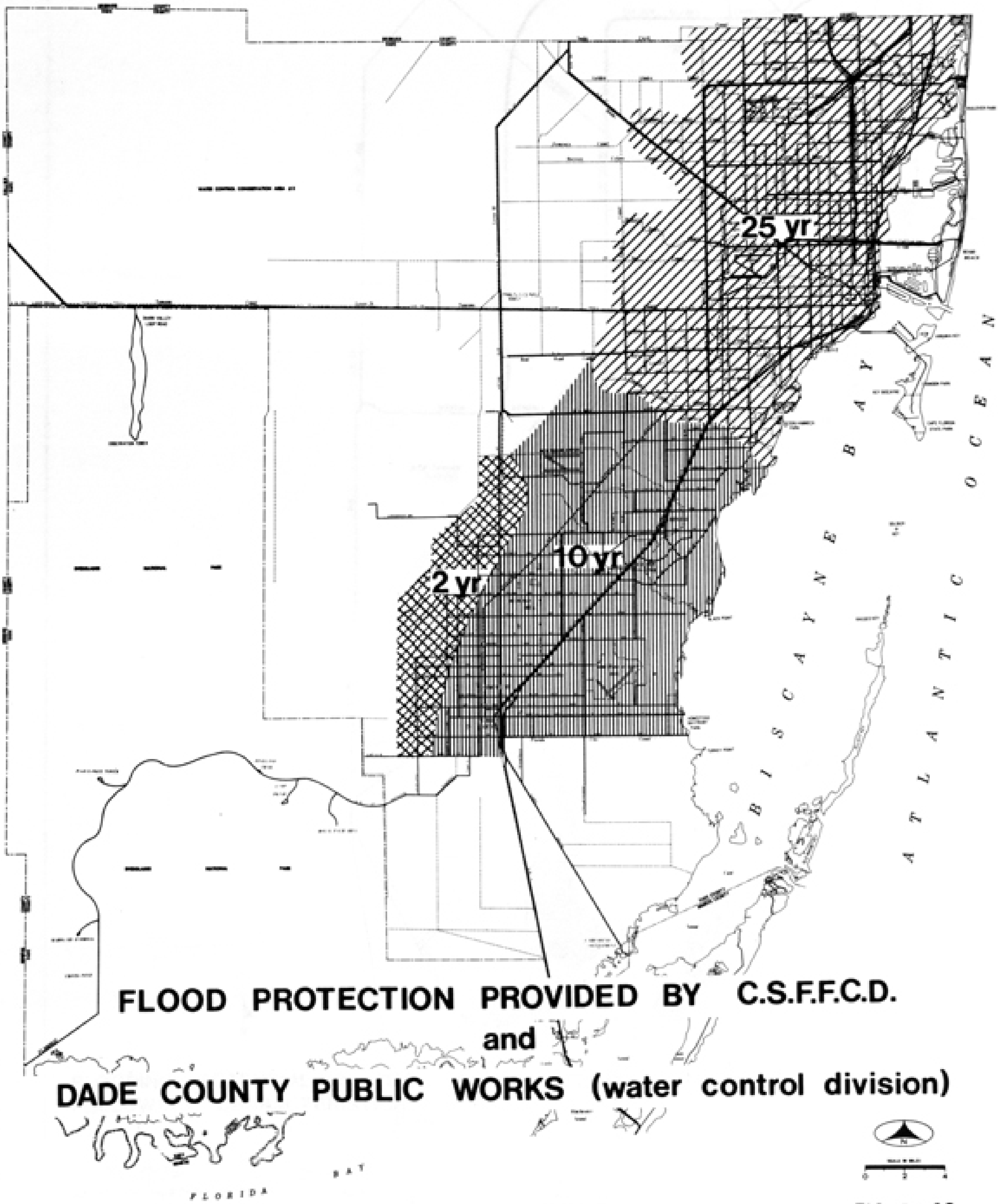


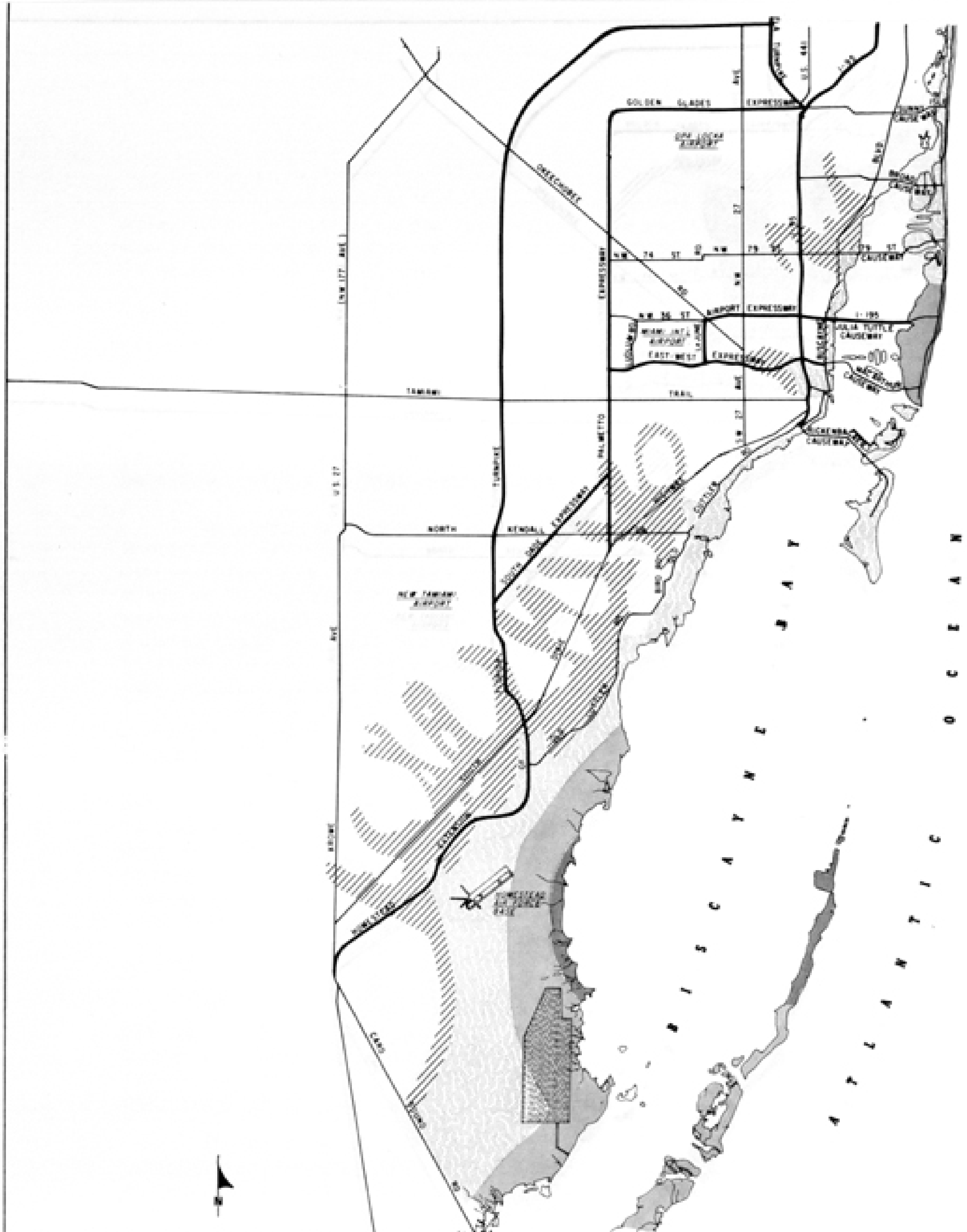
FIGURE 25

HYDROLOGIC CONSTRAINTS



FLOOD PROTECTION PROVIDED BY C.S.F.F.C.D. and DADE COUNTY PUBLIC WORKS (water control division)

FIGURE 26



FLOODING POTENTIAL IN DADE COUNTY FROM A HURRICANE WITH THE FOLLOWING CHARACTERISTICS:

CENTRAL PRESSURE - - - - - - - 940 MILLIBARS

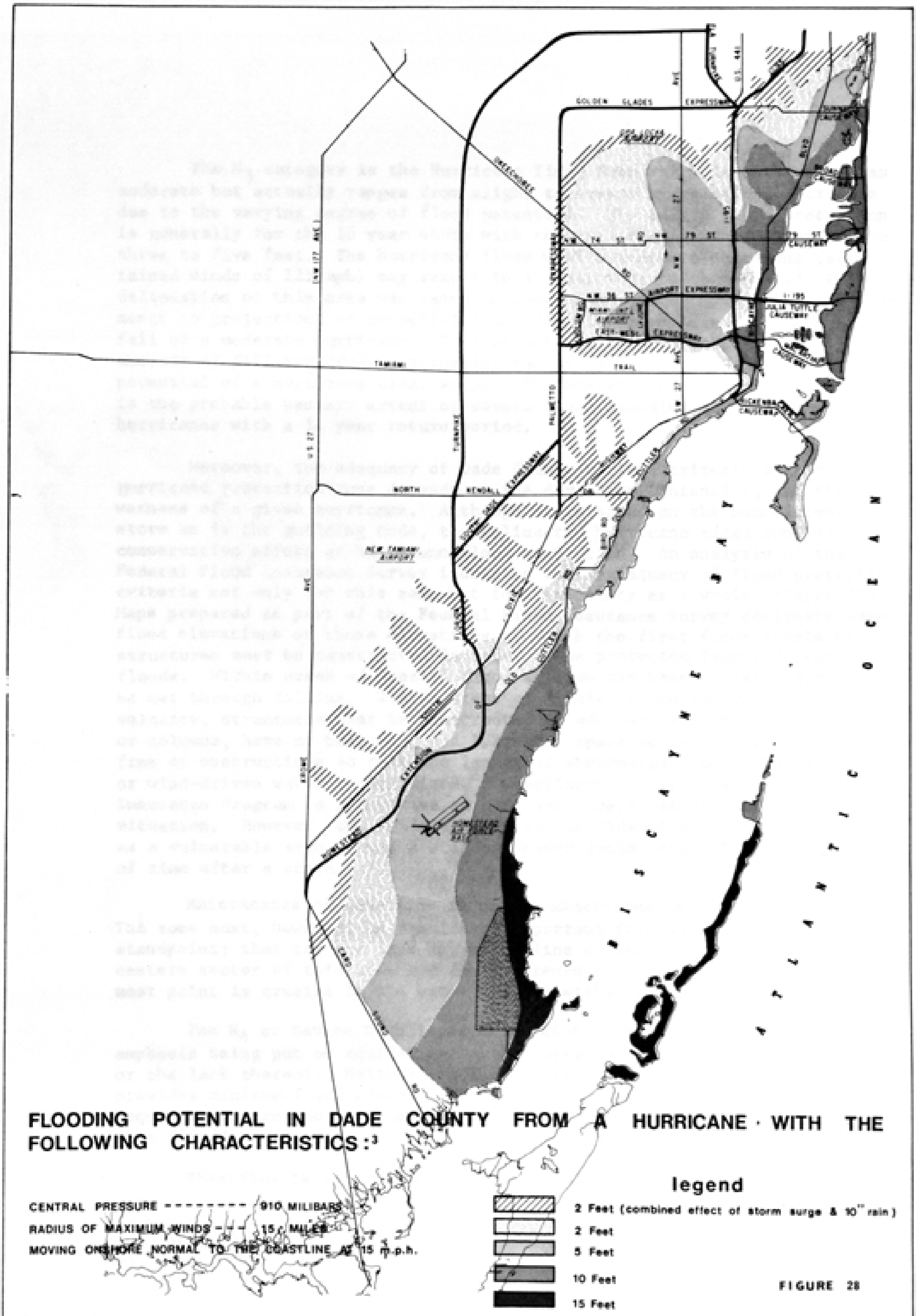
RADIUS OF MAXIMUM WINDS - - - 15 MILES

MOVING ONSHORE NORMAL TO THE COASTLINE AT 15 m.p.h.

legend

- 2 Feet (combined effect of storm surge & 10" rain)
- 2 Feet
- 5 Feet
- 10 Feet

FIGURE 27



FLOODING POTENTIAL IN DADE COUNTY FROM A HURRICANE WITH THE FOLLOWING CHARACTERISTICS: [3]

CENTRAL PRESSURE -------- 910 MILIBARS

RADIUS OF MAXIMUM WINDS ---- 15 MILES

MOVING ONSHORE NORMAL TO THE COASTLINE AT 15 m.p.h.

FIGURE 28

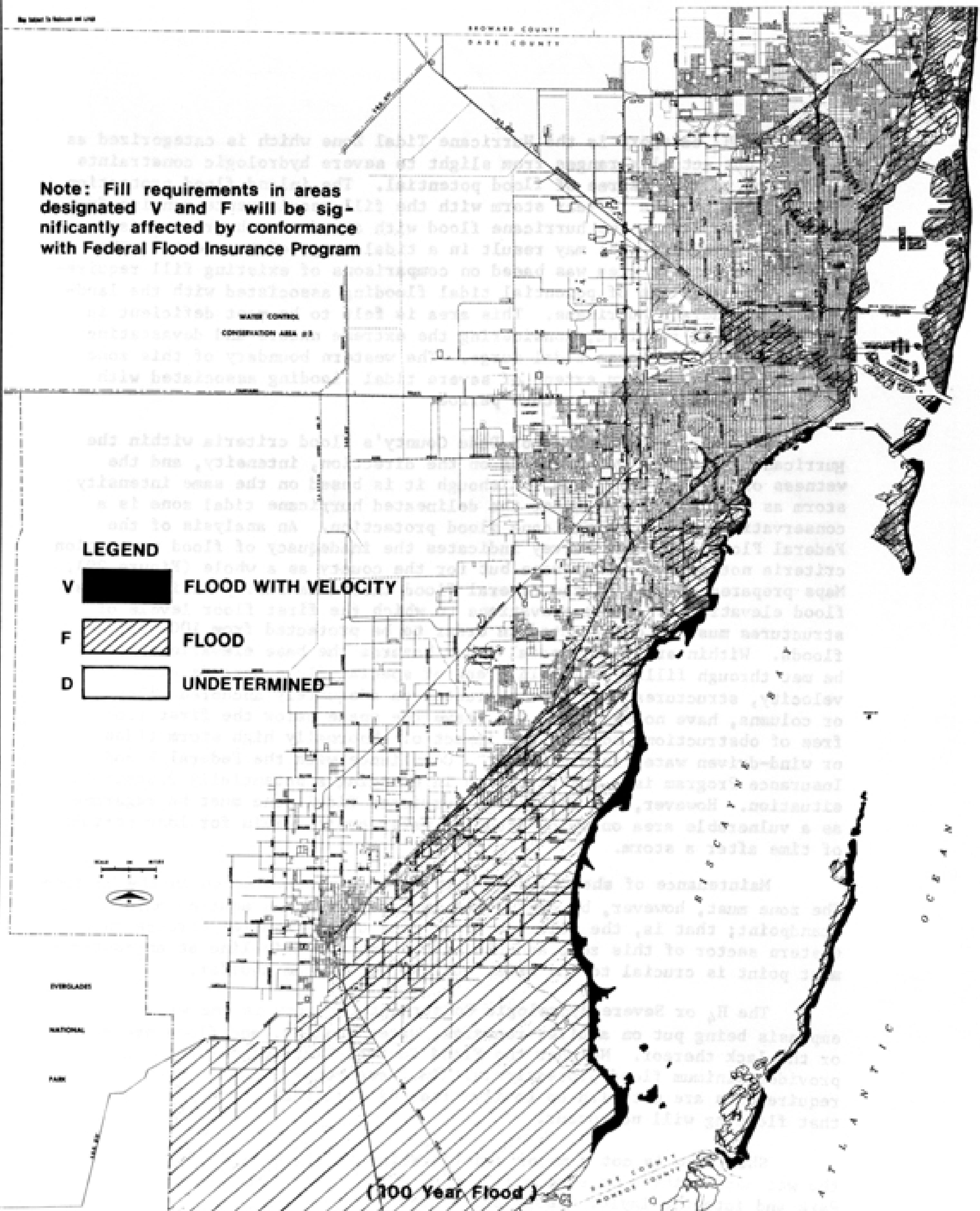
The H_3 category is the Hurricane Tidal Zone which is categorized as moderate but actually ranges from slight to severe hydrologic constraints due to the varying degree of flood potential. The inland flood protection is generally for the 10 year storm with the fill requirements ranging from three to five feet. The hurricane flood with a moderate hurricane (sustained winds of 125 mph) may result in a tidal surge of ten feet.[1] The delineation of this area was based on comparisons of existing fill requirements to projections of potential tidal flooding associated with the landfall of a moderate hurricane. This area is felt to be most deficient in amounts of fill required, considering the extreme nature and devastating potential of a hurricane tidal surge. The western boundary of this zone is the probable western extent of severe tidal flooding associated with hurricanes with a 14 year return period.

Moreover, the adequacy of Dade County's flood criteria within the Hurricane Protection Zone depends on the direction, intensity, and the wetness of a given hurricane. Although it is based on the same intensity storm as is the Building Code, the delineated hurricane tidal zone is a conservative effort at hurricane flood protection. An analysis of the Federal Flood Insurance Survey indicates the inadequacy of flood protection criteria not only for this zone but for the county as a whole (Figure 29). Maps prepared as part of the Federal Flood Insurance Survey designate base flood elevations or those elevations to which the first floor levels of structures must be constructed in order to be protected from 100 year floods. Within areas of special flood hazards the base elevations may be met through filling. Within areas of special flood hazards with velocity, structures must be constructed on adequately anchored piles or columns, have no basement, and leave the space below the first floor free of obstructions so that the impact of abnormally high storm tides or wind-driven water is minimized.[2] Compliance with the Federal Flood Insurance Program is a positive step in avoiding a potentially disastrous situation. However, the designated Hurricane Tidal Zone must be regarded as a vulnerable area on which standing water could remain for long periods of time after a storm.

Maintenance of sheetflow is only a minor consideration in the H_3 zone. The zone must, however, be considered important from an aquifer maintenance standpoint; that is, the salt intrusion line of the aquifer borders the eastern sector of this zone and the maintenance of this line at an eastern-most point is crucial to the water quality within the aquifer.

The H_4 or Severe Hydrologic Constraint category is one with primary emphasis being put on aquifer recharge, water quality, and flood protection or the lack thereof. Neither the Flood Control District nor the County provides minimum flood protection within these zones. Thus, where fill requirements are met with up to five feet of fill there is no assurance that flooding will not occur.

Sheetflow is not a major consideration in all H_4 areas although during the wet season there is some overland flow from H_4 areas into the National Park and into the Taylor Slough Basin north of the Park. Also, there is some sheetflow to the marshes in the Southern Coastal Province (See figure 30).

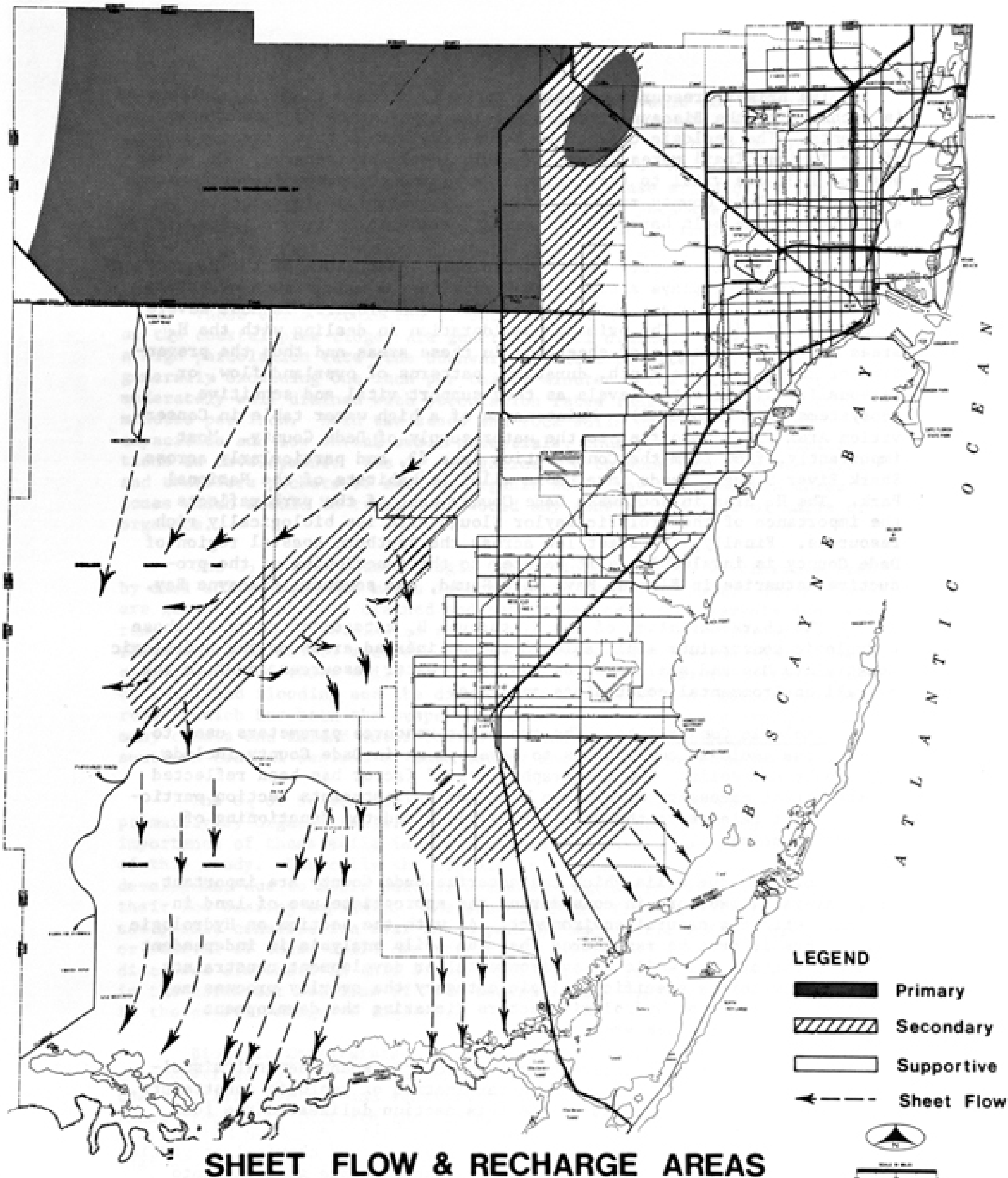


(100 Year Flood)

AREAS OF GREATEST FLOOD POTENTIAL

(As defined by the DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, Federal Insurance Administration)

FIGURE 29



SHEET FLOW & RECHARGE AREAS

FIGURE 30

The primary resource parameter to be considered in the H_4 categories is recharge of the Biscayne Aquifer for the maintenance of groundwater gradients. The geologic character of the area within this category north of the Tamiami Trail makes it particularly ideal for recharge. The areas west of L-31 are vital to the National Park; and the areas in southeastern and southern Dade County must be effectively controlled to maintain stability of the salt barrier line and estuarine salinity gradients.

The category of Very Severe Hydrologic Constraints or the H_5 category is one where water plays a significant role in the maintenance of natural ecosystems and also where the threat of life and property is most severe from tidal flooding. The primary consideration in dealing with the H_5 areas is the maintenance of sheetflow in these areas and thus the prevention of changes in the depth, duration, patterns of overland flow, or seasonality of the water levels as they support vital and sensitive ecosystems (see Figure 30). Maintenance of a high water table in Conservation Area #3 is important to the water supply of Dade County. Most importantly, flow from the Conservation Area #3, and particularly across Shark River Slough, feeds invaluable wildlife habitats of the National Park. The H_5 area in southwest Dade County east of the park reflects the importance of the prolific Taylor Slough with its biologically rich resources. Finally, the sheetflow across the southern coastal region of Dade County is invaluable as it relates to the functioning of the productive estuaries in Florida Bay, Card Sound, and southern Biscayne Bay.

The characteristics of the H_1 through H_5 categories serve as those hydrologic constraints applicable to the delineated areas on the Hydrologic Constraints Map and shall provide the basic water resources input to the overall environmental constraints analysis.

Geologic Constraints. The two major resource parameters used to dictate the geologic constraints to development in Dade County include topography and soils. The topographic relief factor has been reflected to the extent necessary within the Hydrologic Constraints section particularly as it relates to the water table level and the functioning of conveyance canals.

However, the soils which characterize Dade County are important from several viewpoints in considering the appropriate use of land in harmony with the natural environment. As with the section on Hydrologic Constraints it must be remembered that the soils analysis is independent of other factors and while no environmental or development constraints may appear within a specific geologic category the overlay process may result in biologic or hydrologic factors dictating the development implications for a given area.

Initially, eight different soil associations and several miscellaneous soils were analyzed in the determination of geologic constraints. Although the initial analysis within this section delineated the four basic soil types--sands, rockland, marls, and shallow and deep phase organics--through the analysis of various physical and chemical properties of the various soils it was determined that appropriate grouping into three constraints groups would be manageable and would not detract from the study's credibility. Therefore, the sands, rockdales and rockland soils were grouped under the G_1 or Minor Geologic Constraints category (See Figure 31 The marl soils composed the G_2 or Moderate Geologic Constraints category and the deep and shallow phase organics formed the G_3 or Severe Geologic Constraints category. The parameters for determining the constraints characteristic of these soils include percolation rates, bearing capacity, shrink swell potential, and depth of organic material.

Those soils within the G_1 category, which are located primarily on the coastal pine ridge, are generally well drained. Most sands have a high percolation rate (the downward movement of water through soil) generally exceeding one inch per thirty minutes. The rock soils are moderately well drained with percolation rates ranging from 30 to 60 minutes per inch. Both the sands and rock soils have high bearing capacities and low shrink swell potentials, thus presenting no limitations to development. The G_1 categories are to some extent generalized and therefore pockets of marl or organic soils may exist within these zones which should be treated as would any generalized zone of marls or organics.

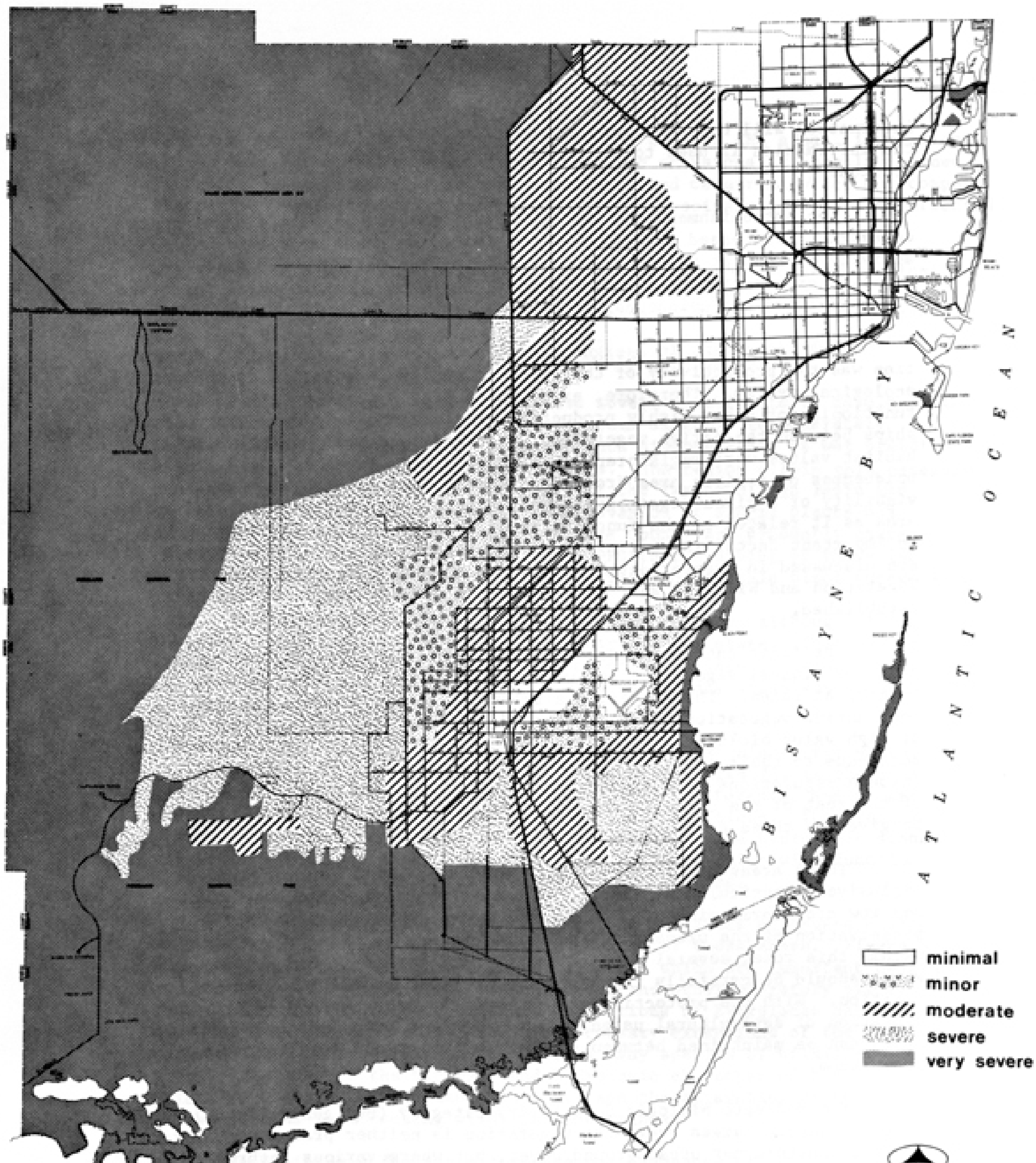
The G_2 or Moderate Geologic Constraints category is characterized by marl soils, with the marls in some cases overlying peat. The marls are generally not well drained and have moderately slow percolation rates, ranging from 60 to 90 minutes per inch. The shrink swell potential of these soils is low to moderate and the bearing capacity the same. The significance of these soils as they relate to development is the problem of localized flooding and the disposal of generally poor quality surface runoff which has been the suspected cause of water quality problems in many canals and inland water bodies. These soils are located in the southern coastal regions of Dade County and within the transverse glades.

The G_3 or Severe Geologic Constraints category is characterized primarily by organic soils. An indepth analysis of the character and importance of these soils is available in the Environmental Setting Chapter of this study. Basically the organic soils present many obstacles to development due to their natural wetness, high shrink swell potential and their low bearing capacity. The present South Florida Building Code does not permit construction over these peat or muck soils and the destruction or removal of these soils can result in a series of water quality problems discussed elsewhere in this study. The organic soils are located primarily in the northwest sections of Dade County in the Everglades Waterway and in the coastal mangrove regions.

<u>Biologic Constraints</u>. The Biologic Constraints Composite is characterized by five environmental sensitivity categories which reflect the viability, value, and sensitivity of various biological communities. These properties indicate the biological constraints which range from minimal to very severe (see Figure 32). In addition to terrestrial vegetative communities consideration is also given to the aquatic communities within Biscayne Bay and Card Sound. Although the Biscayne Bay

GEOLOGIC CONSTRAINTS

FIGURE 31



BIOLOGIC CONSTRAINTS

FIGURE 32

information will not form part of the five biological constraint categories, the information is used to determine the criteria necessary for Bay protection.

The establishment and the ranking of the five biologic constraints categories were based primarily on the following considerations: wildlife activity or habitat values characteristic of the various vegetative communities or associations; the viability or existing condition of the given community; and the uniqueness of natural features.

Most important in assigning values to the given biological communities was the productivity of the given community in relation to the total ecological system. Therefore, areas which are integrally tied to the functioning of other highly productive areas or where synergistic relationships between the native vegetation, wildlife, and soils exist, high habitat values were registered. Values were also ascribed based on the uniqueness of a given area from an aesthetic standpoint. Finally, the viability of a given vegetative association or the contiguousness of an area as it related to the functioning of the surrounding environment was an important factor in ranking areas of biologic value. These factors are discussed in greater depth in the Environmental Setting Chapter under Vegetation and Wildlife and their relevance and applicability has been established.

The first category under Biologic Constraints encompasses those areas of minimal vegetative and wildlife value and has been assigned a B_1 habitat value. These areas are urban and suburban landscape where most native vegetation has been removed. Within this category are pockets of high value biologic areas. Such unique areas within the minimal value zone--due to their scarcity and isolated nature--will be dealt with through regulations specific to their situation. The scarified nature of the rest of the urban landscape dictates that no special attention be given to these areas.

Those areas of Minor Biologic Constraints (B_2) include, almost exclusively, agricultural land. The native vegetation has been removed and row crops predominate. The major concern in these areas is the preservation of the present agricultural character. However, there are, within this zone, several hammock forests and stands of Dade County Pine which should be carefully regulated due to their scarcity and ecological function. With the protection of the hammocks and pineland and the continuation of agricultural usage in some of these areas effective buffer zones can be maintained between urban development and functioning natural ecosystems.

The Moderate Biologic Sensitivity category (B_3) generally delineates somewhat natural areas where the vegetation is neither predominantly row crop agriculture nor urban ground cover, but where various anthropogenic changes have occurred. These areas have often been drained and, accompanying the lowering of the water table, have been subject to burning and scarification. Most of the areas were formerly wet prairies or marshes;

though a high water table still characterizes some of the areas, inundation of the land is not prolonged. These areas are occasionally heavily invaded by exotic plants, primarily shinus, melaleuca, and casuarina, which out-compete the native vegetation. The drainage and organic soils oxidation also affected the vegetative character of these areas.

The Redlands, due to their unique character of associated tropical grovelands and pinelands, is considered an area of Moderate Biologic Constraints (B_3). Though some of this area is in row crops special attention must be given to the overall character of the area in order to conserve it as an identifiable, unique community in Dade County.

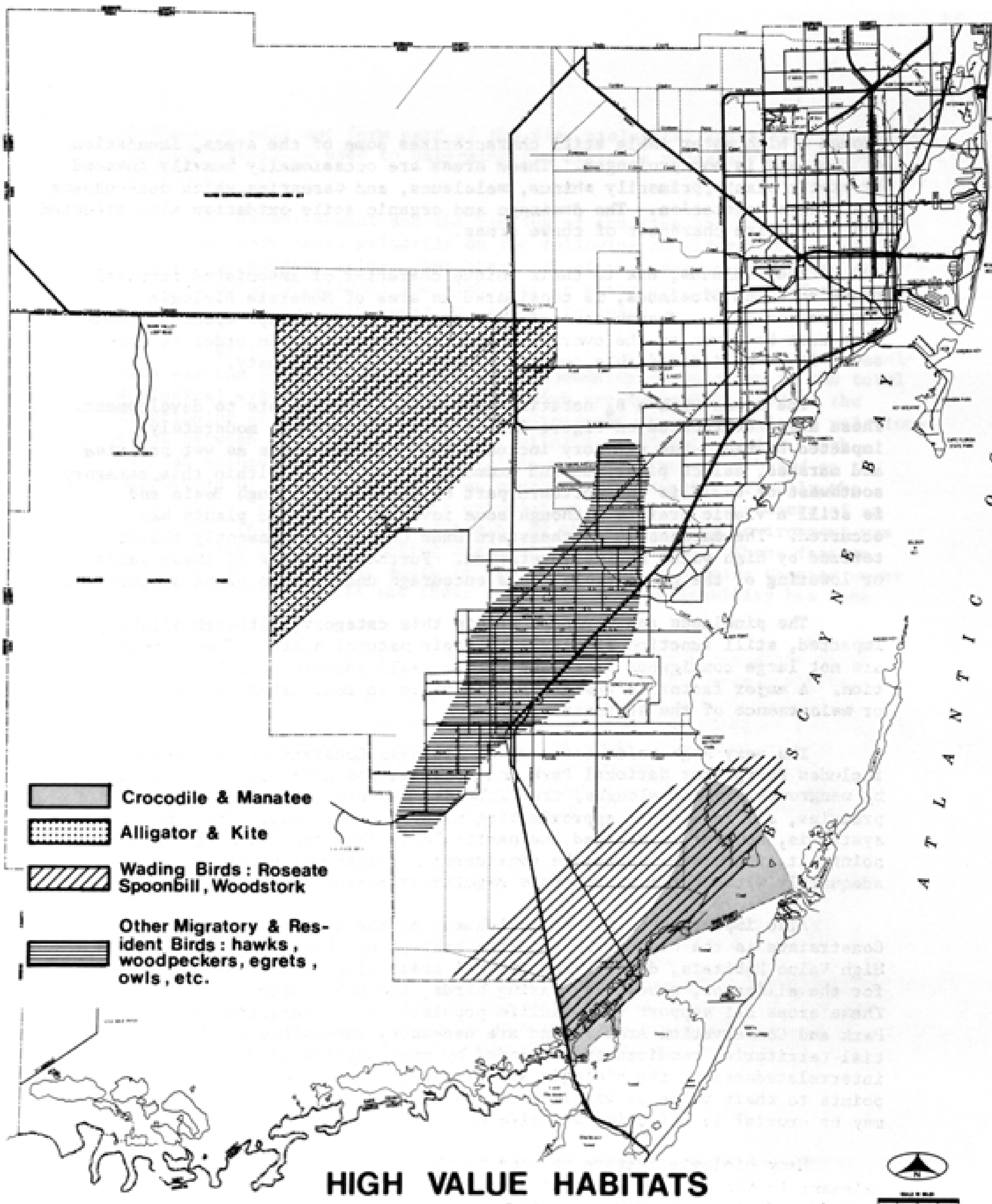
The areas with a B_4 notation have severe constraints to development. These areas delineated on Figure 31 are areas slightly to moderately impacted by man. The category includes such diverse areas as wet prairies and marshes, select pinelands and hammocks. The region within this category southwest of L-31N is the northern part of the Taylor Slough Basin and is still a viable prairie although some invasion of exotic plants has occurred. The marshes in southeastern Dade County are presently characterized by high value native vegetation. Further draining of these lands or lowering of the water table could encourage undesirable plant succession.

The pinelands and hammocks within this category, although slightly impacted, still function similarly to their natural state. These areas are not large contiguous areas but rather small pockets of valuable vegetation. A major factor in assigning this value to many areas was uniqueness or maintenance of the ecotones.

The very high value category of Biologic Constraints (B_5) which includes Everglades National Park and Conservation Area #3, is characterized by mangroves, inland sloughs, tree islands, cypress forests, and coastal prairies, all in a state approximating natural conditions. The overall system is, however, a managed one particularly from the hydrologic standpoint; it, therefore, cannot be considered a system which will function adequately without the appropriate regulatory measures.

Also important in the establishment of the areas of Severe Biologic Constraints is the high value wildlife habitat of these zones. Figure 33, High Value Habitats, depicts the general areas which are important habitats for the alligator, crocodile, wading birds, and other migratory birds. These areas all support the wildlife populations of Everglades National Park and Conservation Area #3 and are necessary extensions of the residential territorial requirements demanded by many species of wildlife. The interrelatedness of the biologic and hydrologic character of these areas points to their value as viable habitats and the alteration of these factors may be crucial in affecting wildlife populations.

Many biologic factors related to the character of Biscayne Bay are relevant to the determination of environmental constraints on the land area of Dade County. Since the treatment of Biscayne Bay within this Environmental Protection Guide was not a part of the overlay process or



HIGH VALUE HABITATS

(Outside Everglades National Park and Conservation Area 3)

FIGURE 33

methodology being discussed here the discussion and analysis pertinent to Biscayne Bay is presented in the Environmental Zone Description Chapter.

The Composite Overlay Process

Having described each of the inputs into the Hydrologic, Geologic, and Biologic Constraints Maps it is appropriate to explain how these three Constraints Maps interrelate to produce the Environmental Protection Zone Map for Dade County.

Each composite was illustrated on a transparent overlay. As was indicated previously each category within each composite was assigned a numerical value from 1 to 5 or 1 to 3, indicating ranking from minor to very severe environmental constraints as they relate to development. When the three composite maps, Hydrologic Constraints, Geologic Constraints, and Biologic Constraints, having five, three, and five categories respectively, were overlaid the result was a final Environmental Constraints Composite Map. Figure 34, Final Composite Insert, is a sample of that map. Each of the potential 75 areas (5 x 3 x 5 = 75) has a designated numerical value which may be interpreted based on the following chart.

Hydrologic Constraints

1 = Minor	4 = Severe
2 = Slight	5 = Very Severe
3 = Moderate	

Geologic Constraints

1 = Minor	3 = Severe
2 = Moderate	

Biologic Constraints

1 = Minimal	4 = Severe
2 = Minor	5 = Very Severe
3 = Moderate	

Using the above numerical system ordered consistently with Hydrology first, Geology second, and Biology third the Final Composite Insert would be interpreted as indicated by the following example:

#433: Severe Hydrologic Constraints
Severe Geologic Constraints
Moderate Biologic Constraints

Not all of the 75 combinations that are arithmetically possible will occur in nature. One such impossibility would be H_1-G_1-B_5, the numerical designation which would be assigned to a well-drained area, with sandy or rocky soils, coinciding geographically with a viable freshwater marsh or mangrove community.

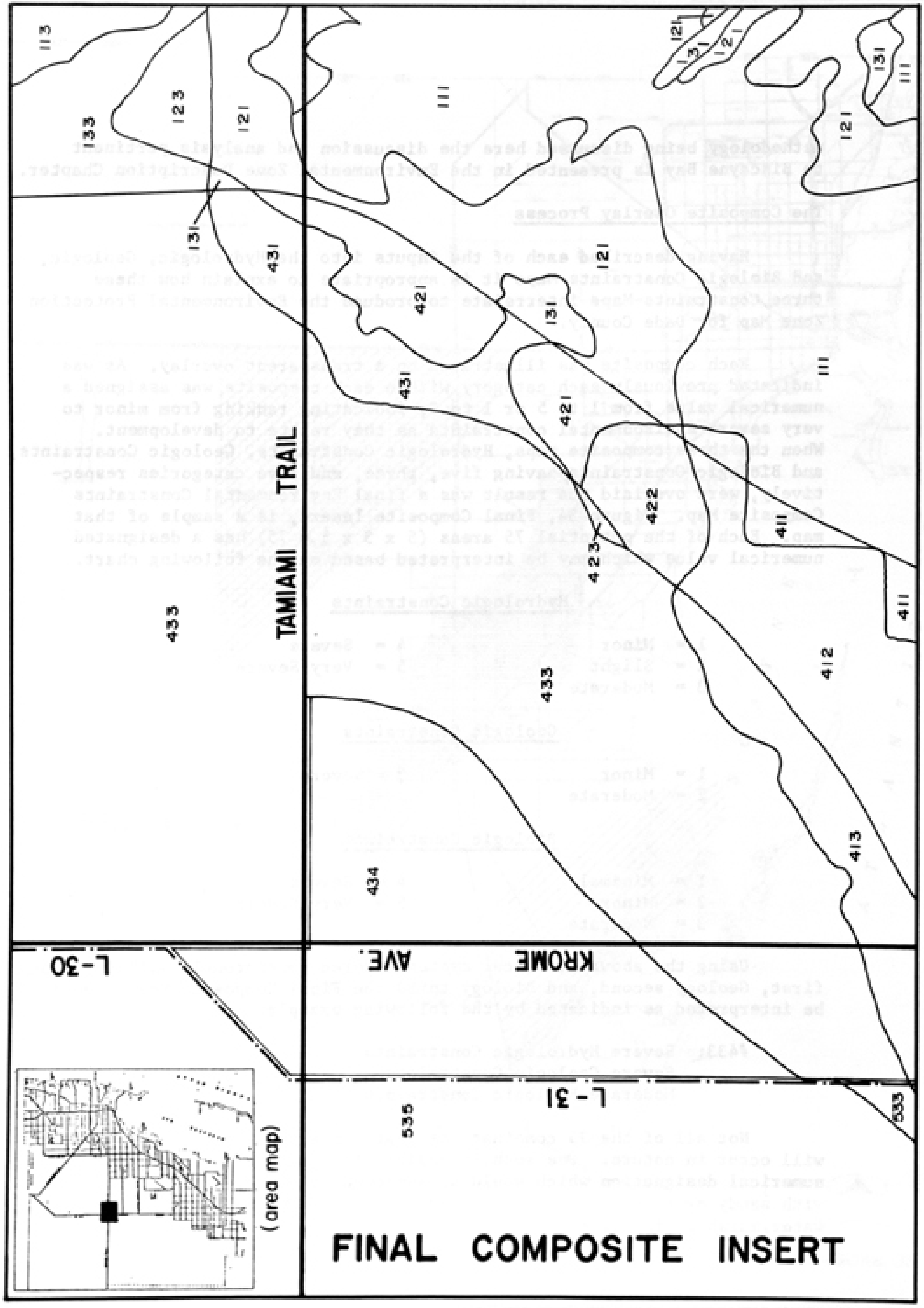

FINAL COMPOSITE INSERT
TAMIAMI TRAIL
KROME AVE.
L-30
L-31
(area map)
113
123
121
133
131
111
431
421
422
423
411
412
413
433
434
535
533

FIGURE 34

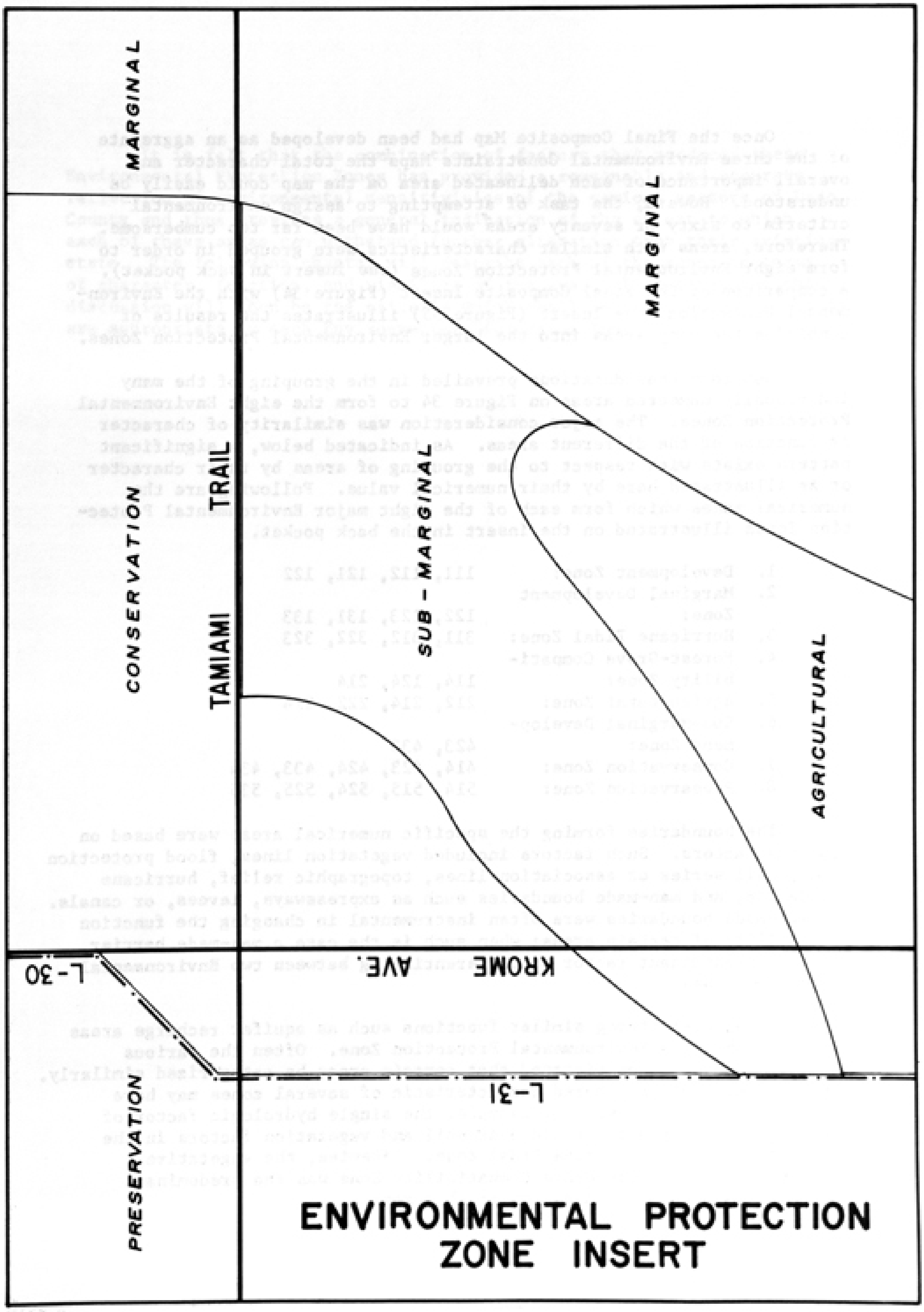

MARGINAL
CONSERVATION
TAMIAMI TRAIL
SUB-MARGINAL
MARGINAL
AGRICULTURAL
L-30
KROME AVE.
L-31
PRESERVATION
ENVIRONMENTAL PROTECTION
ZONE INSERT

FIGURE 35

Once the Final Composite Map had been developed as an aggregate of the three Environmental Constraints Maps the total character and overall importance of each delineated area on the map could easily be understood. However, the task of attempting to assign environmental criteria to sixty or seventy areas would have been far too cumbersome. Therefore, areas with similar characteristics were grouped in order to form eight Environmental Protection Zones (see insert in back pocket). A comparison of the Final Composite Insert (Figure 34) with the Environmental Protection Zone Insert (Figure 35) illustrates the results of combining the many areas into the larger Environmental Protection Zones.

Numerous considerations prevailed in the grouping of the many individually numbered areas on Figure 34 to form the eight Environmental Protection Zones. The major consideration was similarity of character or function of the different areas. As indicated below, a significant pattern exists with respect to the grouping of areas by their character or as illustrated here by their numerical value. Following are the numerical zones which form each of the eight major Environmental Protection Zones illustrated on the insert in the back pocket.

1. Development Zone:	111, 112, 121, 122
2. Marginal Development Zone:	122, 123, 131, 133
3. Hurricane Tidal Zone:	311, 312, 322, 323
4. Forest-Grove Compatibility Zone:	114, 124, 214
5. Agricultural Zone:	212, 214, 222, 224
6. Sub-Marginal Development Zone:	423, 433
7. Conservation Zone:	414, 423, 424, 433, 434
8. Preservation Zone:	514, 515, 524, 525, 535

The boundaries forming the specific numerical areas were based on numerous factors. Such factors included vegetation lines, flood protection lines, soil series or association lines, topographic relief, hurricane inundation, and man-made boundaries such as expressways, levees, or canals. The man-made boundaries were often instrumental in changing the function or viability of certain areas; when such is the case a man-made barrier may be a predominant factor in differentiating between two Environmental Protection Zones.

Areas with strong similar functions such as aquifer recharge areas fell into the same Environmental Protection Zone. Often the various physiographic features dictated that certain areas be categorized similarly. A single overwhelming shared characteristic of several zones may have determined the grouping. For example, the single hydrologic factor of hurricane inundation prevailed over soil and vegetation factors in the delineation of the Hurricane Tidal Zone. Likewise, the vegetative character of the Forest-Grove Compatibility Zone was the predominant factor in setting the boundaries of this zone.

It is felt that the combination of factors that produced these Environmental Protection Zones has provided a reasonable and accurate reflection of environmental sensitivities of the various sectors of Dade County and thus provides a general indication of the extent to which each of these areas can withstand further alteration from their existing state. The following chapter will describe each of the zones in terms of character, function, and viability of the area. Emanating from this discussion will then be the criteria which shall indicate which activities are appropriate in each Environmental Protection Zone.

ZONE DESCRIPTIONS

Prior to the development of criteria for the Environmental Protection Zones it is necessary to understand the character of each zone. This chapter describes, in detail, some of these most pertinent characteristics. This is accomplished by describing the present environmental character of the area; alterations of the area from its natural state; the area's existing value; and existing or potential conflicting land uses.

Preservation Zone

The Preservation Zone is the most environmentally sensitive of the zones delineated in this study. Although much of the zone is managed due to extensive water control devices, the geologic and biologic nature of the zone approximates natural conditions. Uses permitted within this zone must be very limited and should in no way adversely affect the viability of the functioning ecosystems. The Preservation Zone consists of four subzones, each of which is described below.

Water Conservation Area #3 (P-1)

This preservation subzone occupies the extreme northwestern section of Dade County (see Figure 37). It is bordered on the west by Collier and Monroe Counties, on the north by Broward County, on the east by the Central and Southern Florida Flood Control District's Levees 33 and 30, and on the south by U.S. Highway 41 - Tamiami Trail - and Everglades National Park. The approximate size of this subzone is 360 square miles. As delineated above, this Preservation Zone includes the portions of the Big Cypress Swamp within Dade County. The 35 square miles is presently within the boundary of the Big Cypress Swamp "Area of Critical State Concern" and funds for its acquisition should soon be appropriated.

The subzone is characterized generally as part of the "Everglades Waterway". Thus the area is primarily a slough or wet prairie with sawgrass, sedges, tree islands, and bay and willow heads being the principal vegetation identified there. The subzone is relatively flat with the sheetflow movement across it being almost imperceptible. The elevations range from 10 feet above mean sea level (msl) in the northwest cypress region to 6 feet above msl in the southeast prairie region.

The underlying bedrock is Miami Oolite, a highly permeable limestone. The soils range from Ochopee fine sandy marls in the west to Loxahachee peat (shallow and deep phase) and Everglades peat in the east.

The vegetation in the subzone includes cypress swamps with major cypress stands in the northwest, sawgrass and wet prairie, bay heads, willow heads, and tree islands including hardwood hammocks.

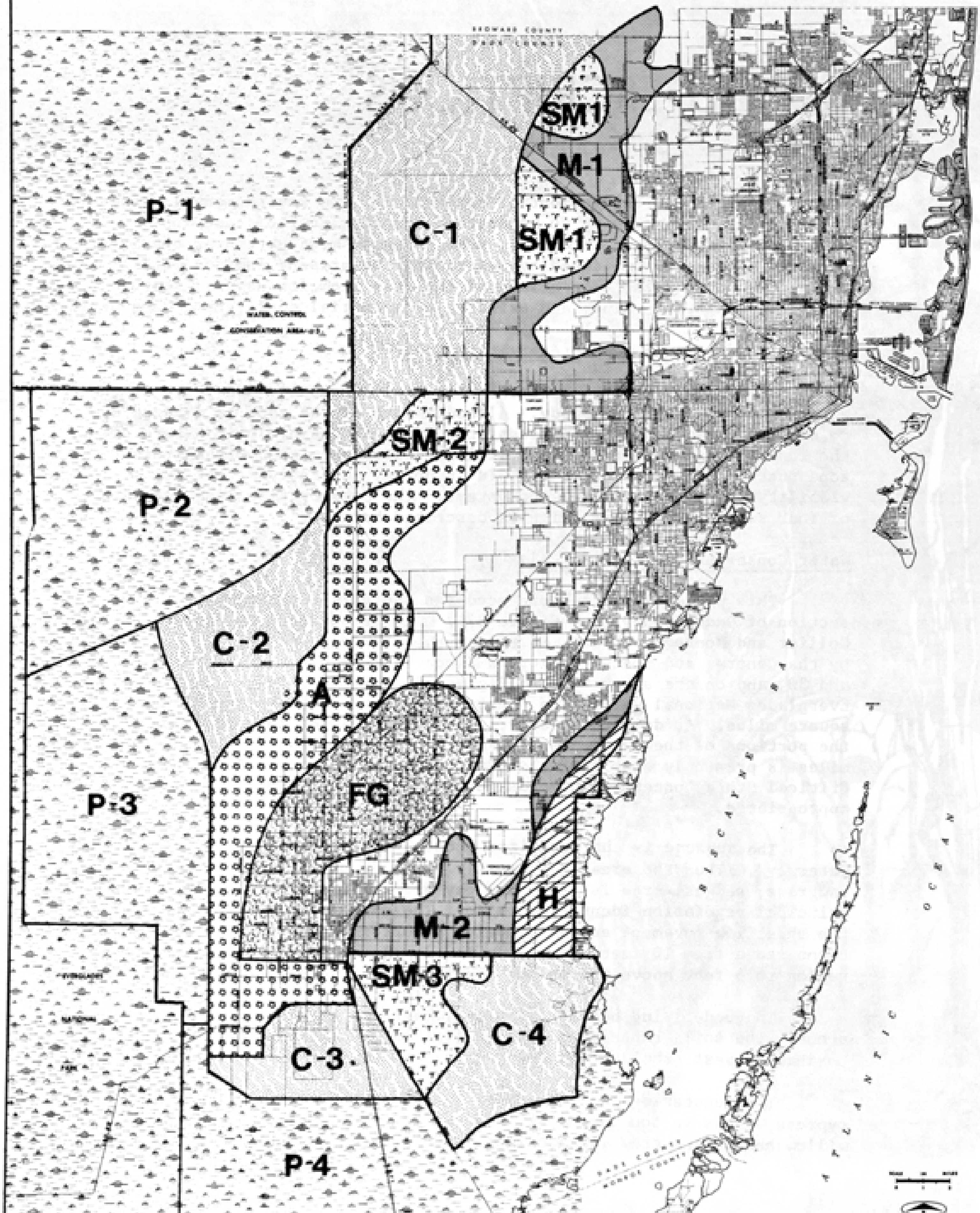
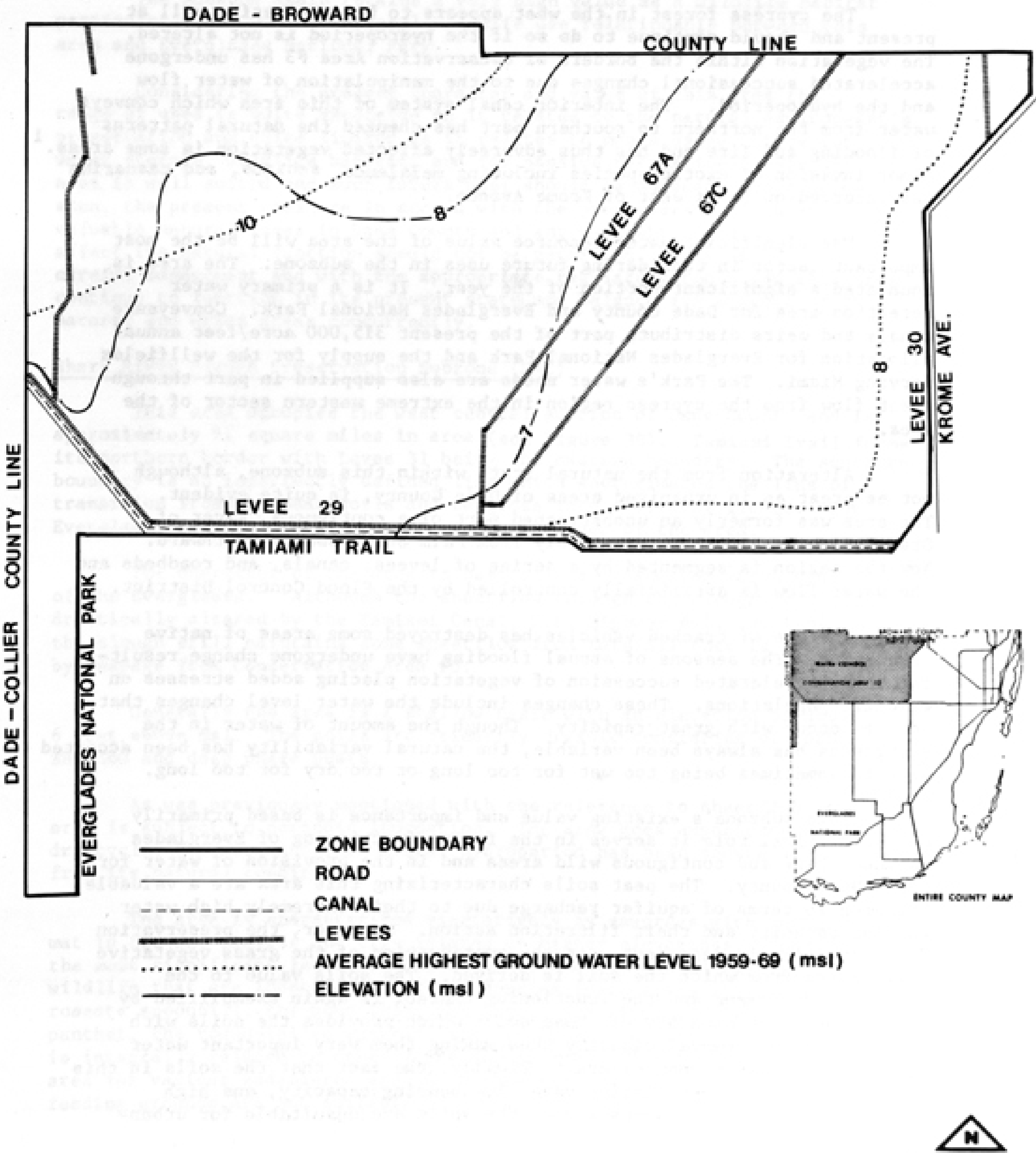


FIGURE 36

ENVIRONMENTAL PROTECTION ZONES



WATER CONSERVATION AREA 3 P-1

FIGURE 37

The cypress forest in the west appears to be propagating well at present and should continue to do so if the hydroperiod is not altered. The vegetation within the borders of Conservation Area #3 has undergone accelerated successional changes due to the manipulation of water flow and the hydroperiod. The interior canal system of this area which conveys water from the northern to southern part has changed the natural patterns of flooding and fire and has thus adversely affected vegetation in some areas.[1] Minor invasion of exotic species including melaleuca, schinus, and casuarina has occurred on berms west of Krome Avenue.

The significant water resource value of the area will be the most important factor in considering future uses in the subzone. The area is inundated a significant portion of the year. It is a primary water retention area for Dade County and Everglades National Park. Conveyance canals and weirs distribute part of the present 315,000 acre/feet annual allocation for Everglades National Park and the supply for the wellfields serving Miami. The Park's water needs are also supplied in part through sheet flow from the cypress region in the extreme western sector of the area.

Alteration from the natural state within this subzone, although not as great as in urbanized areas of Dade County, is quite evident. The area was formerly an unobstructed part of a contiguous "River of Grass" flowing almost imperceptibly from Palm Beach County southward. Now the region is segmented by a series of levees, canals, and roadbeds and the water flow is artificially controlled by the Flood Control District.

The use of tracked vehicles has destroyed some areas of native vegetation. The seasons of annual flooding have undergone change resulting in an accelerated succession of vegetation placing added stresses on wildlife populations. These changes include the water level changes that now can occur with great rapidity. Though the amount of water in the Everglades has always been variable, the natural variability has been accented with it sometimes being too wet for too long or too dry for too long.

This subzone's existing value and importance is based primarily on the critical role it serves in the future functioning of Everglades National Park and contiguous wild areas and in the provision of water for urban Dade County. The peat soils characterizing this area are a valuable resource in terms of aquifer recharge due to their extremely high water holding capacity and their filtration action. Moreover, the preservation of these soils is dependent upon the continuation of the grass vegetative communities from which the soil is derived. The soils value to the natural environment and the functioning thereof is again exemplified by the ion exchange capacity of these soils which provides the soils with a high nutrient removal capacity thus making them very important water quality maintenance controllers.[2] Finally, the fact that the soils in this subzone have a low percolation rate, low bearing capacity, and high shrink-swell capacity suggests that the soils are unsuitable for urbanization.

The subzone again retains a very high value as a wildlife habitat particularly due to the integral wildlife use relationship between this area and Everglades National Park.

Considering the present character and value of this area the range of uses is quite extensive as it relates to the natural environment's preservation and quite limited as it relates to man's usage. Thus for water storage, wildlife habitat, and for passive recreational uses, the area is well suited and such future uses should be pursued. In conclusion, the present uses are in accord with the preservation of these valuable natural areas in Dade County and any uses which would detrimentally affect its natural function should not be permitted. Only with careful management and with the appropriate regulatory tools can this area continue to function in its present state and balance its support of the natural and urban areas concurrently.

Shark River Slough Preservation Subzone (P-2)

This area occupies the west central section of Dade County and is approximately 91 square miles in area (see Figure 38). Tamiami Trail forms its northern border with Levee 31 being the eastern boundary. The southern boundary is an imperfectly defined line which approximates the line of transition from the peat soils and sawgrass into the rocky glades. The Everglades National Park forms the western border of the area.

The character of the area is basically a freshwater marsh typical of the Everglades. Although the sheetflow through the slough is drastically altered by the Tamiami Canal, U.S. Highway #41, and L-67 Ext., the slough still maintains some sheetflow from rainfall that is supported by seepage from Conservation Area #3.

Generally the area is a shallow basin with an elevation of about 6 feet above msl. The soils are primarily organic consisting of both shallow and deep phase peats.

As was previously mentioned with the reference to sheetflow, the area is subject to periodic inundation. The area does experience a wet-dry cycle, however, and the natural hydroperiod has been shortened somewhat from its natural condition.

The area is characterized vegetatively by sawgrass with periphyton mat in the wet prairie and tree islands on higher elevations. Perhaps the most significant factor in this area is the endangered species wildlife that are inhabitants. These species include the alligator, the roseate spoonbill, the wood ibis, the Everglades kite, the Everglades panther, the round-tailed muskrat, and the Everglades mink. The area is integrally related to other areas and is used extensively as a feeding area for various endangered species during periods when their primary feeding grounds are not suitable.

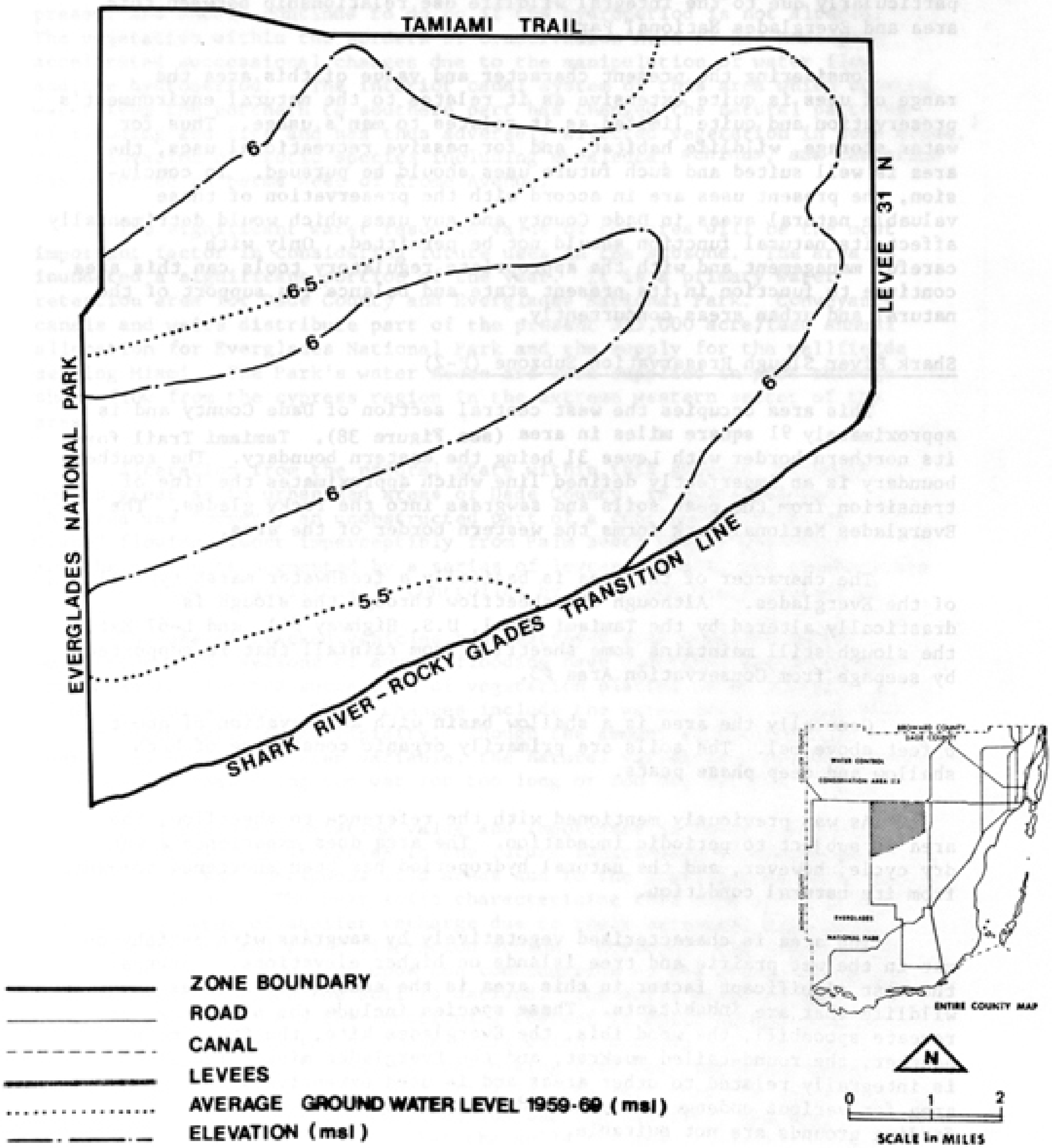


FIGURE 38

SHARK RIVER SLOUGH PRESERVATION SUBZONE P-2

Alterations from the natural state have not been significant in this area to date. However, the hydroperiod has changed and willows in the area have consequently been burned. The levees on three sides of the area (north, east, west) also indicate the artificiality of the system managing this area. Alterations of the surface area within the ocky lades area to the south are indicative of the impending threat of development in this area. As an area of perennial high water levels (Figures 8, 9, 10) it contributes to groundwater movement to southeast Dade County. Lowering water levels in P-2 would result in proportional lowering of levels downgradient (south and southeasterly).

The subzone is important as a recharge area of nutrient rich water for Everglades National Park. Important soil producing succulent vegetation as well as periphyton characterizes the area and forms part of the self perpetuating system which can be maintained in this area if an adequate water table and the appropriate hydroperiod is maintained.

The range of alternative uses is somewhat limited in this area due to the integral relationships between this area and the Park. The uses characteristic of such a preservation zone might include passive recreation, wildlife habitat, and a water retention area. Few conflicts exist in the area presently or due to proposed projects. However, the platting of land in the southeast sector of the zone and the laying out of roads is indicative of development pressure which is occurring in this area.

Taylor Slough Basin Preservation Subzone (P-3)

This basin which encompasses the headwaters of Taylor Slough is contiguous to and crucial to the eastern portion of Everglades National Park (see Figure 39). This subzone is bordered on the west by Everglades National Park, on the north by Shark River Slough, on the east by the eastern limit of the Taylor Slough drainage basin and L-31, and on the south by the Park and State Road 27.

This subzone ranges in elevation from 7 feet in the north to just under 5 feet near the park entrance. The soils are predominantly rockland covered in some areas by shallow marls in this 81 square mile area.

The basin provides an important source of fresh water that enters the National Park just north of the park headquarters. Although the overland flow from this basin into the park is of shorter duration than flow through Shark River Slough, it is more rapid than the Shark River Slough flow. The mean monthly flow in Taylor Slough thus ranges from .01 cubic feet per second in April to 152 cubic feet per second in September. Virtually all of the flow out of this basin is the result of precipitation on the basin.[3]

Vegetatively the area is a wet prairie consisting of grasses, sedges, and small tree islands. Wildlife includes various invertebrates, fishes, amphibians, reptiles, and birds.

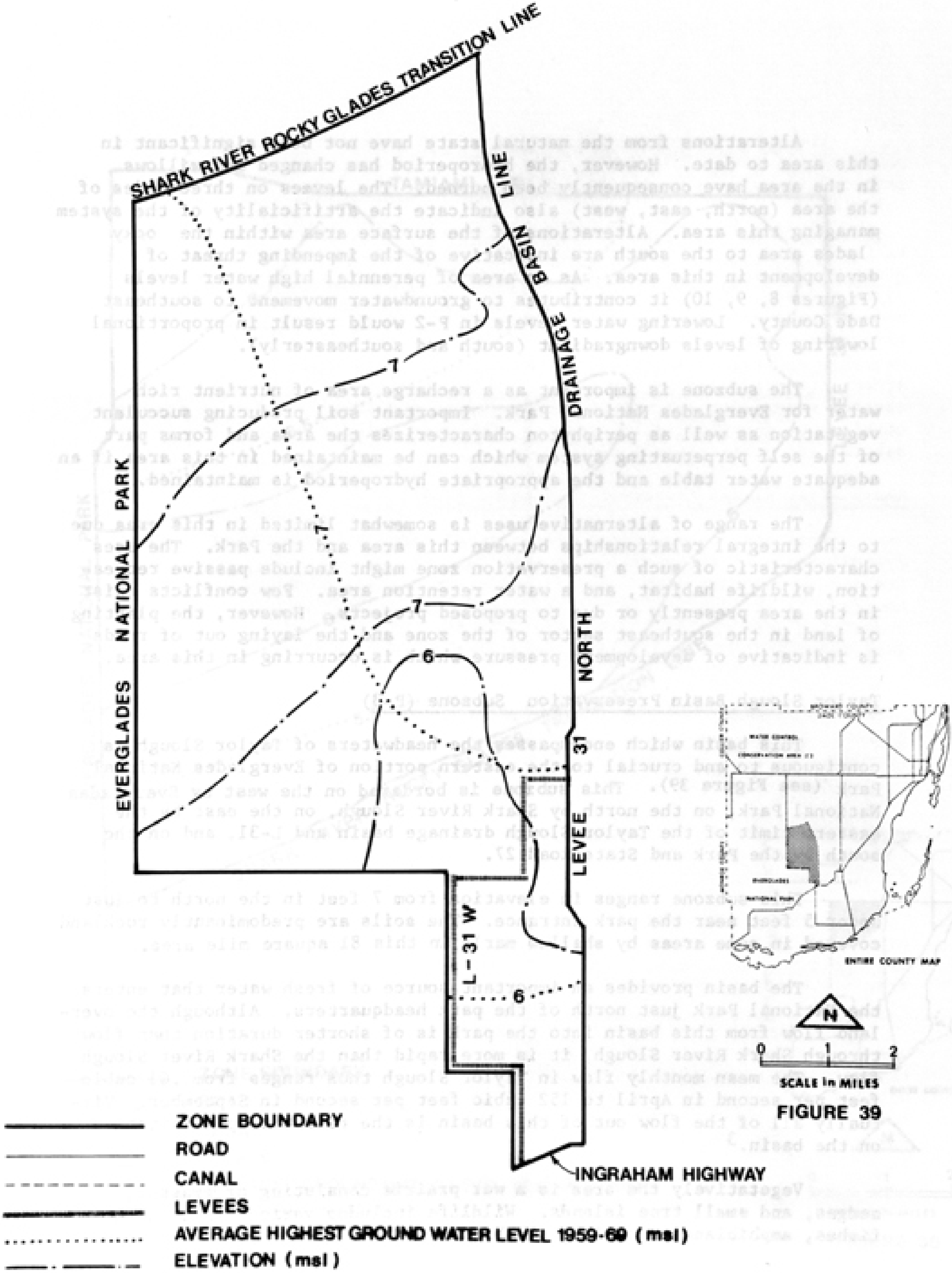


FIGURE 39

TAYLOR SLOUGH BASIN PRESERVATION SUBZONE P-3

The construction of several canals and levees have had some effects on the hydrology of the Taylor Slough Subzone. Levee 31N and C-111 have created an artificial border on the east where the higher elevations of the coastal pine ridge previously formed the natural eastern boundary of the basin. A proposed project to convey more water into the Taylor Slough by diverting water from Conservation Area 3 to the north through the expansion of L-31 borrow canal is in the planning stage. This project would guarantee adequate flow to the slough and considerable care is being taken to insure that the increase of flow will not adversely affect the flora and fauna of the slough.

It would be appropriate to point out that the Flood Control District has established official policy relative to future construction of flood control works as recently as February 1974. Notable among the deactivated works were various projects in this subzone and the next discussed subzone. Flood Control District deactivated works include "the remaining works of the 1962 authorization for south Dade County and all of the 1965 authorization for southwest Dade County." Comments by the F.C.D. Executive Director exemplify the overall change in F.C.D. policy which should be considered throughout this study when questions of the development potential of wetlands in western Dade County arise. "Deciding not to dig in these instances instead of just going ahead with whatever was authorized years ago, is appropriate to the orientation of today's F.C.D. toward preservation of the environment. If works are needed and justified, fine--but if the economics or environmental consequences are doubtful we are standing pat."[4]

The Taylor Slough Basin's value lies in its importance as a source of fresh water that enters the eastern portion of Everglades National Park. This water, which flows southward across Flamingo Road, is crucial to the major attraction of the Park--Royal Palm Visitor Center. Here are alligator holes, marshes, and a tropical hardwood hammock. Taylor Slough is also essential to the maintenance of viable habitat areas for wildlife in the eastern portion of the park. The vegetation and the variety of fauna in this area depend on this water for survival.

As with the other preservation zones this area is crucial to the maintenance of the viable functioning Everglades ecosystem. Thus, the range of alternative uses of the area should include water preserve, hunting and fishing area, camping use, nature study, or other passive recreation uses that would not interfere with the viability of the basin.

The basin is now characterized by some significant conflicts between a range of compatible uses and actual or proposed uses in the area. First, the nearby agricultural activity poses little threat to the water quality of the slough from pesticides or fertilizers. However, any significant expansion of agriculture into the basin could severely affect the water quality and threaten the existence of fauna and flora in the slough.

Effective land use controls are paramount and the allowance of industrial or residential development in this zone may be tantamount

SOUTHERN COASTAL PRESERVATION SUBZONE P-4

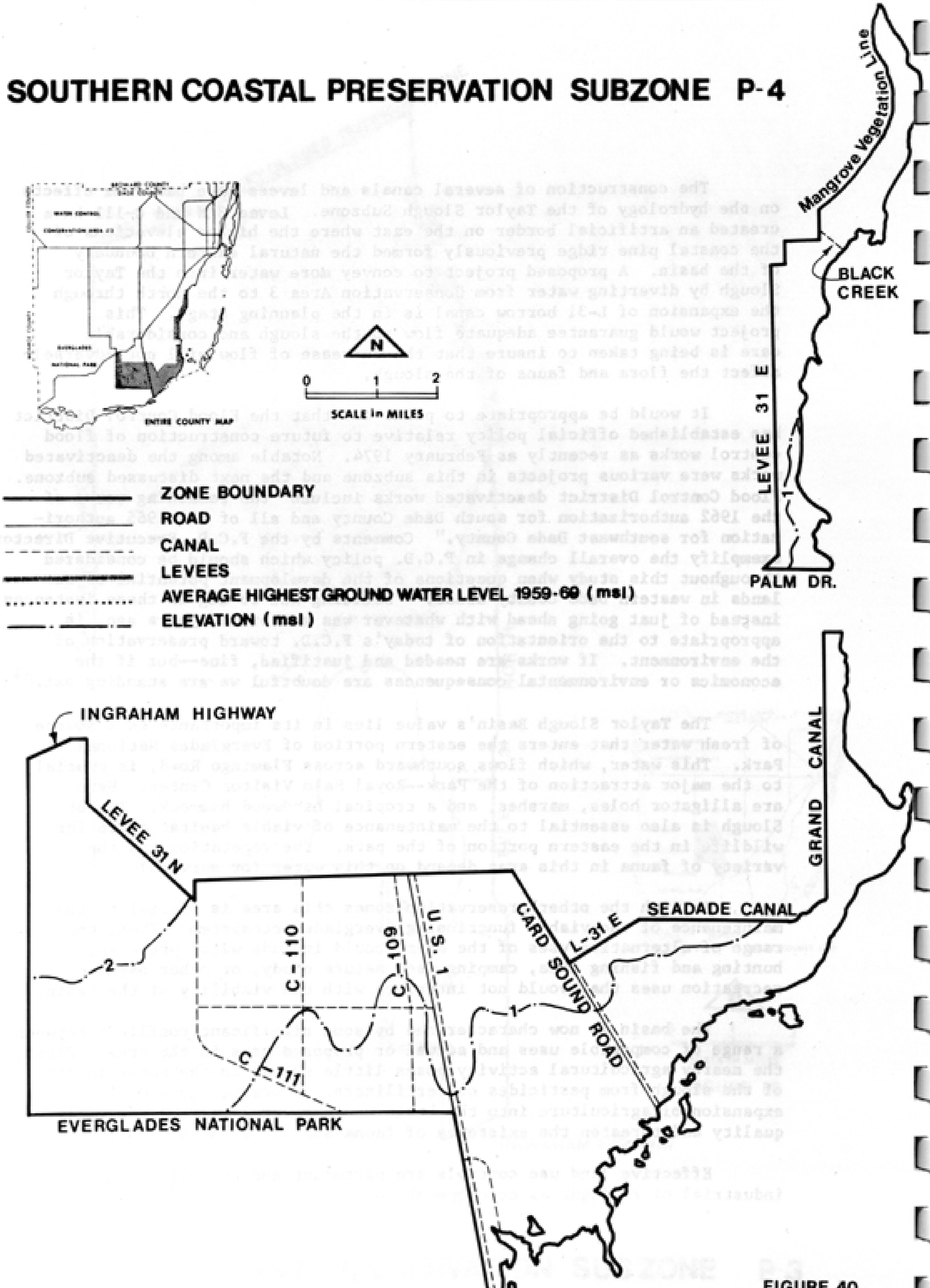


FIGURE 40

to permitting the destruction of the natural ecosystems characterizing the basin.

Southern Coastal Preservation Subzone (P-4)

This region of salt and fresh water marshes occupies the southernmost sector of Dade County (see Figure 40). Everglades National Park forms the western border, and the Park, Card Sound and Barnes Sound constitute the boundary on the south. The eastern boundaries include Biscayne Bay and Card Sound. The northern boundaries are Canal 111, and a line from the middle of Section 22-58-38 to the center of 21-58-39. The surface area of this subzone is approximately 77 square miles.

The topography is characterized by elevations ranging from a maximum of five feet above msl near the park entrance grading almost imperceptably down to sea level to the south and east. However, the majority of the area lies below the 3 foot elevation.

The western quarter of the zone is primarily marl soil over bedrock with marl over peat characterizing the eastern portions of the subzone. Mangrove peat underlies the estuarine areas along the coast where the elevation is generally less than one foot above msl.

Mean annual water table levels range from msl to 3 feet above msl generally, with a high of 5 feet msl near the park entrance. Most of the subzone, therefore, is inundated on an annual basis to a depth of at least one foot. Inundation in the southern portions of the area is more frequent and longer lasting than in the northern sector. The northern reaches of the subzone west of U.S. Route #1 are bisected by Canals 111, 110, and 109. Although C-111 is connected to tide, Canals 110 and 109 are presently plugged to prevent drainage of the area. Canal 111 is equipped with gated control structures to prevent overdrainage of the coastal region and to retard landward intrusion of saltwater. Canal 111 is also equipped with a levee on the north side of the canal which has a series of inlet structures which alleviate some of the ponding that backs up along the levee and U.S. #1. These inlets and the overflow structures on the south side of C-111 provide a semblance of natural sheetflow conditions across the canal which permits sheetflow to the coastal estuaries in southern Dade County.

Predominant vegetation in this subzone includes the spikerush, beakrush, and sawgrass typical of wet prairies. South of C-111 widely dispersed sloughs support the growth of shrubs and stunted trees. The algal-mat or periphyton community is a dominant feature which forms the foundation of the biological web of the freshwater marshes and also plays an important role as a water filtering agent and soil builder.

The wildlife habitat value of this area is extremely high. Numerous vertebrates, invertebrates, fishes, reptiles and amphibians including several endangered species inhabit the area. The mangrove estuaries are of extremely high productivity and serve as essential nesting areas for the crocodile and manatee.

Alterations within this area are primarily of a hydrologic nature. Historically the area was characterized by uninterrupted overland flow of freshwater during high water periods from the pine ridge in the vicinity of Florida City southward and eastward over the buttonwood embankment and into the coastal mangrove estuaries. This sheetflow provided for the wide dispersal of nutrients with productivity peaks being reached in the brackish - saline ecotone and in mangrove estuaries.

The natural conditions have since been altered by an aggressive drainage project undertaken in the mid 1960's to reclaim the southern wetlands northwest of L-31. Canal 111 in addition to its drainage function was intended to be used as a navigable waterway for barge traffic. However, at the insistence of various agencies and organizations, both public and private, Canals 109 and 110 were left with earthern plugs thus preventing the drainage of these valuable wetlands, and C-111 was equipped with gated control structures.

The U.S. 1 roadbed, C-109 plug and C-111 control structure have created a ponding situation where a vegetative reversal to wet prarie is taking place. U.S. 1 and Card Sound Road also act as levees thus isolating the intermediate area. Levee 31E, which parallels the Biscayne Bay coast, is a 7.5 foot levee constructed in 1966 to prevent tidal flooding in the lowlands east and north of Card Sound Road. This levee effectively prevents overland flow of fresh water into the coastal mangrove estuaries northeast of Card Sound Road thereby potentially decreasing the productivity of these estuarine areas.

Notwithstanding the fact that this area has been altered by a number of canals, levees and roads, the area is still a highly productive biological area; assuming no additional obstructions to sheetflow, the area can continue to function as a highly productive area. The area is still an intact expanse of wet prairies and sawgrass from which nutrient laden waters flow into the mangrove estuaries all along the south and southeastern coast of Dade County.

The prairie vegetation of the upland portions of this subzone supports diverse populations of organisms existing in delicate balance to form a food web which is basic to the consumer species inhabitating and protected by Everglades National Park but which nest and feed in this area outside the park. The exports from this coastal prairie ecosystem are transported down gradient by the overland flow of fresh water into the mangrove estuaries. It has been demonstrated that the productivity of the mangrove estuaries is dependent upon a steady input of terrestrial nutrients.[5] It has also been shown in other areas that the yield of gamefish must decline following red mangrove destruction even where there is further detritus production from seagrasses and from benthic macroalgae.[6] Maintenance of the mangrove estuaries and their integrally related marsh prairies is critical to the production of gamefish, commercial fish, and the perpetuation of all that man benefits from their existence.

The range of uses within this subzone as it relates to the value and present condition of the area is much the same as other preservation areas. Thus activities which would not upset the natural balance might include hunting, fishing, other forms of passive recreation, and use of the area for camping or as a wildlife habitat.

Potential conflicts between appropriate and existing or proposed uses do exist. Any development of the coastal marsh would not be in harmony with this environment. Removal of the earthern plugs in Canals 109 and 110 or of the salt barrier structure from C-111 would further drain the area and invite salt intrusion. Another potentially damaging activity would be the development of Mangrove Point to an active park in which destruction of mangroves would occur. A final conflict might be the proliferation of rock quarries in the area which would continue the scarification of the natural vegetation.

Conservation Zone

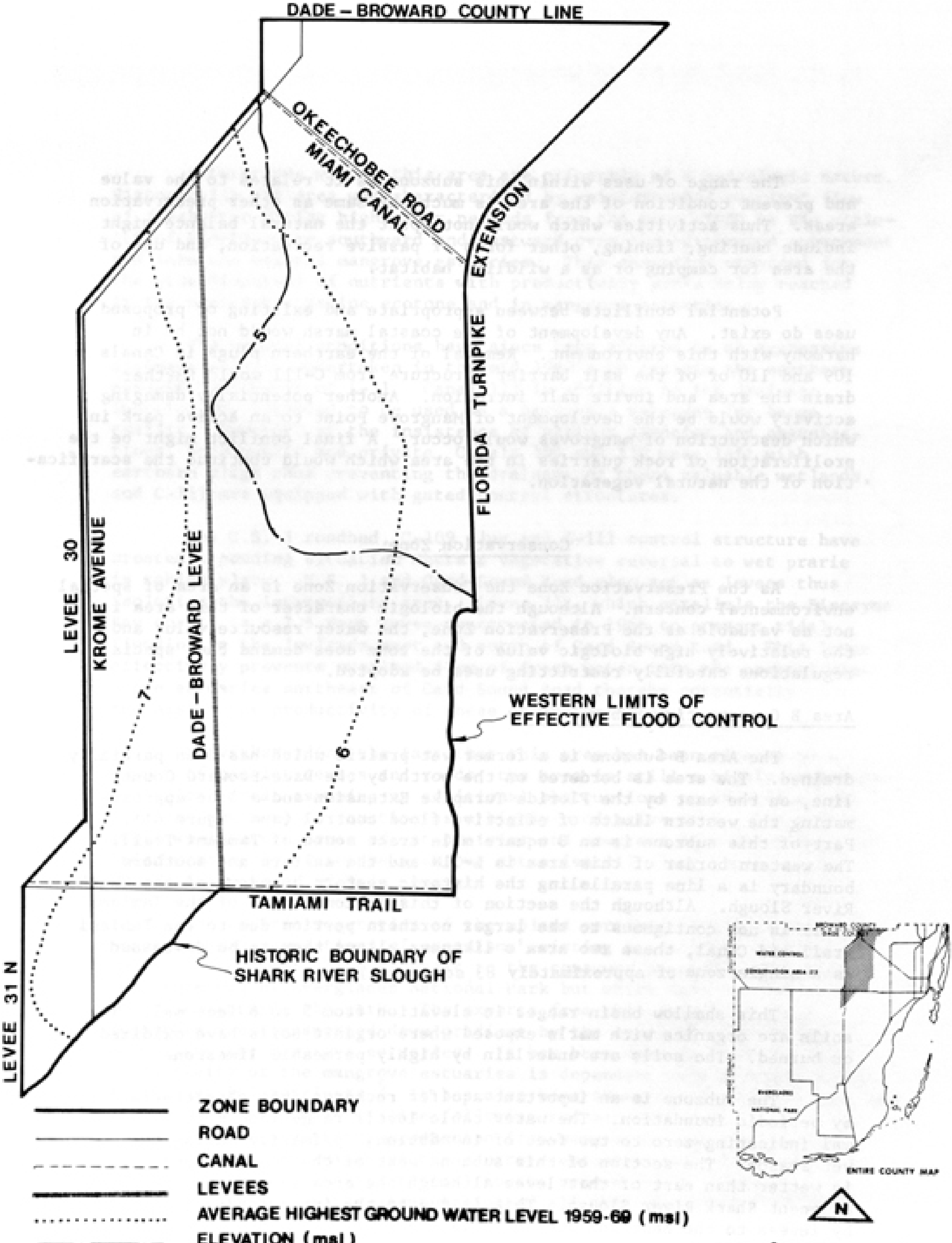
As the Preservation Zone the Conservation Zone is an area of special environmental concern. Although the biologic character of this area is not as valuable as the Preservation Zone, the water resource value and the relatively high biologic value of the zone does demand that special regulations carefully restricting uses be adopted.

Area B Conservation Subzone (C-1)

The Area B Subzone is a former wet prairie which has been partially drained. The area is bordered on the north by the Dade-Broward County line, on the east by the Florida Turnpike Extension and a line approximating the western limits of effective flood control (see Figure 41). Part of this subzone is an 8 square mile tract south of Tamiami Trail. The western border of this area is L-31N and the eastern and southern boundary is a line paralleling the historic eastern boundary of the Shark River Slough. Although the section of this subzone south of the Tamiami Trail is not contiguous to the larger northern portion due to the Tamiami Trail and Canal, these two area's likeness allows them to be discussed as a single zone of approximately 83 square miles.

This shallow basin ranges in elevation from 5 to 6 feet msl. The soils are organics with marls exposed where organic soils have oxidized or burned. The soils are underlain by highly permeable limestone.

The subzone is an important aquifer recharge area characterized by periodic inundation. The water table levels range from 4 to 7 feet msl indicating zero to two feet of inundation, primarily during the wet season. The section of this subzone west of the Dade-Broward levee is wetter than east of that levee although the area is not as wet as the adjacent Shark River Slough. This is due to the interception of runoff by levees to the east and west of this area and on the south by the Tamiami Trail.



CONSERVATION ZONE C-1

FIGURE 41

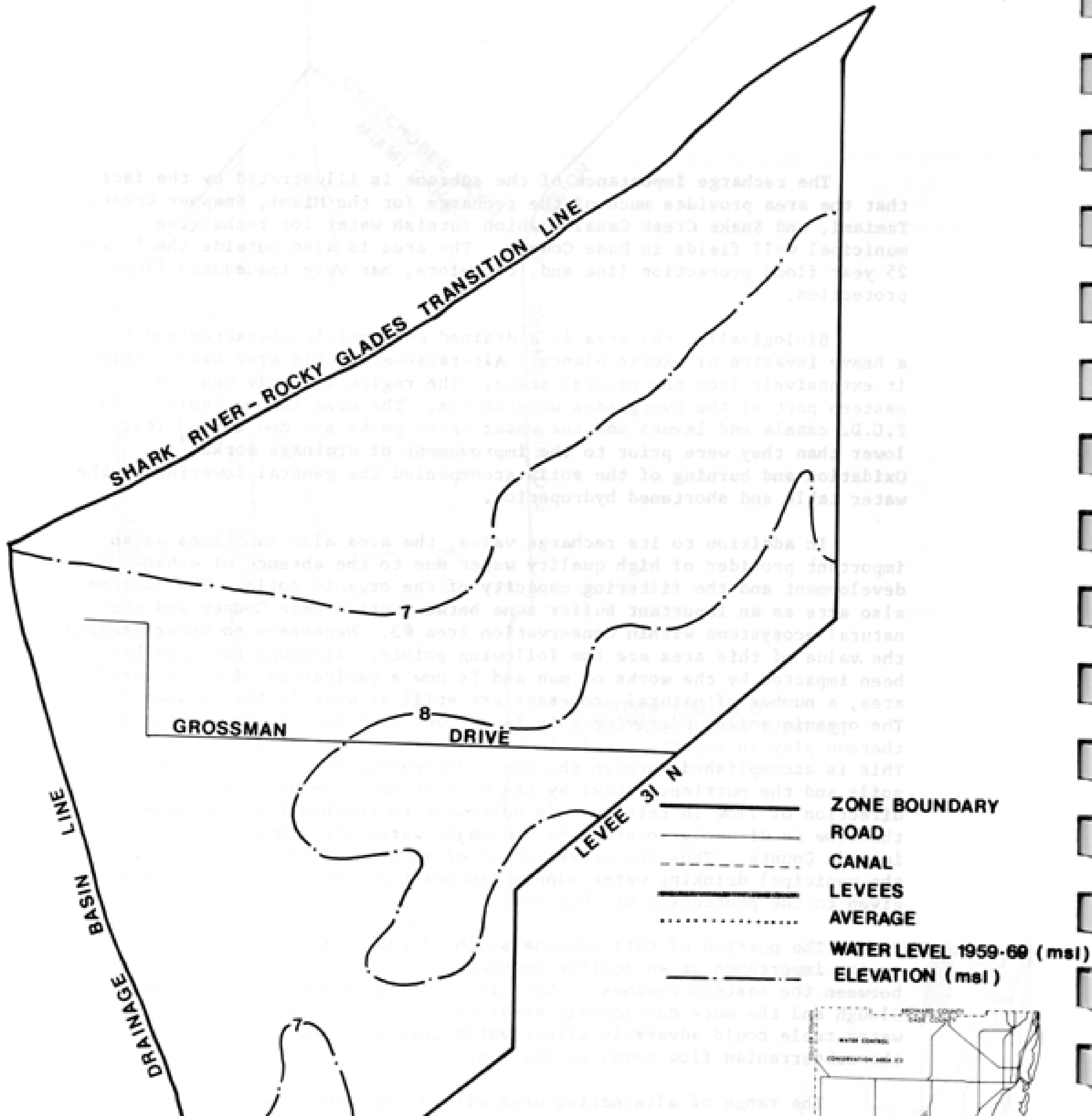
The recharge importance of the subzone is illustrated by the fact that the area provides much of the recharge for the Miami, Snapper Creek, Tamiami, and Snake Creek Canals, which furnish water for recharging municipal well fields in Dade County. The area is also outside the F.C.D. 25 year flood protection line and, therefore, has very inadequate flood protection.

Biologically, the area is a drained wet prairie characterized by a heavy invasion of exotic plants. Alterations in this area have changed it extensively from the natural state. The region formerly was the eastern part of the Everglades watercourse. The area is now isolated by F.C.D. canals and levees and the water level peaks are now 2 to 3 feet lower than they were prior to the improvement of drainage works.[7] Oxidation and burning of the soils accompanied the general lowering of the water table and shortened hydroperiod.

In addition to its recharge value, the area also functions as an important provider of high quality water due to the absence of urban development and the filtering capacity of the organic soils. The subzone also acts as an important buffer zone between urban Dade County and the natural ecosystems within Conservation Area #3. Necessary to understanding the value of this area are the following points. Although the area has been impacted by the works of man and is now a caricature of the natural area, a number of natural processes are still at work in the region. The organic soils underlying this former wet prairie and the vegetation thereon play an important role in the natural purification of water. This is accomplished through the ion exchange capacity of the organic soils and the nutrient uptake by the vegetation. The groundwater direction of flow in this area is northwest to southeast which means the flow is directly towards the two major water withdrawal points in Dade County. Thus the preservation of water quality as it relates to the municipal drinking water supply demands that prime consideration be given to the protection of this area.

The portion of this subzone south of the Tamiami Trail, in addition to its importance as an aquifer recharge area, functions as a buffer zone between the eastern reaches of the biologically productive Shark River Slough and the more developable areas to the east. The lowering of the water table could adversely affect water levels in Shark River Slough as the subterranian flow moves to the east.

The range of alternative uses within this Conservation Subzone as it relates to the area's value and existing condition is determined primarily by the environmental concern of ground-water quality. The terrestrial ecology has been impacted to such a degree that it serves little purpose as a wildlife habitat. However, the association of organic soils and prairie vegetation acts as a water purification system insuring percolation of a high quality water into the Biscayne Aquifer, the county's primary source of potable water.



ROCKY GLADES CONSERVATION SUBZONE

FIGURE 42

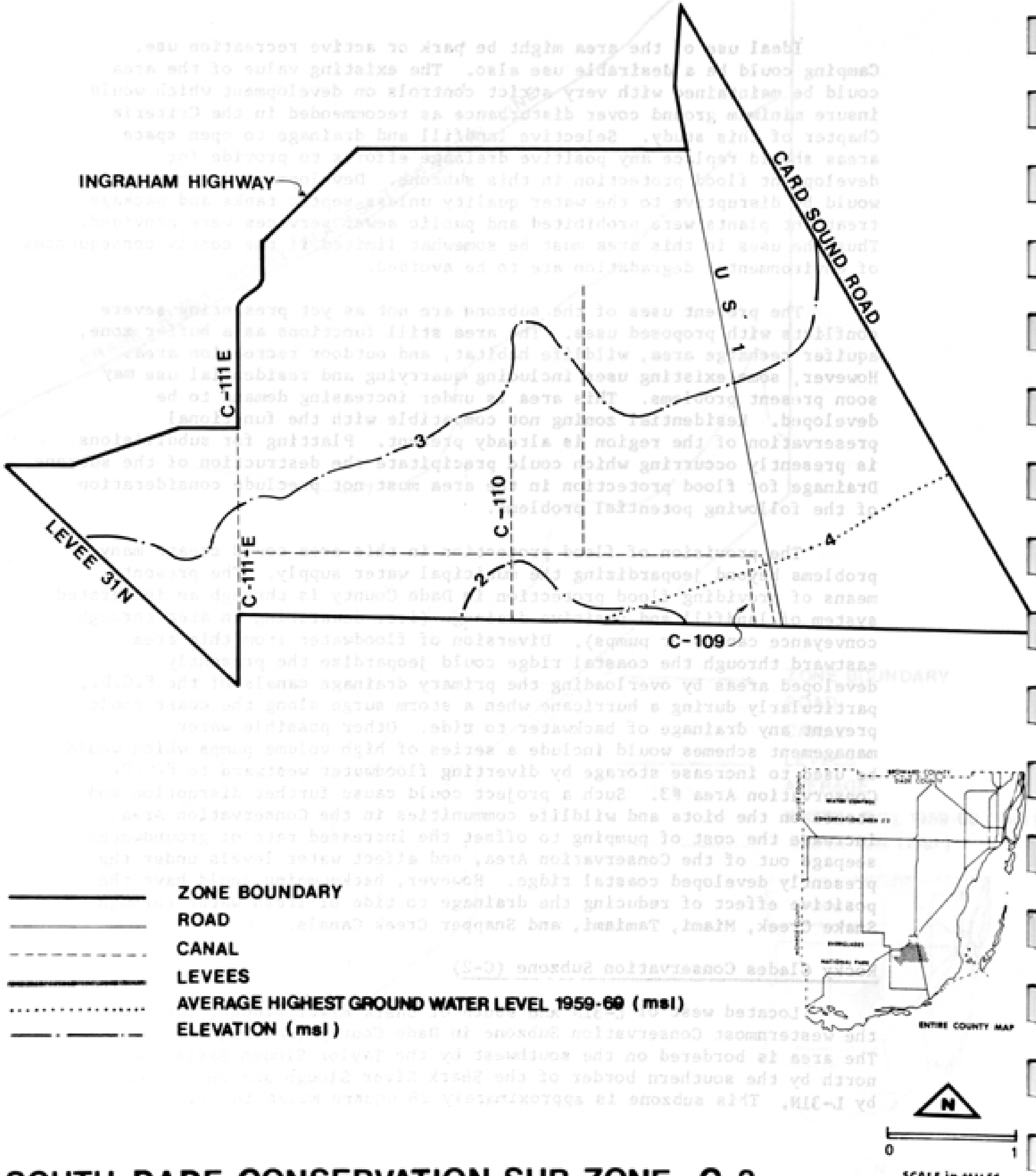
Ideal use of the area might be park or active recreation use. Camping could be a desirable use also. The existing value of the area could be maintained with very strict controls on development which would insure minimum ground cover disturbance as recommended in the Criteria Chapter of this study. Selective landfill and drainage to open space areas should replace any positive drainage efforts to provide for development flood protection in this subzone. Development in the area would be disruptive to the water quality unless septic tanks and package treatment plants were prohibited and public sewer services were provided. Thus the uses in this area must be somewhat limited if the costly consequences of environmental degradation are to be avoided.

The present uses of the subzone are not as yet presenting severe conflicts with proposed uses. The area still functions as a buffer zone, aquifer recharge area, wildlife habitat, and outdoor recreation area. However, some existing uses including quarrying and residential use may soon present problems. This area is under increasing demand to be developed. Residential zoning not compatible with the functional preservation of the region is already present. Platting for subdivisions is presently occurring which could precipitate the destruction of the subzone. Drainage for flood protection in the area must not preclude consideration of the following potential problems.

The provision of flood protection in this area could create many problems beyond jeopardizing the municipal water supply. The present means of providing flood protection in Dade County is through an integrated system of landfill and positive drainage (i.e. dewatering an area through conveyance canals or pumps). Diversion of floodwater from this area eastward through the coastal ridge could jeopardize the presently developed areas by overloading the primary drainage canals of the F.C.D., particularly during a hurricane when a storm surge along the coast could prevent any drainage of backwater to tide. Other possible water management schemes would include a series of high volume pumps which would be used to increase storage by diverting floodwater westward to F.C.D. Conservation Area #3. Such a project could cause further disruption and stress on the biota and wildlife communities in the Conservation Area, increase the cost of pumping to offset the increased rate of groundwater seepage out of the Conservation Area, and affect water levels under the presently developed coastal ridge. However, backpumping could have the positive effect of reducing the drainage to tide of fresh water through Snake Creek, Miami, Tamiami, and Snapper Creek Canals.

Rocky Glades Conservation Subzone (C-2)

Located west of L-31N and south of Shark River Slough, this is the westernmost Conservation Subzone in Dade County (see Figure 42). The area is bordered on the southwest by the Taylor Slough Basin, on the north by the southern border of the Shark River Slough and on the east by L-31N. This subzone is approximately 28 square miles in size.



SOUTH DADE CONSERVATION SUB-ZONE C-3

FIGURE 43

Topographically, the area is quite flat with elevations ranging from 7 to 8 feet msl. The soil is primarily rockland and is, in its natural state, characterized by numerous solution holes and outcroppings of limestone weathered to pinnacle rock.

The area is partially inundated during the wet season and is outside the area provided with flood protection by the F.C.D. However, internal drainage is good within this area and most drainage is subterranean and southeastward, then intercepted by L-31N. Soils other than the rock are scarce and, generally, are accumulated only in the solution holes.

The vegetation of the subzone is marsh with sawgrass, sedges, and small tree islands predominating. Deer and various birds may be found in the natural areas. Innundation of this area, which occurs as a result of the rising of the water table during the wet season, has been gradually diminishing in recent years; this may be due to increased water withdrawals or diversions upgradient, improved outlets downgradient, natural climatic occurances, or a combination of these. Consequently this area has been less of a challenge to hardy agricultural minded settlers. Numerous roads and small farms now characterize the area once deemed unsuitable for agricultural activity which requires dry land during the growing season. The impact of this development is not great at this time, but as minor flooding plagues such agricultural attempts, the settlers requests for drainage facilities may persist. Making this land hydrologically suitable for agriculture would disrupt groundwater gradients throughout Shark River Slough and the Taylor Slough Basin. In addition, widespread application of pesticides and fertilizers in this area would disrupt the balance of the fragile Everglades communities just a few miles downgradient. The drainage works programmed for this area were among the Deactivated Projects of the Flood Control District (see Figure 15).

South Dade Conservation Subzone (C-3)

Located directly south of Florida City, this subzone is approximately 19 square miles in size (see Figure 43). Card Sound Road forms the eastern border and a line extending from the half-section line on Section 22-58-38, through the half-section line on Section 21-58-39, forms the southern boundary. The western border is C-111, and the northern border of Sections 10-58-38, 16-58-38, 17-58-38, 1-58-38, and 2-58-38 forms the northern boundary of the area.

Elevations within the area range from 5 feet msl along Ingraham Highway in the north to 3 feet msl in the southern part of the area. The soils in the area are predominantly Perrine marl and marl over peat with some areas of rockdale soils near Ingraham Highway which is located at the southern end of the coastal ridge.

Due to the poorly drained soils and the water table which annually rises above the ground elevation, the area is not well drained. Moreover, the flat topography is not conducive to adequate surface runoff. The area is not adequately served by the Flood Control District and thus, no degree of flood protection is present in the subzone.

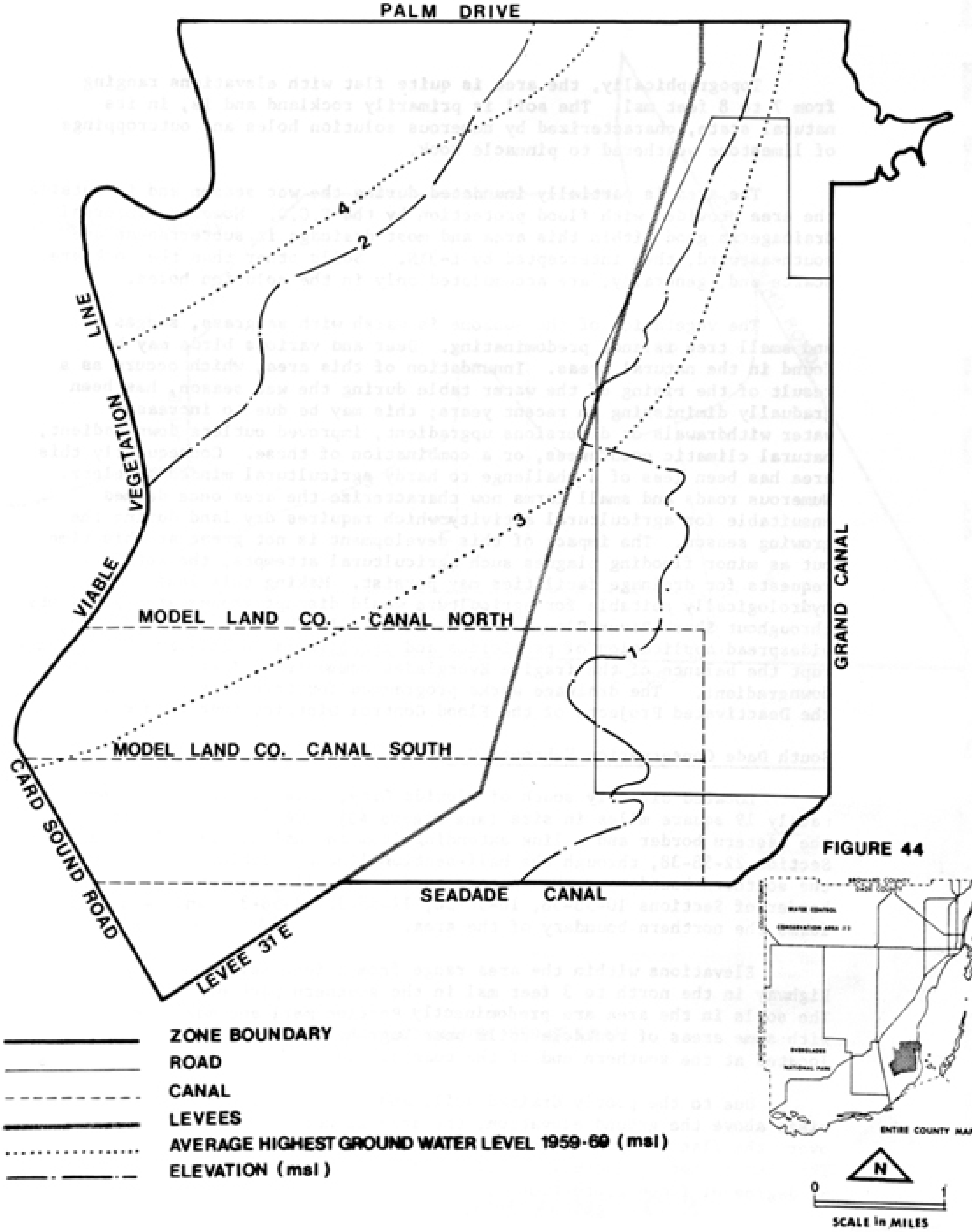


FIGURE 44

SOUTHEAST DADE COUNTY CONSERVATION SUB-ZONE C-4

Although the area was originally a fresh water marsh, the character of the vegetation has changed immensely. A dense band of exotic vegetation including Florida holly and Australian pine characterize the area between Card Sound Road and U.S. 1, and along the northern fringe of the region, with increasing amounts of willow near the Park entrance.

Alterations in the form of roadways, canals, and scarification for early agricultural attempts are the primary causes of the change in vegetation. The northwestern section of the area is drained by C-111. U.S. 1 and Card Sound Road bisect the area and act as a barrier to water and wildlife movement. The abandoned agricultural lands in the north have also been drastically altered--first by the scarification for agriculture and then by the invasion of exotic vegetation.

The subzone presently functions as an important hydrologic area from two standpoints. The area serves as an aquifer recharge area during wet seasons and at the same time supports the areas to the south and east in the maintenance of a salt barrier line. The maintenance of the area as an open space buffer zone for the Southern Coastal Preservation Zone could be an important factor in maintenance of high water quality in southeast Dade County.

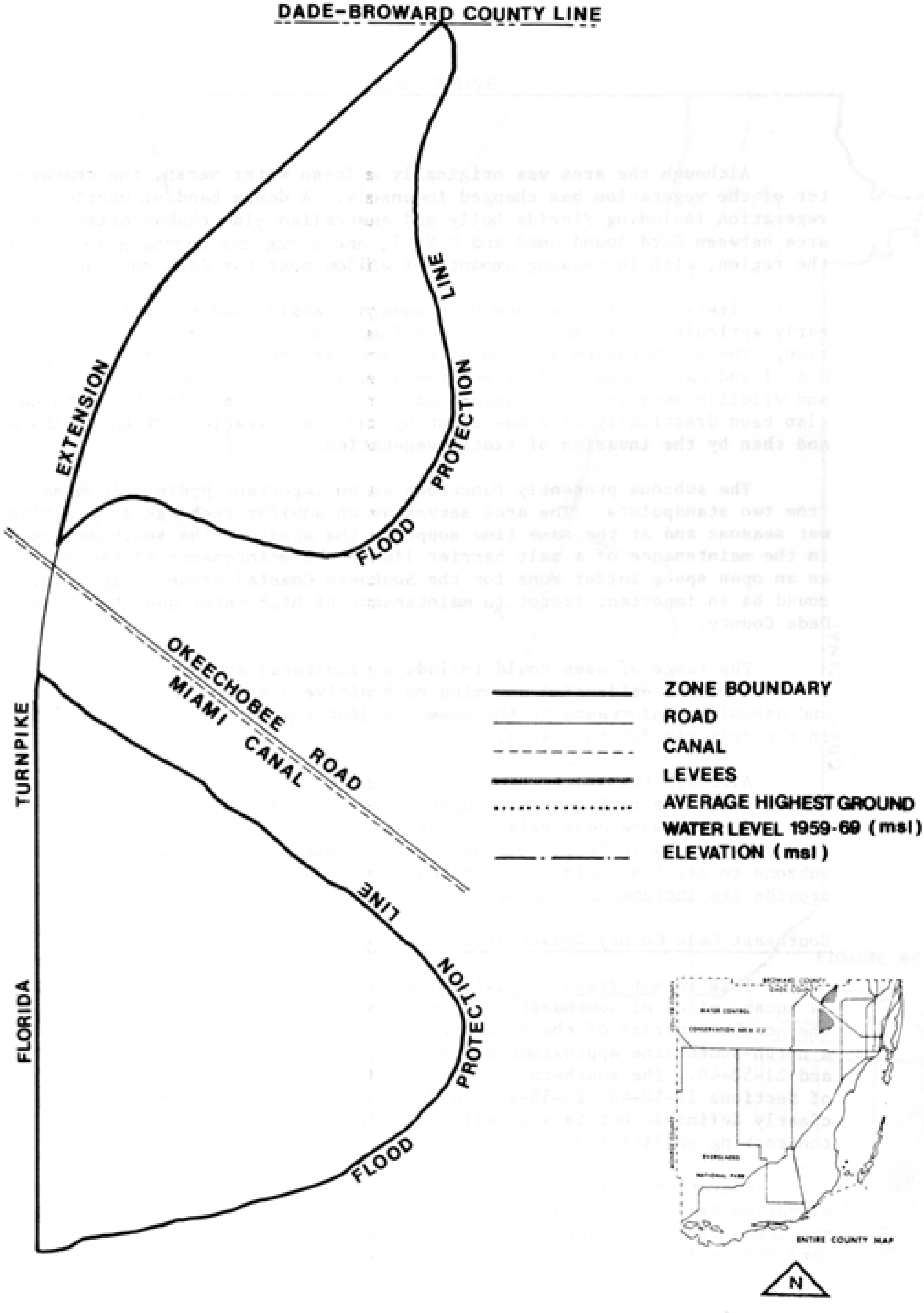
The range of uses could include agricultural and associated estate density residential assuming no positive drainage of the area and assuming conformance to the coverage disturbance limits recommended in the criteria for this area.

Although the only potentially damaging uses present in the area at this time are rock quarrying operations which disturb natural vegetation, some pressure does exist for urban development. Appropriate precautions need to be taken, therefore, to minimize conflicts in this subzone to see that this area can function in a manner necessary to provide its incremental support to the southeast Florida ecosystem.

<u>Southeast Dade County Conservation Subzone (C-4)</u>

This former fresh and salt water marsh occupies a relatively intact 34 square miles of southeastern Dade County (see Figure 44). Palm Drive forms the northern border of the area with the eastern boundary being formed by a north-south line approximating the eastern boundary of Sections 34-57-40 and 21-58-40. The southern border is L-31E and the southern boundary of Sections 19-58-40, 20-58-40 and 21-58-40. The western border is not clearly definable but is generally a delineation between areas with contrasting qualities of vegetation.

Elevation variations in this area are very slight with the highest elevation of 3 feet msl being in the northwest and the lowest approaching sea level along the eastern end of the subzone. The soils are Perrine marl and marl over peat with mangrove peats in the east.



0 1
SCALE in MILES

SUBMARGINAL ZONES NORTH SM-1

FIGURE 45

The area is subject to considerable flooding and has minimum drainage by unmaintained canals. Potentially severe flooding from a hurricane tidal surge exists in the area and the presence of L-31E allows for the possibility of large amounts of tidewater being trapped west of the levee during a hurricane.

Biologically, the area is a former sawgrass marsh which has experienced some invasion of exotic plants including melaleuca, casuarina, and schinus.

Alteration to the area has been primarily the result of canals or levees. Levee 31E bisects the area and Model Land North and South Canals cross the area from west to east. Almost total alteration of the subzone east of L-31E has resulted from the cooling canals constructed by Florida Power and Light Company.

The area, excepting FP & L property, functions as a valuable water recharge area for the maintenance of a salt barrier line and presently is characterized by relatively intact native vegetation. Its conservation is important to the preservation areas to the south and east in that the maintenance of open space in the Conservation Subzone is related to the preservation of high water quality moving into the coastal estuarine zones.

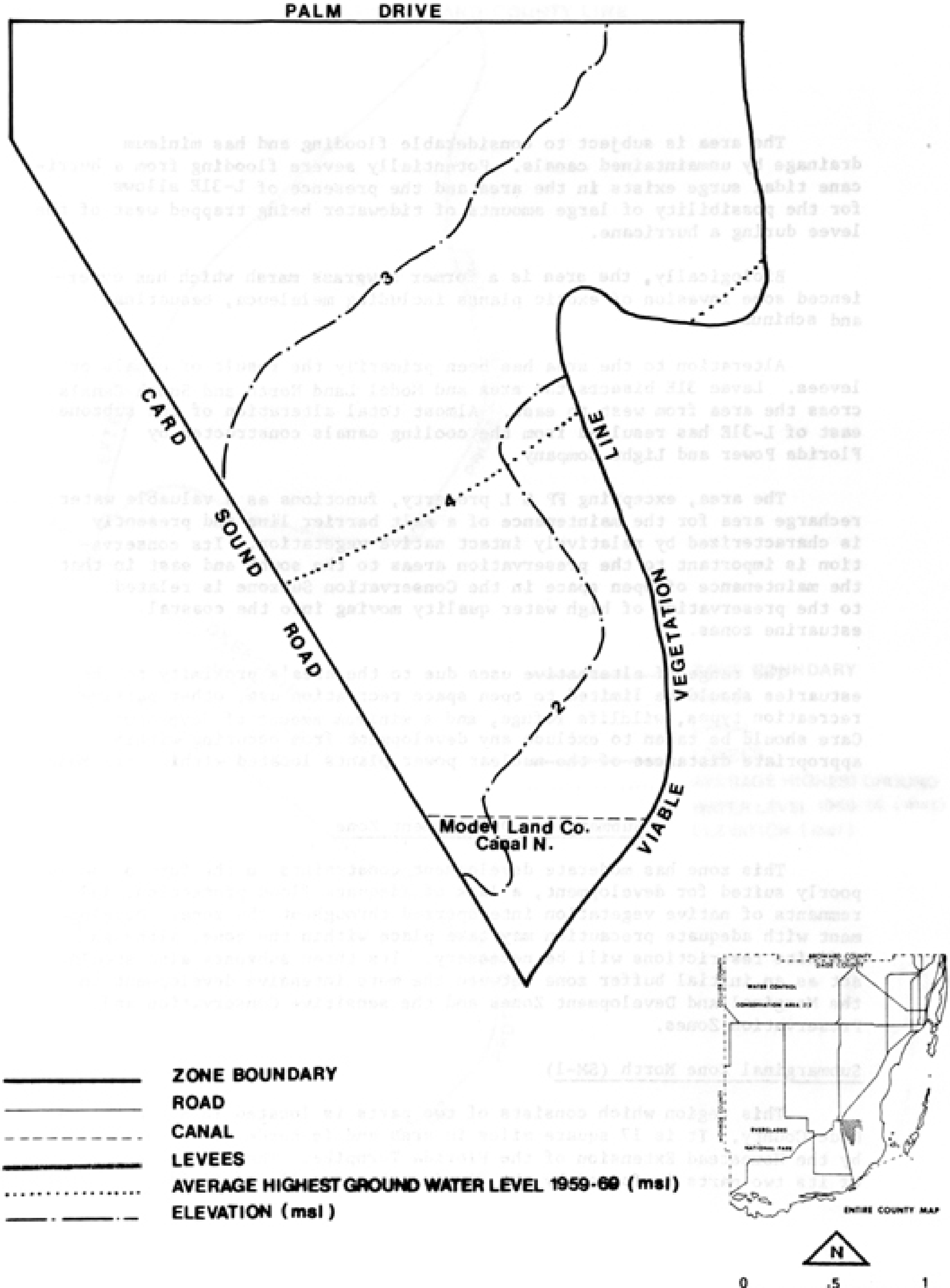
The range of alternative uses due to the area's proximity to the estuaries should be limited to open space recreation use, other passive recreation types, wildlife refuge, and a minimum amount of development. Care should be taken to exclude any development from occuring within appropriate distances of the nuclear power plants located within this zone.

Submarginal Development Zone

This zone has moderate development constraints in the form of soils poorly suited for development, a lack of adequate flood protection, and remnants of native vegetation interspersed throughout the zone. Development with adequate precaution may take place within the zone, although definite restrictions will be necessary. Its three subzones also should act as an initial buffer zone between the more intensive development in the Marginal and Development Zones and the sensitive Conservation and Preservation Zones.

Submarginal Zone North (SM-1)

This region which consists of two parts is located in north-central Dade County. It is 17 square miles in area and is bordered on the west by the Homestead Extension of the Florida Turnpike. The eastern boundary of its two parts is formed by the flood protection line (see Figure 45).



SUBMARGINAL ZONE SOUTH SM-3

FIGURE 46

Both areas were historically on the eastern fringe of the Everglades Waterway. These former wet prairies are not now characterized as unique and sensitive ecological systems. However, they do have special soil and hydrologic constraints which demand that certain development restrictions be imposed. The area is relatively flat with an elevation of five feet msl. The soils are predominately shallow phase organics or Everglades peat. Drainage has accelerated oxidation of the organic soils and thus left exposed marl soils in many places.

A high water table characterizes this area and periodic inundation is common. The interaction of surface water in this area with ground-water demands that the preservation of water quality must be given high priority in developing this area.

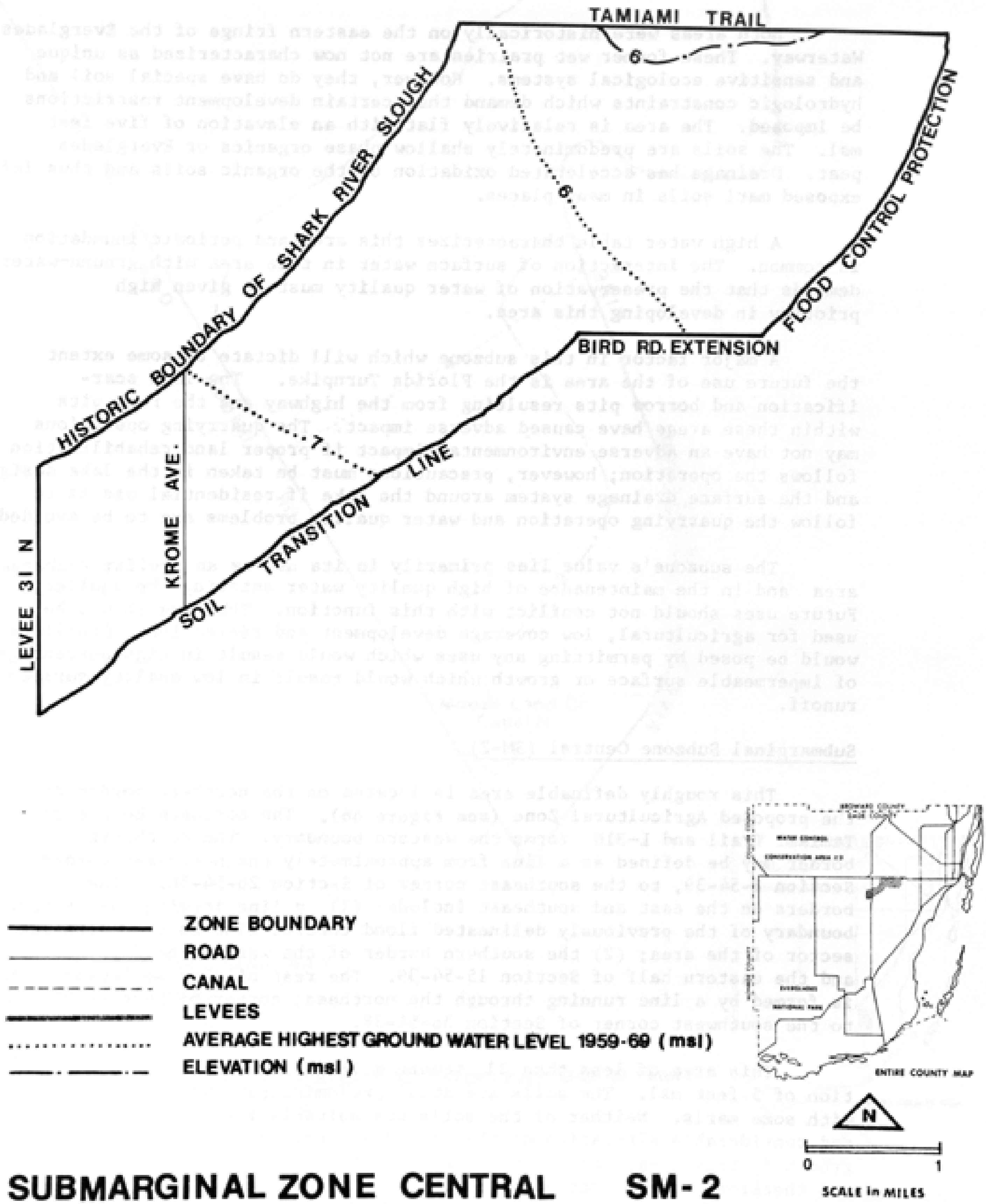
A major factor in this subzone which will dictate to some extent the future use of the area is the Florida Turnpike. The land scarification and borrow pits resulting from the highway and the rock pits within these areas have caused adverse impact. The quarrying operations may not have an adverse environmental impact if proper land rehabilitation follows the operation; however, precautions must be taken in the lake design and the surface drainage system around the lake if residential use is to follow the quarrying operation and water quality problems are to be avoided.

The subzone's value lies primarily in its use as an aquifer recharge area and in the maintenance of high quality water entering the aquifer. Future uses should not conflict with this function. The area should be used for agricultural, low coverage development and recreation. Conflicts would be posed by permitting any uses which would result in high percentages of impermeable surface or growth which would result in low quality surface runoff.

Submarginal Subzone Central (SM-2)

This roughly definable area is located on the northern border of the proposed Agricultural Zone (see Figure 46). The northern border is Tamiami Trail and L-31N forms the western boundary. The northwest border may be defined as a line from approximately the northeast corner of Section 8-54-39, to the southeast corner of Section 26-54-38. The borders on the east and southeast include: (1) a line forming the western boundary of the previously delineated flood control line on the northeast sector of the area; (2) the southern border of the western half of Section 14 and the eastern half of Section 15-54-39. The rest of that southeast boundary is formed by a line running through the northeast corner of Section 21-54-39 to the southwest corner of Section 36-54-38.

This area of less than 11 square miles has an approximate elevation of 5 feet msl. The soils are still predominantly Everglades peat with some marls. Neither of the soils are suitable for development and considerable alteration of the ground surface must accompany any growth in this area. Since the area is west of the flood protection line and therefore poorly drained, the water table level annually rises above the land surface.



SUBMARGINAL ZONE CENTRAL SM-2

FIGURE 47

Although the area has been drained to some extent it is still characterized by native grasses and sedges. Sheet flow through the area no longer persists due to the isolation by roadbeds and levees. Adverse impact on the area may continue if more water is removed because oxidation of the soils and subsequent destruction of vegetation has already begun and will continue if the water table is lowered.

The buffer zone function of this area for wetlands to the west and the area's function as an aquifer recharge area constitute the major value of the zone. Development in the area is almost nonexistent. Positive drainage in this area would have severe effects upon its current function. As in other Submarginal Subzones, low density, low coverage development, and recreation are the desired uses.

Submarginal Subzone South (SM-3)

This region lies to the southeast of Florida City and encompasses a land area of only about thirteen square miles (see Figure 47). Palm Drive forms the northern boundary and Card Sound Road is the south and western boundary. The eastern border of the subzone is not clearly definable but is generally a delineation between areas with contrasting qualities of vegetation. A legal definition of the border would be a line directly from the northeast corner of Section 26-57-39 to the southwest corner of Section 15-58-39.

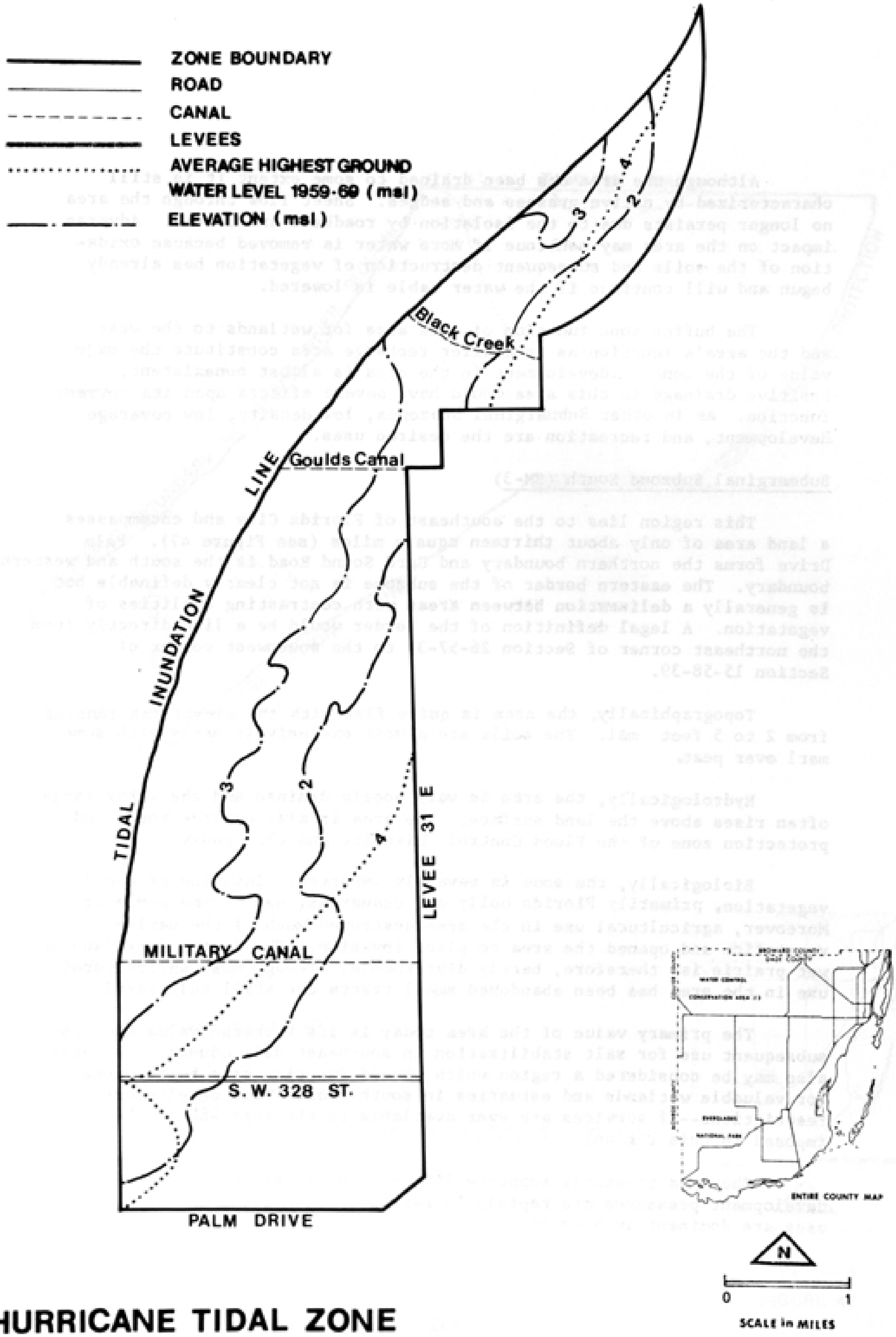
Topographically, the area is quite flat with the elevations ranging from 2 to 5 feet msl. The soils are almost exclusively marls with some marl over peat.

Hydrologically, the area is very poorly drained and the water table often rises above the land surface. The area is also outside the flood protection zone of the Flood Control District and the County.

Biologically, the zone is severely impacted. Invasion of exotic vegetation, primarily Florida holly and casuarina, has become dominant. Moreover, agricultural use in the area destroyed much of the native vegetation and opened the area to plant invasion. The former marshland and wet prairie is, therefore, barely discernable. Though most agricultural use in the area has been abandoned small tracts are still cultivated.

The primary value of the area today is its recharge value and its subsequent use for salt stabilization in southeast Dade County. The area also may be considered a region which should function as a buffer zone for valuable wetlands and estuaries in south Dade. Thus development restrictions--if services are ever available to the area--should be imposed in this region.

The area presently supports little or no development, although development pressures are rapidly increasing. Open space and agricultural uses are dominant at present.



HURRICANE TIDAL ZONE

FIGURE 48

Future use of the area should be limited to low intensity residential with special precautions taken to preserve water quality. Limited agriculture and recreational uses could not be considered incompatible in the area. Development of a high land coverage with resulting adverse water quality effects could present a potential threat to the estuaries to the South.

Hurricane Tidal Zone (H)

Lying in southeastern Dade County the Hurricane Tidal Zone is characterized by low elevations ranging from one to five feet msl. The area generally delineates the region (excepting the Coastal Preservation Zone to the east) susceptible to at least five feet inundation from the hurricane tidal surge of a moderate hurricane (one with sustained winds of 125 miles per hour). The boundaries of the zone include L-31E on the east, Palm Drive on the south and the five foot inundation line for the above described Hurricane Zone on the west. The low elevation of the area indicates the probability of a high water table in the area and the flood potential both from hurricanes and inland rainfall. This zone is approximately 14 square miles in size.

Soils also pose a development constraint within this zone. The Perrine marls characteristic here have very poor internal drainage. Most of the area was formerly salt or fresh water marsh, however, the drainage of the area, the isolation by levees, and the clearing of land for agriculture have heavily impacted the vegetation of the area. Remnants of the natural salt marsh may still exist, but interaction with tide is totally devoid due to the presence of L-31E. Because the land elevation is low, the soils are marl, the area is crisscrossed by numerous filled road beds, and is bordered on the east by L-31E, drainage is very slow and standing water for several days after a storm is not uncommon.

A primary concern in this zone is hurricane tidal flooding. Although areas of much greater size may flood, depending on the intensity and direction of the hurricane strike, this zone represents the area of greatest vulnerability to severe inundation by the tidal surge.

The delineation of this area was based on comparisons of existing fill requirements throughout the county to projections of potential tidal flooding associated with the landfall of a moderate hurricane. This zone was found to be most deficient in amounts of fill currently required, considering the extreme nature and devastating potential of a hurricane tidal surge. The western boundary of this zone represents the probable western extent of tidal flooding associated with hurricanes with a fourteen year return period.

With few exceptions, present uses are not in conflict with desirable uses in the area. Since open space and agricultural use predominate in the zone conflicts to date are minimal. However, extreme caution must prevail in dealing with any future development. Conformance with the U.S. Department of Housing and Urban Development's Flood Insurance Administration's guidelines should provide adequate protection to this and all areas of Dade County. Land uses which cannot conform to such guidelines should be discouraged. Intensive use of small portions of this zone may be the most desirable in light of its environmental setting, and most feasable due to the great amounts of fill required under structures.

Land use in this area presents a unique set of problems in regard to water management. At present the area is used extensively for agriculture. The marl soils east of U.S. 1 in south Dade, unlike the rockdale soils west of U.S. 1, are suitable for growing legumes and other vegetables under the soil surface. There is, however, a serious problem of soil salinity caused chiefly by evapotranspiration of brackish ground water during dry periods. The inland advance of the salt front during the dry season is usually reversed by fresh water moving seaward during the wet season; however, the advance during a drought, such as that in 1971, would require an event of opposite but equal magnitude to return the salt front to the original position. Current land use in the area does not permit widespread flooding, therefore the chances of returning the salt front to the predrought position without raising water levels is remote.

The long-term solution to the saline soil problem would be to prevent further intrusion from coastal canals by holding water levels higher there during dry periods. The fact that the winter growing season generally corresponds with the annual dry season poses a special problem to the Central and Southern Florida Flood Control District because the respective water-level needs are conflicting. Agricultural use east of U. S. Route 1 requires that water levels in coastal canals be held sufficiently low to farm low-lying fields while water managers require that coastal water levels be held sufficiently high to prevent seawater intrusion. Keeping water levels low during the dry season is a short-term benefit to agriculture. However, the practice often leads to increased seawater intrusion which is a long-term detriment to agriculture. Thus, the outlook for this area is for no improvement in seawater intrusion and saline soil problems unless there are significant changes in land use that will permit the maintenance of higher water levels upstream from the coastal salinity control structures.

Recognizing that the Perrine marl is of major agricultural and economic importance, the need to utilize this valuable resource to the fullest will become more apparent as the need for future food supply and "green areas" increases. The data collected and analyzed by the U.S.G.S. indicates that the problems of seawater intrusion and saline soils in this area are related and that the solution will require changes in land use as water levels are raised to optimum levels to halt seawater intrusion and to reclaim lands already affected by seawater intrusion.

One method of changing the land use would be to mound the marl deposit in low-lying fields so that water levels can be raised. Another method would involve the complete removal of the marl deposit from low-lying lands along the coast and the distribution of the deposit on higher areas to the west. The denuded fields could be filled with crushed limestone for urban development and the raised fields could be used for agriculture and parks. Both methods would permit holding higher water levels above the coastal controls and continued use of the marl for agriculture.[8] Precautions must be taken under this kind of intensive land utilization to insure that polluted urban runoff and agricultural wastes are not released into the Biscayne National Monument via the extensive drainage network in the area. It is therefore recognized that slight but effective density bonuses may be in order to insure ample utilization of detention basins for water quality control in the Hurricane Tidal Zone.

Forest-Grove Compatibility Zone (FG)

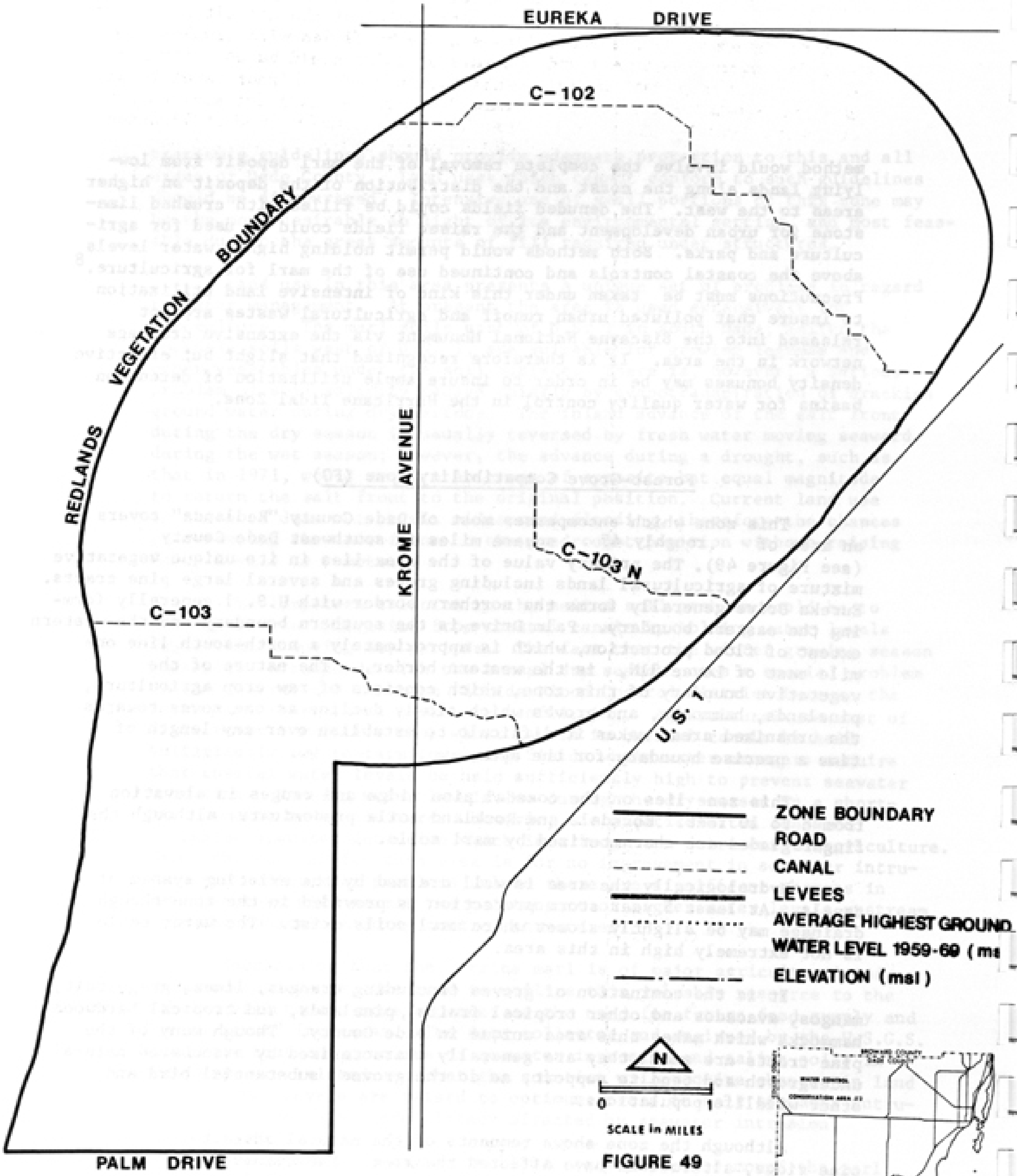
This zone which encompasses most of Dade County "Redlands" covers an area of roughly 47 square miles in southwest Dade County (see Figure 49). The primary value of the area lies in its unique vegetative mixture of agricultural lands including groves and several large pine tracts. Eureka Drive generally forms the northern border with U.S. 1 generally forming the eastern boundary. Palm Drive is the southern boundary and the western extent of flood protection, which is approximately a north-south line one mile east of Levee 31N, is the western border. The nature of the vegetative boundary of this zone, which consists of raw crop agriculture, pinelands, hammocks, and groves which slowly decline as one moves towards the urbanized area, makes it difficult to establish over any length of time a precise boundary for the area.

This zone lies on the coastal pine ridge and ranges in elevation from 8 to 10 feet. Rockdale and Rockland soils predominate, although the finger glades are characterized by marl soils.

Hydrologically the area is well drained by the existing system of canals. At least 5 year storm protection is provided in the zone though drainage may be slightly slower where marl soils exist. The water table is not extremely high in this area.

It is the comination of groves (including oranges, limes, grapefruit, mangos, avacados and other tropical fruits), pinelands, and tropical hardwood hammocks which makes this area unique in Dade County. Though many of the pine tracts are small they are generally characterized by associated natural undergrowth and tend to support, as do the groves, substantial bird and other wildlife populations.

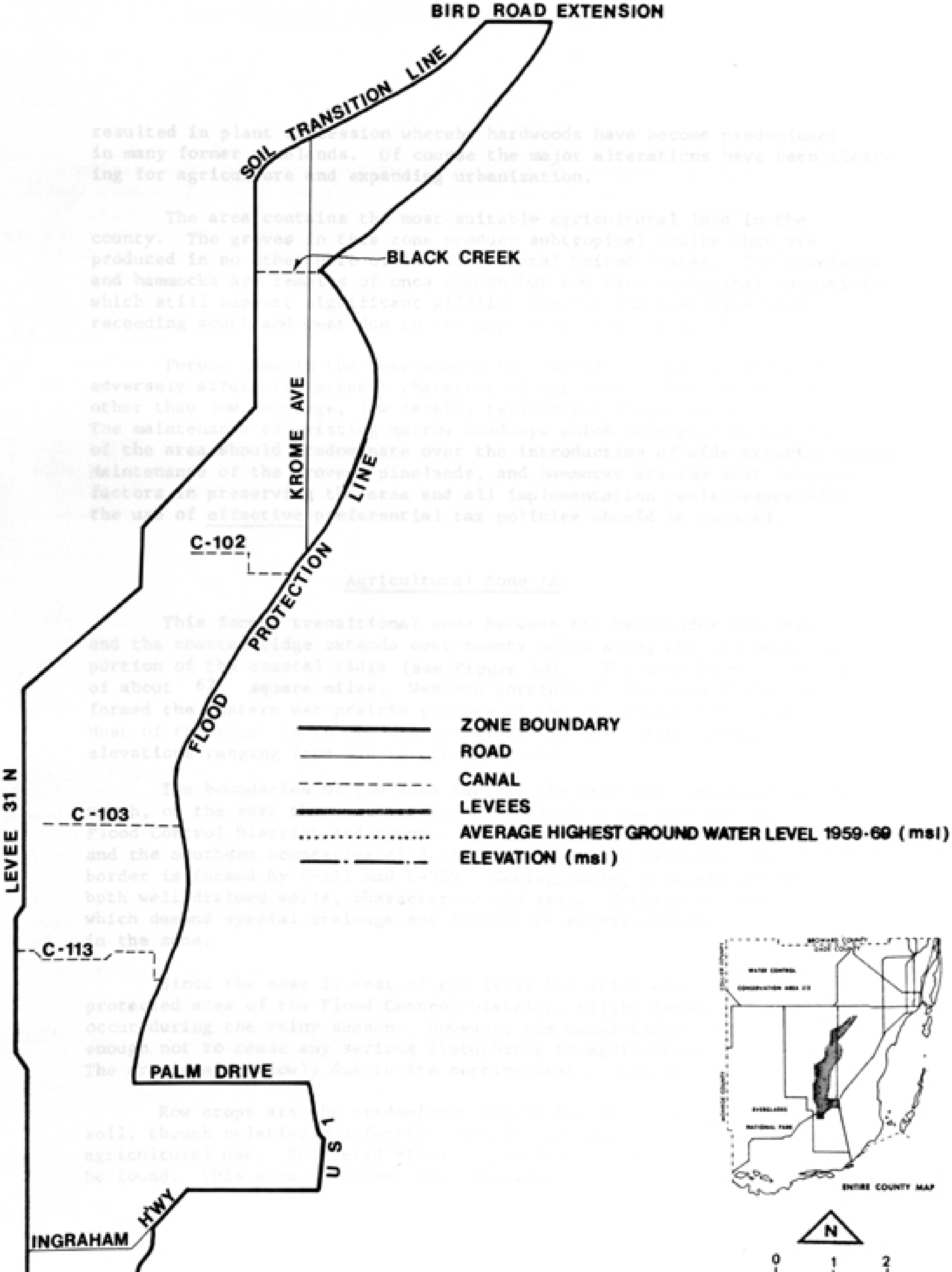
Although the zone shows remnants of the natural character of the pine ridge, alterations have affected the area. The transverse or finger glades have been canalized resulting in a general lowering of the water table. The exclusion of the natural occurence of fire has



FOREST GROVE COMPATABILITY ZONE FG

AGRICULTURAL

PRESERVATION-COASTAL



AGRICULTURAL ZONE A

FIGURE 50

resulted in plant succession whereby hardwoods have become predominant in many former pinelands. Of course the major alterations have been clearing for agriculture and expanding urbanization.

The area contains the most suitable agricultural land in the county. The groves in this zone produce subtropical fruits that are produced in no other part of the Continental United States. The pinelands and hammocks are remains of once common but now rare ecological communities which still support significant wildlife populations that have been receeding south and west due to the expanding urbanization.[9]

Future uses in the zone should be limited to those which would not adversely affect the present character of the area. Thus urbanization other than low coverage, low density residential should not be permitted. The maintenance of existing narrow roadways which form part of the character of the area should predominate over the introduction of wide arterial streets. Maintenance of the groves, pinelands, and hammocks are the most important factors in preserving the area and all implementation tools--especially the use of effective preferential tax policies should be pursued.

Agricultural Zone (A)

This former transitional zone between the Everglades Waterway and the coastal ridge extends over twenty miles along the southwestern portion of the coastal ridge (see Figure 50). The zone is a narrow band of about 62 square miles. Western portions of the zone historically formed the eastern wet prairie regions of the Everglades and Rocky Glades. Most of the area is on the western slopes of the coastal ridge with elevations ranging from six to nine feet msl.

The boundaries of the zone include the Bird Road extension on the north, on the east the western extent of flood protection assured by the Flood Control District and County, and on the south by Ingraham Highway and the southern boundaries of Sections 8-58-38 and 9-58-38. The western border is formed by C-111 and L-31N. Geologically, Rockdale and Rockland, both well drained soils, characterize the area. Pockets of Perrine marl, which demand special drainage and foundation considerations are also found in the zone.

Since the zone is east of the levee but still west of the flood protected area of the Flood Control District, slight inundation does occur during the rainy season. However, the water table does remain low enough not to cause any serious disturbance to agricultural activities. The area drains slowly due to its setting west of the ridge.

Row crops are the predominant vegetation in the zone. The rockland soil, though relatively unfertile, can be economically prepared for agricultural use. Scattered sites of pineland and hammock still may be found. This area of former low pinelands and hammocks has been biologically destroyed relative to its native character. The pinelands were heavily lumbered in the 1920's and 1930's and no virgin stands remain. Drainage has recently opened the area more to agriculture, although, somewhat later than the slightly higher elevation Forest Grove Compatibility Zone. If early winter planting is practiced, winter crops can be raised and harvested before the water table rises during the summer rainy season.

The necessity for fill in the zone to accommodate urban uses, the present adequacy of the area for agricultural use, the open space demands for the county, the essential need for a buffer zone between urbanized Dade County and western Preservation and Conservation Zones, and perhaps most importantly the need to protect the economic integrity of agriculture in the county all indicate that a substantial portion of this zone should remain in open space agricultural use. Thus uses in the zone should be restricted to agriculture and limited residential uses. Due to the large expanses of existing cleared land and the relative scarcity of pineland and hammocks, the remaining pineland and hammocks should be preserved.

Marginal Development Zones

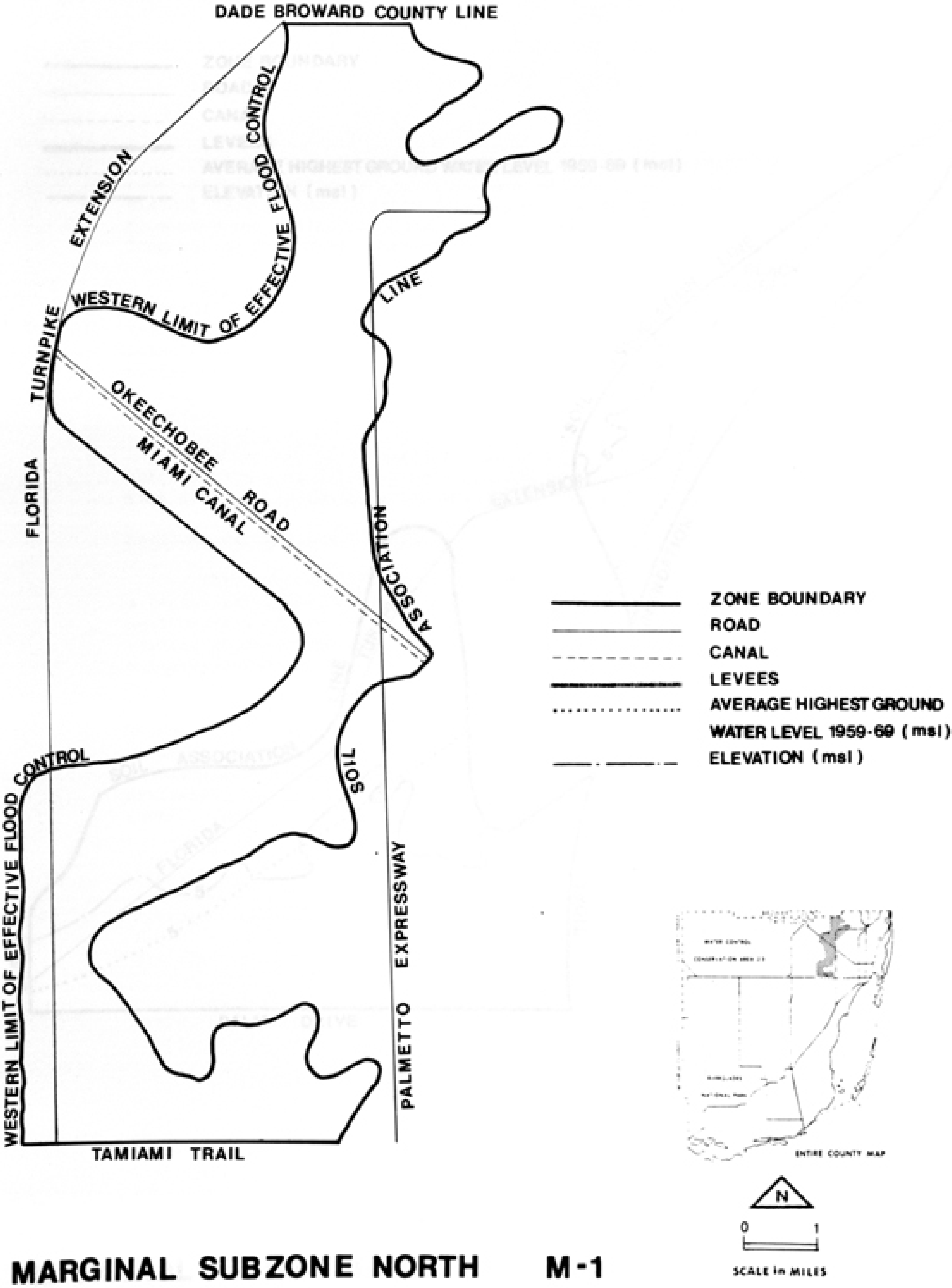
The Marginal Zones present fewer development constraints than all other zones except the Development Zone. Special consideration must be given in the Marginal Zone to drainage due to the poor drainage character of the marl soils which characterize the zone.

Marginal Subzone North (M-1)

The Marginal Development Zone, like the Development Zone, is located within the area of adequate water table management and is considered to have protection from the 10 to 25 year flood when flood criteria are met. However, unlike the Development Zone, these zones are characterized by lower elevations where more fill is required and by marl and organic soils which pose substantial drainage and foundation problems. Marginal Subzone North lies west of the Palmetto Expressway, north of Tamiami Trail, south of the Dade-Broward County line, and has its meandering boundaries formed by soil delineations and the western fringe of the F.C.D. flood protection zone (see Figure 51). This subzone is roughly 28 square miles in size.

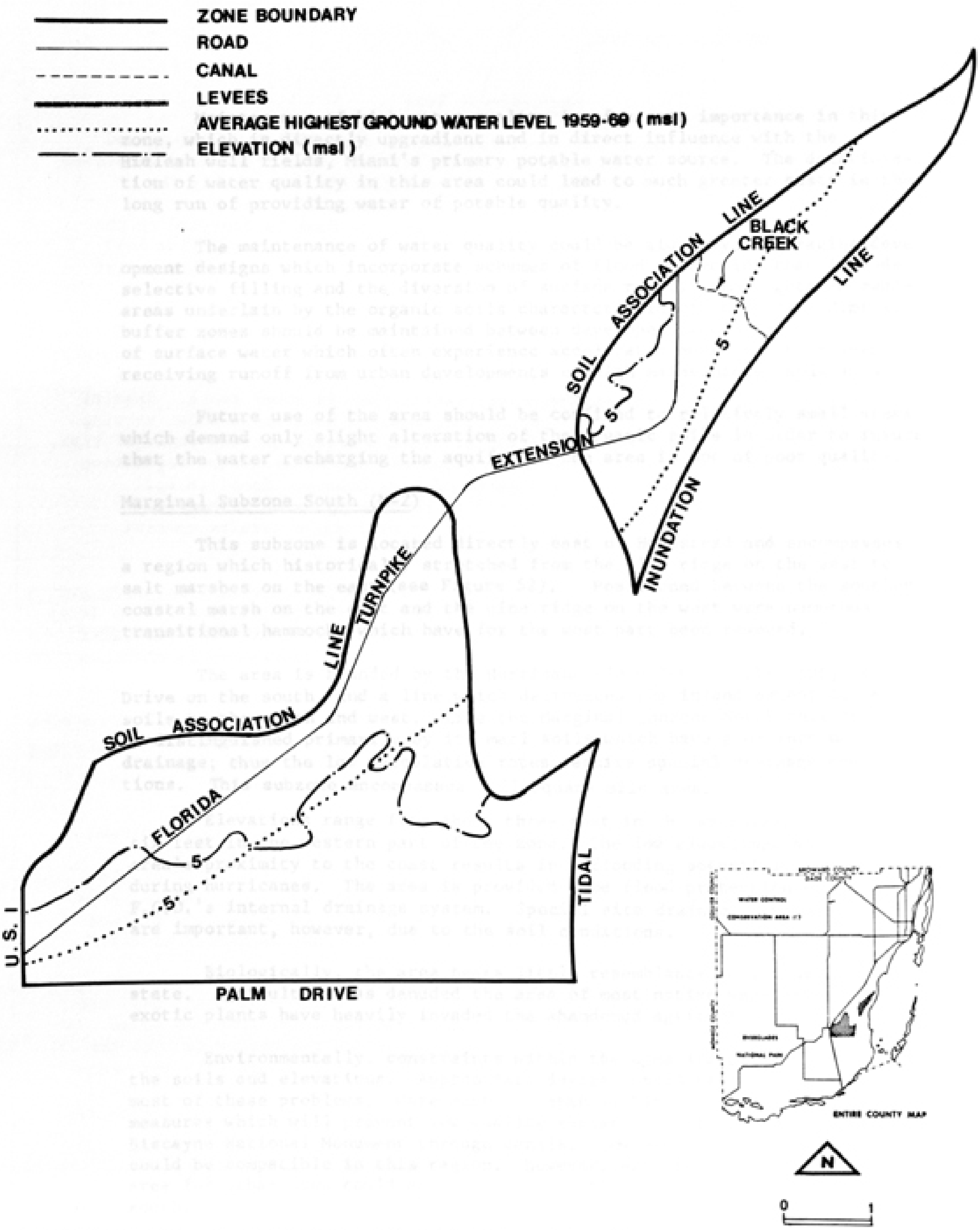
The area is quite flat with elevations of five to six feet msl. The soils are predominantly Everglades peat with some pockets of Hialeah mucky marl. Both soils have slow percolation rates, high shrink-swell capacities, and low bearing values, all parameters indicative of soils poorly suited for development.

Vegetation is predominantly prairie or improved pasture previously used for grazing. This is a former sawgrass marsh which has been effectively drained, although the annual mean high water table still rises to within one foot of the land surface creating a rather moist soil condition during the wet season.



MARGINAL SUBZONE NORTH M-1

FIGURE 51



MARGINAL SUBZONE SOUTH M-2

FIGURE 52

Maintenance of high water quality is of utmost importance in this zone, which is directly upgradient and in direct influence with the Hialeah well fields, Miami's primary potable water source. The deterioration of water quality in this area could lead to much greater costs in the long run of providing water of potable quality.

The maintenance of water quality could be aided by encouraging development designs which incorporate schemes of flood protection that include selective filling and the diversion of surface runoff into vegetated swale areas underlain by the organic soils characteristic of the area. Similar buffer zones should be maintained between developed tracts and open bodies of surface water which often experience accelerated eutrophocation when receiving runoff from urban developments or high maintenance landscapes.

Future use of the area should be confined to relatively small areas which demand only slight alteration of the organic soils in order to insure that the water recharging the aquifer in the area is not of poor quality.

Marginal Subzone South (M-2)

This subzone is located directly east of Homestead and encompasses a region which historically stretched from the pine ridge on the west to salt marshes on the east (see Figure 52). Positioned between the southern coastal marsh on the east and the pine ridge on the west were numerous transitional hammocks which have for the most part been removed.

The area is bounded by the Hurricane Flood Zone on the east, Palm Drive on the south, and a line which delineates the inland extent of marl soils to the north and west. Like the Marginal Subzone North this area is distinguished primarily by its marl soils which have poor internal drainage; thus the low percolation rates require special drainage considerations. This subzone encompasses a 21 square mile area.

Elevations range from about three feet in the southeast corner to six feet in the western part of the zone. The low elevations and the area's proximity to the coast results in a flooding potential, particularly during hurricanes. The area is provided some flood protection by the F.C.D.'s internal drainage system. Special site drainage considerations are important, however, due to the soil conditions.

Biologically, the area bears little resemblance to its natural state. Agriculture has denuded the area of most native vegetation and exotic plants have heavily invaded the abandoned agricultural areas.

Environmentally, constraints within the area are primarily due to the soils and elevations. Appropriate design considerations can overcome most of these problems. Care must be taken within the subzone to implement measures which will prevent low quality surface runoff from reaching the Biscayne National Monument through canals. Low ground coverage development could be compatible in this region. However, extensive development of the area for urban uses could adversely affect the estuaries to the east and south.

Development Zone

The Development Zone includes most of urbanized Dade County and all of the land area not included in one of the seven previously described zones or within National Park Service jurisdiction. Basically the environmental constraints including soils, vegetation, and water are minimal within the zone. For the most part the zone is confined to the coastal ridge where the soils are generally rock or sand and thus well drained, where most native vegetation has been removed, and where water table levels are low relative to the land surface.

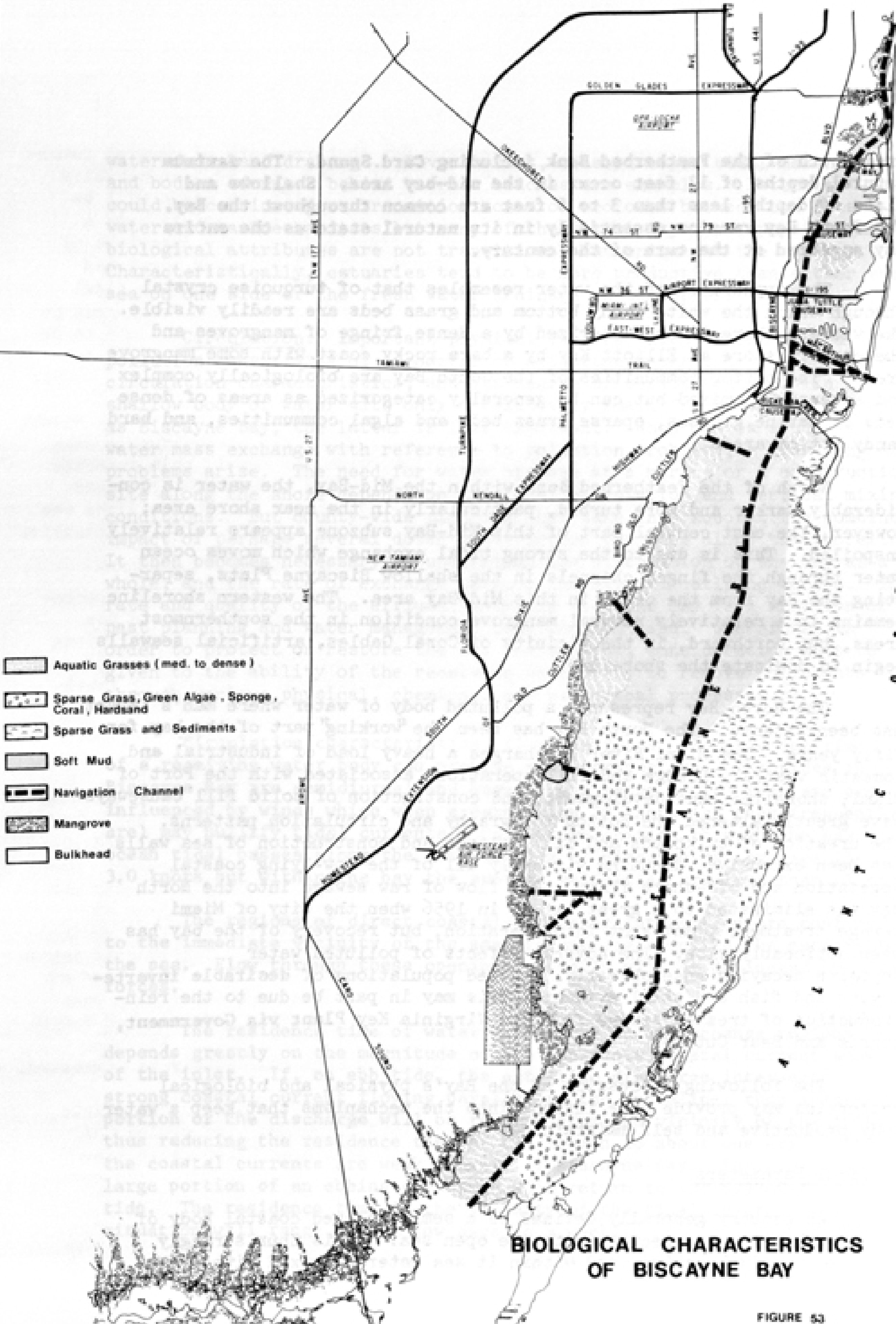
One should not interpret the Development Zone as being an area in which any kind of activity can take place anywhere without environmental degradation. It is simply from a natural environmental standpoint an area where fewer constraints exist overall than in other zones. Special considerations in the Development Zone, must be undertaken under varying conditions. For example, policies to minimize water quality deterioration, protection of tracts of pinelands, hammocks, and other unique vegetation must be strived for within all parts of Dade County. Specific soil conditions not delineated in detail in this study exist within the Development Zone where pockets of peat or marl soils require special development considerations.

However, if the environmental protection policies of this study are to be realized it will be necessary to make most efficient use of the large expanses of developable land within the Development Zone; such practices should result in an alleviation of development pressures in the more sensitive environmental zones.

Biscayne Bay

Biscayne Bay is a shallow subtropical estuary partially isolated from the Atlantic Ocean by a series of barrier islands and shoals; it is inhabited by a very large number of species of plants, invertebrate animals, fishes, and other vertebrates. The Bay is a very complex, productive, and sensitive ecological region, which (including Dumfoundling Bay in the north and Card Sound in the south) is approximately 45 miles long and reaches a maximum width of ten miles.

The basins of Biscayne Bay (North Bay, Middle Bay, South Bay) are separated from each other by shoals and causeways, and from the ocean by shoals and barrier islands. Exchange between the basins is over the shoals and through dredged navigation channels. Exchange with the ocean takes place through numerous tidal inlets and across the Biscayne Flats which are honeycombed with narrow "finger" channels. North Biscayne Bay may be defined as that portion of the Bay north of the Rickenbacker Causeway, the Mid-Bay as the area between the Rickenbacker Causeway and Featherbed Bank (which is east of Black Point), and South Bay as that



BIOLOGICAL CHARACTERISTICS OF BISCAYNE BAY

FIGURE 53

area south of the Featherbed Bank including Card Sound. The maximum natural depths of 12 feet occur in the mid-bay area. Shallows and flats of depths less than 3 to 5 feet are common throughout the Bay. The South Bay remains essentially in its natural state as the entire Bay appeared at the turn of the century.

The appearance of the water resembles that of turquoise crystal through which the white sandy bottom and grass beds are readily visible. The western shore is characterized by a dense fringe of mangroves and the eastern shore at Elliott Key by a bare rocky coast with some mangrove areas. The bottom communities of the South Bay are biologically complex and extensively mixed but can be generally categorized as areas of dense beds of marine grasses, sparse grass beds and algal communities, and hard sandy bottom areas.

North of the Featherbed Bank within the Mid-Bay, the water is considerably darker and more turbid, particularly in the near shore area; however, the east central part of this Mid-Bay subzone appears relatively unspoiled. This is due to the strong tidal exchange which moves ocean water through the finger channels in the shallow Biscayne Flats, separating the Bay from the ocean in this Mid-Bay area. The western shoreline remains in a relatively natural mangrove condition in the southernmost areas, but northward, in the vicinity of Coral Gables, artificial seawalls begin to dominate the shoreline.

The North Bay represents a polluted body of water where man's impact has been intense. The North Bay has been the "working" part of the bay for fifty years. The Miami River discharges a heavy load of industrial and domestic wastes. Dredge and fill operations associated with the Port of Miami, shoreline land development, and construction of solid fill causeways have greatly altered the bottom topography and circulation patterns. The creation of bulkheads and fill islands and construction of sea walls has been extensive, denuding virtually all of the low-lying coastal vegetation and off-shore flats. The flow of raw sewage into the North Bay was eliminated to a great extent in 1956 when the City of Miami sewage treatment plant went into operation, but recovery of the bay has been noticeably slow. The adverse effects of polluted water deposits decaying anaerobically, reduced populations of desirable invertebrates and fish are still evident. This may in part be due to the reintroduction of treated sewage from the Virginia Key Plant via Government, Norris and Bear Cuts.[10]

The following discussion of the Bay's physical and biological properties may provide some insight into the mechanisms that keep a water body productive and self maintaining.

<u>Physical Parameters</u>

An estuary generally defined is a semi-enclosed coastal body of water with a free connection with the open sea. It is thus strongly affected by tidal action, and within it sea water is mixed with fresh water from land drainage. River mouths, coastal bays, tidal marshes, and bodies of water behind barrier beaches are examples. Estuaries could be considered as transition zones or ecotones between the fresh water and marine habitats but many of their most important physical and biological attributes are not transitional but unique to the estuary. Characteristically, estuaries tend to be more productive than either the sea on one side or the fresh water drainage on the other.

Circulation. Important physical factors which determine the pollution sensitivity of a coastal or estuarine water body are the water's circulation characteristics, and its degree of stratification. In a very shallow body of water with only a relatively small freshwater input, such as Biscayne Bay, the latter is less important. When one is studying water mass exchange with reference to pollution problems, a hierarchy of problems arise. The need for water hygiene at a marina or a construction site along the shore depends on the local circulation and vertical mixing conditions. But county-wide planning must take into account the combined impact of perhaps several dozen construction projects along the shoreline. It then becomes necessary to understand the circulation of the bay as a whole, and the rate of exchange between the bay and outlying waters. The rate and quality of the effluent entering Biscayne Bay is a function of past planning and water management practices on land. Therefore, in order to protect or restore the Bay environment, consideration must be given to the ability of the receiving water body to remove pollutants through various physical, chemical, and biological processes.[11]

Circulation characteristics, flushing rates, or residence time of a receiving water body can provide some perspective. The tides in Biscayne Bay are semidiurnal and have a mean range of 1.5 feet and are influenced by winds which when greater than 20 knots (as they frequently are) may nullify tidal currents. Current velocities through the bay to ocean tidal passes along the eastern side of Biscayne Bay average .5 to 3.0 knots,but within the bay the average velocities are less than .5 knots.

The regions of direct coastal-estuarine interaction are confined to the immediate vicinity of the seaward opening coupling the estuary to the sea. Flow through these openings normally will be dominated by tidal forces.

The residence time of water within the inlet exchange regions depends greatly on the magnitude of the longshore coastal current seaward of the inlet. If, on ebb tide, the estuarine discharge intersects a strong coastal current flowing parallel to the shoreline, then a large portion of the discharge will be removed from the vicinity of the inlet, thus reducing the residence time of the region to about one day. Often, the coastal currents are weak seaward of Biscayne Bay. Therefore, a large portion of an ebbing discharge will return to the bay on the flood tide. The residence time in the vicinity of the tidal inlet in this situation will range from a few days to a week.

In an estuary such as Biscayne Bay that consists of several interconnected basins, the exchange of interior water will be predominantly between the different basins. Direct exchange with the ocean will be restricted to the regions in the vicinity of the tidal inlets. As a result of the simple reversing tidal current pattern, the interiors of the basins in Biscayne Bay will exchange with the adjacent north and south basins with very little direct exchange with the ocean by tidal mechanisms. The residence time of interior waters has been estimated to be on the order of one year. Wind induced circulations were found to be capable of reducing the residence time by a factor ranging from 10 to 100. The strong northerly or northwesterly winds which set up the proper offshore currents reducing the residence time are associated with the passage of cold fronts during the winter months of December through March. However, during the remainder of the year, winds are predominantly weak in intensity and in an onshore direction, with the result that interior water exchange is dependent upon the tides. The effect on pollutants being discharged into the bay will be to accumulate pollutants along the mainland shore with very little removal except during periods of intensive meteorological activity.[12]

Salinity. Salinities in Biscayne Bay range from chloride concentrations well below that of seawater (which is normally 35 parts per thousand) to hypersaline condition during which chloride concentrations can reach 42 parts per thousand. The occasional hypersaline condition can result from lack of rainfall and no terrestrial discharge of fresh water for extended periods, in conjunction with high evaporation rates from the partially enclosed, shallow embayment.

Under predevelopment conditions, terrestrial surface water discharge during the rainy season flowed through the shallow transverse glades dissecting the coastal ridge. The few natural streams continued to flow as a result of ground water seepage, and underflow occurred along the coast and bay floor for several months after the rainy season. Under present day highly urbanized conditions, water management and water control practices have resulted in an acceleration of the discharge of fresh water to Biscayne Bay (via canals) thus causing great fluctuations in bay salinities in the vicinity of the major canals. The general implications of the various land use controls and artificial manipulation of the system has caused salinities to be both higher and lower than what would be expected under natural conditions. Moreover, if proposed F.C.D. backpumping practices become operational, the freshening in Biscayne Bay will be less frequent, and bay salinity will most likely be increased.

Temperature. In all ecosystems, whether terrestrial or aquatic, temperature is a factor to which the biota responds. The ecology of Biscayne Bay is based on normal annual temperatures which range from approximately 70° F in winter to as high as 90° F in summer. The optimal temperature for diversity of species and numbers of individuals is approximately 80° F. The occurence and behavior of the Bay's biota responds markedly to significant deviations from normal seasonal temperatures. The growth of benthic macro-flora is retarded by normally high summer temperatures but recovers during the cooler winter months. Similarly the spawning of most animals is critically tied to the normal annual progression of temperature change.

Studies of South Biscayne Bay to determine the effects of the discharge of heated water on the biota in the vicinity of the Turkey Point power plants have shown that sea grasses, benthic algae, invertebrates, and fish were all significantly affected by elevated temperature near the point of discharge. The most obvious effects were the decreases in the number of algal species and the decline in the growth of sea grasses over an area of several hundred acres of bay bottom with barren conditions being created on some 50 acres. In general, animals where shown to be affected by temperatures exceeding 91° F.[13]

Biology. The productivity of the Biscayne Bay estuary is dependent upon the viability of the two major vegetative communities: the shoreline mangrove community and the benthic marine grass beds with their associations of macro algae. These vegetative types support a detritus-based ecosystem of high productivity in terms of numbers of individuals whose value to man is realized in terms of water clarity and an abundance of lower order species which attract large populations of game fishes. The value of the mangroves as they relate to the health of flora and fauna has been discussed in detail in the chapter on Natural Systems. For this reason, it is discussed very briefly here.

The mangrove swamp is an example of a detritus-based ecosystem which until recently has been little understood. Formerly, mangrove swamps were erroneously considered to be biological wastelands, but recent reasearch has yielded important information about the productivity of these areas and the importance of red mangroves to Florida fisheries. It is now believed that fragmented leaves of red mangrove trees supplement phytoplankton as the primary base of the nutrient pyramid in tropical coastal waters. When the mangrove leaves fall in the warm shallow waters they become covered with fungi, bacteria, and protozoa which are themselves rich sources of vitamins and protein and are subsequently decomposed into minute particles called detritus. As the detrital particles decrease in size, their surface area increases, and the increased surface leads to more fungi, bacteria, and protozoa thereby increasing the relative concentration of protein and caloric value making them more valuable as a food source. These particles are fed upon by a key group of detrital consumers such as amphipods, mysids, copepods, shrimp and some species of fish.[14]

The extensive prop root system produces a maze reducing tidal currents causing the deposition of suspended silt, and providing surfaces for attachement of marine organisms and protection for juvenile fishes from predators. The penetration of the mangrove roots deep into the anaerobic mud of the shoreline is basic to mineral cycling necessary for maintaining the high primary productivity of this aquatic community. Gross photosynthesis of mangroves has also been shown to be sensitive to the terrestrial inflow of nutrients from adjacent upland vegetation.[15]

Although mangroves are effective in converting nutrients into a form useable by aquatic life, they are subject, as are all eutrophic systems, to overenrichment, oxygen depletion and fish kills. This illustrates both the role of the mangroves in the maintenance of water quality, and the desirability to plan and properly design developments upland from mangrove areas.

Within the bay itself the most important biotic community is that of the marine grasses and associated algae. The grass community is composed of turtle grass (Thalassia testudinum), the manatee grass (Syringodium filiforme), and Cuban shoal weed (Diplanthera wrightii). These grasses may form a dense cover on the bottom. Thalassia rhizomes form a thick mat penetrating the bottom for up to eighteen inches. Grass beds of varying densities occur throughout the bay depending upon the depth of water, physical and chemical consistency, and thickness of the sediment deposit. The shoreline sediment wedge in the South Bay sustains a far higher thalassia population than the mid-bay area with shallow sediment. The deeply penetrating root and rhizome system plays an important role in nutrient recycling as well as aiding in water clarity by accumulating and stabilizing sediments. The grasses and algae are the Bay's primary contribution of nutrient and habitat to small food chain animals and early stages of commercially important species. Some of the more conspicuous species inhabiting this area are toadfish, gobies, snapper, mussels, oysters, mud crabs and snapping shrimp as well as a wide variety of other animals.

Areas of shallow silt deposits support what can be considered a suborder of the above community. In these areas the grass beds are sparse and macro algae predominate. These communities are generally found just seaward from the coastal sediment fringe in the South Bay and support large populations of mojarras, pinfish, caridean shrimp, and a wide variety of mollusks.

On the hard sandy bottom areas of south Biscayne Bay a less productive zone exists. Here the grass and algal beds are patchy and confined to pockets of sediment. On the hard bottom, sponges, corals, and sea feathers have attached themselves and creatures of the offshore coral reefs such as crabs and starfish may be seen. This is a beautiful though less productive zone as most of the enrichment is gained from the adjacent thalassia beds and from the import of mangrove detritus.[16]

Grassbeds of varying densities and productivity occur throughout the Bay depending upon the depth and salinity of water and the thickness and consistence of bottom sediments. However, the water clarity and bottom condition of much of the north bay is unfavorable for any significant plant growth. A layer of unconsolidated sediment has accumulated as a result of years of serving as the "sink" for urban wastes. This mud is easily stirred up by wind, perpetuating the unfavorable turbid conditions.

Unfortunately, the shoreline has attracted considerable urban development. A particularly unfortunate modification that has been made to nearly two-thirds of the shoreline of Biscayne Bay is the removal of mangroves and other shoreline vegetation by practices of dredging, filling and bulkheading. This destroys an essential zone of productivity and creates residential property that is more vulnerable to storm tides, the brunt of which would have been borne by the mangroves. Vertical seawalls also directly reflect wave action without dissipating much of the wave's force. An improvement over the vertical seawall, where they presently exist, would be replacement with a sloping riprap shoreline which would help dissipate the force of wave action as well as provide a favorable surface on which mangroves can establish themselves. Biologists of the F.C.D. and the Florida State Marine Laboratory in St. Petersburg consider the reforestation of mangroves as a positive action that can be taken to enhance the condition of the State's estuarine environment.

Appraising the high costs of creating residential property out of estuarine shorelines and the costs of maintenance and repair of storm damage, as opposed to the high potential of the unmodified estuarine shoreline for production of marine life essential to commercial fisheries, sport fisheries, and tourism as well as maintenance of a clean water body fit and attractive to use by residents, it becomes clear that shoreline planning and management and preservation as a functioning marine nursery ground is its best use.

Along with the southward expansion of urban development in Dade County is the concurrent southward recession of biologically productive estuarine areas in Biscayne Bay. Reasons for this are numerous. Some are easily avoidable, others are not. Bulkheading can be avoided and replaced with a sloping riprap shoreline. Mangroves can be preserved and replanted. Shallow grassbeds can be adequately marked so as to avoid rilling by power boats. New marinas and boating facilities can be located in areas least sensitive to necessary alterations. Access facilities in the vicinity of South Biscayne Bay can be designed exclusively for the types of craft suitable for use in the shallow grassy environment.

One problem which does not have an easy solution is the cleanup of the primary drainage canal system which systematically discharges slugs of stagnant water, laden with anaerobic sludge, into Biscayne Bay. The anaerobic sludge is stirred up bottom material. It forms under the canal's stagnant conditions and from a steady input of urban and agricultural runoff laden with insecticides, herbicides, fertilizers, and animal excrement washed from lawns, gardens and parks; oil and grease from automobiles, service stations, garages and junk yards; chemical products from auto washing, laundries and industry; and garbage, trash and other refuse also finds its way into the canals. Ground water flow also adds inputs of pollutants from septic tanks and leachates from cumps and landfills. Whatever the origin, pollutants of all types find their way into inland waterways and ultimately into Biscayne Bay. Location and design of land uses both along the shore and far inland all have effects upon the aquatic and marine environments through direct interaction and through the highly transmissive Biscayne Aquifer.

Biscayne Bay with its unique coastline, is the priceless heritage not of a few but of all the people; as such, its availability, its accessibility, to all the people must be assured; and above all, its quality and beauty protected and maintained.

General Zone Description Summary

The descriptions of the environmental zones provided in this chapter, which are an outgrowth of the methodology described in the previous chapter should provide the basic information on the character of each area; this background is also germane to the criteria for regulating the use of these zones as presented in the next chapter. Although minute detail was not provided here, the present physiographic nature of each zone must be understood in order to grasp the rationale underlying the recommendations for land use in the various zones.

ENVIRONMENTAL GUIDELINES

The purpose of these guidelines is to insure that future development within Dade County is directed in a manner that is harmonious with the existing natural environment. More specifically, the purpose of the guidelines is to: (a) preserve viable functioning ecosystems in a state approximating natural conditions; (b) provide assurance that the natural water supply's quality and quantity is not threatened by urban growth, and (c) insure that the carrying capacity of given natural areas is not exceeded by regulating development based on hydrological conditions, the suitability of soils, and the character and viability of the vegetation.

These guidelines, moreover, have important implications as they relate to the existing urban areas. It is intended that adherence to the guidelines of this Environmental Protection Guide will help alleviate, in areas to be developed, some of the characteristic urban problems such as air and water pollution.

County-wide Guidelines

The following guidelines are considered minimum guidelines and apply to all of Dade County except where a greater degree of protection is offered by a guideline within a specific environmental protection zone or subzone.

General Environmental Considerations

In case of a conflict between guidelines proposed herein and other criteria which are a proper exercise of authority of a governmental jurisdiction, the more restrictive criterion will govern.

The environmental impact of major developments to be specified will be assessed under a Dade County Development Impact Ordinance or an Environmental Impact Ordinance.

Drainage, Flood Control, and Water Quality

The construction of additional canals, ditches or other waterways is permitted only in accordance with the guidelines established for each specific Environmental Protection Zone.

Minimum flood protection and water quality control on future developments is to be provided to the maximum extent possible through use of retention basins and/or grassy swale areas for handling surface water runoff. Undisturbed open space areas accompanying development may be used as retention basins. The degree of on-site retention will be a function of the site character and will depend on soil character, peak flow, storage volume, seepage rates, and water quality information as may be available from existing and future surface water runoff studies for Dade County.

The approval of inland water body construction shall be contingent upon meeting the following guidelines:

Bulkheading shall be discouraged.

Surface runoff from new developments to be handled in accordance with the previous guideline on minimum flood protection is to avoid to the maximum extent possible the diversion of runoff directly to a water body through the following design considerations:

Setbacks
Proper contouring
Swale areas
Retention basins

No septic tanks are permitted on lots less than one acre. Septic tank approval on lots one acre or larger is conditioned on Department of Pollution Control approval based on soil and water table suitability which insures no adverse effects on public health. Septic tanks will be phased out as soon as the regional wastewater system is able to serve the various zones.

No septic tanks or appurtenances thereto are permitted within 100 feet of any surface water body.

The sponsors of developments are required to inform all prospective home buyers of the flood hazard from hurricane tidal surge or flooding from rainfall inundation, and from a combination of the two factors. The potential frequency and extent of inundation must be provided for a 10 year and 100 year flood.

Vegetation and Site Alteration

Development is not permitted in the mangrove estuaries below mean high water except for the expansion of existing or the construction of already planned and funded public bay access facilities.

Within viable hammocks (less than 40 percent exotic vegetation) the following guidelines shall apply:

Viable hammocks are considered areas of high priority for public acquisition to be used as passive recreation areas.

A maximum 25 percent site alteration (includes any ground cover disturbance including structures, streets, sidewalks, parking, yards, etc.) is permitted within any viable hammock which is one acre or larger.

The altered area is, to the maximum extent possible, to be confined to the least viable areas.

Recognized standards dictate the type and amount of fill permitted around various tree species within the 25 percent maximum disturbed area.

Tree wells or contouring are considered adequate substitutes for fill.

Within impacted hammocks (40-60 percent exotic plants) construction is, to the maximum extent possible, to be confined to areas characterized by exotic vegetation. A maximum 50 percent site alteration is permitted.

Within stands of Dade County Pine of one acre or larger the following standards apply:

A maximum of 50 percent site alteration is permitted.

The altered area is, to the maximum extent possible, to be confined to the least viable areas.

A maximum of 6 inches of fill may be placed at the base of any pine tree during and after development.

Where fill exceeds 6 inches tree wells or contouring may be considered as alternatives.

Within all areas of allowable site alterations the existing native vegetation is to be incorporated into the landscape plan of the development to the maximum degree possible.

Revegetation is to be accomplished with preexisting species or other suitable species except that the undesirable exotic species (see list below) are not to be replanted or propagated.

Ardisia (marlberry) - <u>Ardisia Solanacea</u>
Australian pine - <u>Casuarina spp.</u>
Bishopwood - <u>Bischofia javanica</u>
Brazilian pepper (holly) - <u>Schinus terebinthfolius</u>
Castor bean - <u>Ricinus communis</u>
Colubrina - <u>Colubrina asiatica</u>
Common snakeplant - <u>Sanseviera trifasciata</u>
Guava - <u>Psidium guajava</u>
Melaleuca (cajeput) - <u>Melaleuca quinquenervia</u>
Trailing wedelia - <u>Wedelia trilobata</u>

Preservation Zone Guidelines

These guidelines are considered minimum standards and apply to all preservation areas except where specific subzone guidelines offer a higher degree of protection for areas of greater environmental sensitivity. Any deviation from these guidelines must be justified in the Environmental Impact Ordinance.

No development is permitted which would remove or displace organic soils, native vegetation, or endangered species of wildlife. Restricted development includes, but is not limited to:

Rock pits or borrow pits
Paved surfaces or roadbeds
All structures

Passive recreation facilities and public facilities essential to public health, safety and welfare, approved under the Environmental Impact Ordinance, are regulated as follows:

Where facilities for sanitary waste are necessary, self-contained facilities may be utilized.

Transportation facilities which would retain, divert or otherwise block surface water flow of a 50 year storm must provide for the reestablishment of sheet flow through the use of interceptor spreader systems or performance equivalent structures and shall provide for passage of stream, strand or slough waters through the use of bridges, culverts, piling construction or performance equivalent structures or systems. Channelization of such areas shall be the minimum length necessary to maintain reasonable flow and prevent weed blockage.

Placement of structures must be accomplished in a manner that will not adversely affect surface water flow or tidal action.

No activities which alter the depth, duration, or seasonality of inundation are permitted.

No tracked vehicles except for fire fighting purposes are permitted off roadways.

<u>Flood Control District Conservation Area #3 Subzone Guidelines (P-1)</u>

Backpumping should be pursued to increase water storage provided that:

Flood plain zoning or other preservation mechanisms are initiated to protect recharge areas having deep organic soils and ground-water within these areas is maintained at the highest practicable level.

The quality, quantity and seasonality of water in the Conservation Area 3A is maintained to protect the natural Everglades environment and the water supply of the Everglades National Park.

The water which is backpumped will have no detrimental effects upon the Everglades.

Coastal Preservation Subzone (P-4)

Public bay access facilities are limited to the expansion of existing facilities and the construction of already planned public bay access facilities. These facilities are to be located and designed, to the maximum extent possible, in a manner which has minimum impact on mangrove communities.

Within the boundaries of South Biscayne Bay and Card Sound (to be defined as those waters to the mean high water mark) dredge and fill, bulkheading, and new navigation channels is permitted only in accordance with already planned public bay access facilities.

Redevelopment along Biscayne Bay is to be accompanied by the replacement of existing bulkheads with a riprap shoreline with a 3:1 slope to the bay bottom.

Development regulations within one mile of coastal waters should minimize surface runoff to South Biscayne Bay to preserve water quality. Use of fertilizer and pesticides should be minimized.

Conservation Zone Criteria

No septic tanks, package treatment plants, dumps or sanitary landfills are permitted in these zones. Self-contained waste treatment systems may be permitted.

Site alteration is limited to 25 percent of any given tract.

There is to be no further destruction of tree islands, bay heads, and willow heads.

High maintenance landscaping is discouraged and revegetation with native vegetation is encouraged to minimize water consumed for sprinkling and the necessity to fertilize.

Conservation Subzone Area B (C-2)

Water control facilities within this subzone are limited to water conveyance facilities (e.g., for backpumping) constructed solely for the purpose of water conservation or water quality control. Thus, water control for the sole purpose of providing flood protection for urban development, is not permitted. Such protection may only be realized through filling.

Hurricane Tidal Zone

These guidelines should be considered minimum standards to protect areas of greatest hurricane flood potential. They are not purported to provide adequate flood protection for other areas or from greater storms.

Development within this zone must have floor elevation at or above the 100 year flood level. This is to be considered an interim guideline until compliance with Federal Flood Insurance Program regulation is realized.

Development is, to the maximum extent possible, to utilize organic soil pockets as retention basins.

No septic tanks are permitted.

Water control facilities within these zones are limited to those additional facilities which will not potentially overload the primary and secondary drainage system now providing flood protection for Dade County.

Submarginal Development Zone

No septic tanks or package treatments are permitted in this zone. Self-contained facilities may be permitted.

Site alteration is limited to 50 percent within any given tract in this zone. The disturbance should be to the maximum extent possible confined to those areas impacted by exotic vegetation and to areas not characterized by organic soils.

The following vegetative associations are to be preserved to the greatest extent possible:

Hardwood hammocks
Bay heads
Cypress domes
Mangrove fingers

Water control facilities within these zones are limited to those additional facilities which will not potentially overload the primary and secondary drainage system now providing flood protection for Dade County.

Southeast Submarginal Development Subzone (SM-3)

Any drainage of this subzone to the southeast across L-31E must insure that a system of weirs to distribute water beyond L-31E as sheetflow across P-4 to the mangrove estuaries is adopted.

Agricultural Zone

Maximum effort should be made to maintain all this zone as agricultural open space. Pineland and hammocks should not be destroyed to provide for agricultural or urban land uses.

Septic tanks are permitted only on lots of one acre or larger.

Water control facilities within these zones are limited to those additional facilities which will not potentially overload the primary and secondary drainage system now providing flood protection for Dade County.

Forest-Grove Compatibility Zone

This area has a maximum site alteration of 50 percent within viable groves.

Removal of pineland for agricultural purposes is not permitted.

Septic tanks are permitted only on lots of one acre or larger.

Water control facilities within these zones are limited to those additional facilities which will not potentially overload the primary and secondary drainage system now providing flood protection for Dade County.

Marginal Development Zone

Development is to the maximum extent possible, to utilize organic soil pockets as retention basins.

No septic tanks are permitted.

Water control facilities within these zones are limited to those additional facilities which will not potentially overload the primary and secondary drainage system now providing flood protection for Dade County.

Development Zone

Within the development zone the only criteria are those applicable to all Dade County. However, water control facilities within these zones are limited to those additional facilities which will not potentially overload the primary and secondary drainage system now providing flood protection for Dade County.

IMPLEMENTATION

The purpose of this chapter is to present a package of proposed tools for implementing the Environmental Protection Guide. These tools are not purported to be a conclusive package, but should provide a broad basis for realizing the major goals of this study. Moreover, some of the tools presented herein will require additional legal research and study before they can be drafted for adoption.

The primary function of the implementation tools recommended include: (a) the preservation of the most unique and valuable natural areas; (b) the regulation of the intensity of development and therefore the overall disturbance of given areas; (c) tailoring the intensity and density of a development in a manner which is compatible with the natural environment; (d) the control of development site design so as to preserve water quality; (e) the strict control of development impact in small areas of unique and valuable vegetation; and (f) the control of site design so as to protect the recharge capacity of the Biscayne Aquifer.

Realization of the above protective measures will necessitate a change in values which will permit decisions to be based on more than short-term economic and political factors. It is, therefore, the aesthetic, psychological, and social benefits of open space and natural area preservation which must insure that these areas are protected in future planning and development.

Without the embodiment of environmental protection measures in legal tools, progress cannot be achieved. Although the field of environmental law is relatively new, there have evolved on the federal, state and local levels many laws related to: flood plain zoning, wetlands protection, coastal zoning and protection, water resource regulation, land use, and environmental impact which reflect a genuine concern for environmental protection.

<u>Environmental Impact Ordinance</u>

The tool which demands immediate attention and is of greatest importance in implementing key recommendations of this study is the Environmental Impact Ordinance. Ostensibly this ordinance will contain the elements necessary to provide substantial protection within designated Preservation and Conservation Environmental Protection Zones as well as within the unique vegetative associations of mangroves, hammocks, and pinelands. This law will, therefore, require the submission of an environmental impact statement which must justify the proposed activity within any area for which the law is applicable. The impact statement for activities within these "Areas of Critical County Concern" must state all impacts on the natural environment and must justify any deviations from the guidelines for the designated areas as embodied in the Environmental Protection Guide. Thus, deviations from permitted uses or recommended site alteration limitations must be thoroughly justified on scientific grounds. Although it cannot be assumed that maximum protection will be provided for these critical areas, substantial protection should be provided until legal research on all potential

Protection mechanisms can be completed.

Special Zoning District

In such cases where adequate protection for the Conservation Environmental Protection Zone or for mangroves, hammocks, or pinelands cannot be provided through the Environmental Impact Ordinance, a second tool should be considered. This tool would be a special zoning district, a second tier of zoning, which would superimpose over all existing zoning districts the following regulations: first, any zoning permitted within the Conservation Zone delineated by this study would be subject to the site alteration limitations and all other guidelines presently applicable to the Conservation Zone; second, any zoning permitted within mangroves, hammocks, or pinelands would be subject **to previously recommended site alteration limitations** and other regulations embodied in the guidelines for these areas. Such a tool would not specify permitted densities (this would be determined by existing zoning), but would impose regulations over and above those embodied in the zoning district dictating permitted density.

Developmental Impact Ordinance

A Developmental Impact Ordinance, unlike the Environmental Impact Ordinance, would provide a systematic and comprehensive review process for development in all Dade County. The tool should require developments of more than 250 units, and up to the threshold at which they meet the standards designating them as (State of Florida) "Developments of Regional Impact" to submit an impact statement outlining the impact the proposed project will have, based on consideration of the following factors:

1. natural characteristics, including geology, soils, hydrology, plant groupings, rare or endangered species, and wildlife habitats;

2. changes in micro-climate, surface water runoff, natural vegetation, air quality, and effects on topography or landscape resulting from soil removal;

3. design process and its relationship with the natural characteristics of the site and surrounding area;

4. sewage generation and capacity of treatment facilities;

5. water consumption and availability;

6. storm water runoff and retention;

7. traffic generation and capacity of roads and public transportation facilities;

8. projected school enrollment and capacity of existing facilities;

9. open space and recreation needs and existing facilities, and

10. Public safety facilities.

The Developmental Impact Ordinance would be designed to assess the impact of a project regardless of its location and, therefore, would be equally useful in protecting the environment in all zones. The ordinance could offer protection to mangroves or sloughs in the Preservation Zones, to hammocks or pineland in the Development or the Forest-Groves Zones, or it could aid in the protection of marshland in the Hurricane Tidal Zone. However, its purpose will be to assess the county-wide impact of any major project and, therefore, should help alleviate some of the major environmental problems which seem to emanate from urban development.

Bay and Shoreline Protection Measures

The adoption of tools to insure the protection of coastal estuaries and Biscayne Bay are essential if water quality and marine productivity are to be maintained in Biscayne Bay. With respect to mangrove protection the adoption of a bulkhead line at or above mean high water should be pursued without hesitation. Although such a regulation may not protect all mangroves, it would provide substantial protection to red mangroves which have been shown to be essential to the maintenance of marine productivity.

A tool which could be useful in the maintenance of, or the reestablishment of biological productivity is a Bulkhead Regulation Ordinance; such an ordinance should prohibit the use of bulkheads in any shoreline development or redevelopment and should require the use of shoreline riprap.

Overall protection of the Bay can only be realized by eliminating the multi-jurisdictional regulation which now exists and establishing a Biscayne Bay Conservation Commission with complete authority over Bay activities such as now exists in the San Francisco area. Under such an agency, permits would be required for all bayshore development, for any discharges into the Bay, and for all other activities within the Bay. The Commission should retain veto power over all bay activity if effective regulation is to be achieved.

Federal Flood Insurance Ordinance

One additional tool which should be adopted as soon as possible is an ordinance adopting the regulations for conformance with the Federal Flood Insurance 100 year flood program. Immediate adoption will insure protection within the Hurricane Tidal Zone designated in this study as well as in other flood prone areas in Dade County.

Wastewater Disposal Ordinances

Another area where protection is needed is the effective regulation of septic tanks and package treatment plants. Although some ongoing studies exist on the water quality effects of septic tanks these conclusions cannot be appropriately applied to areas off the coastal pine ridge where the most severe problems exist due to a high water table and low permeability soils. An ordinance should be adopted which would take a very conservative approach to permitting septic tanks; such action should insure that effective precautionary measures for the protection of our drinking water supply, the Biscayne Aquifer, are taken. The guidelines of the E.P.G. should be considered an appropriate starting point with septic tanks to be prohibited from Preservation, Conservation, Submarginal, and Marginal Zones. Package treatment plants which presently come under County ordinance, only in the requirement of a permit and a public hearing, should be regulated more rigidly with them prohibited in Preservation, Conservation and Submarginal Zones.

Subdivision Regulations

A tool which could be used effectively for environmental protection but which has seldom been put to such use is the Subdivision Code; Chapter 28 of the Metropolitan Dade County Code encompasses these regulations which are presently reviewed and revised, according to the Metro Charter, by the Planning Department. At present the regulations under Chapter 28 are enforced by the Plat Review Committee which has representation from the Public Works, Building and Zoning, Traffic and Transportation, Parks and Recreation, and Planning Departments; the School Board is also represented. One basic shortcoming of the Plat Review Committee has been its inability to effectively review and recommend on issues other than technical or engineering matters which are specifically provided for in the Subdivision Code. In light of the Committee's present membership and responsibilities it would be desirable for the Committee to have the authority to review planned subdivision design. Insurance that site design is compatible with the existing environment should be achieved through amendments to Chapter 28.

An implementation issue which is at the heart of the Environmental Protection Guide is that of controlling surface water runoff and the deleterious effects which it often has on water quality. Changes in Chapter 28 of the Dade County Code and in overall County policy may be necessary to effectively deal with this problem. Although extensive, indepth studies of the adverse nature and effects of surface water runoff have not been conducted in Dade County, various studies throughout the United States point to the severity of this problem. Although recent efforts have been made to effectively deal with this problem on the development site scale a number of additional changes in County policies, plans, and laws may be necessary. A further shift from past County policy which often required positive drainage via culverts, gutters or storm drains, to the incorporation of seepage drainage using retention basins or swale areas, will probably be the most effective means of reducing surface water runoff pollution in developing areas. The extent to which seepage drainage can be used will necessarily depend on the flood protection available to the proposed development site, the soil and vegetative character of the site, and the amount of undisturbed open space available for retention purposes. In certain Environmental Protection Zones it is anticipated that complete on site retention without additional drainage for flood protection may be possible if large enough areas are left as undisturbed open space. The Subdivision Code and the references it makes to the Public Works Construction Manual is the basis for regulating the handling of surface water runoff. Thus, it is this regulatory mechanism which must reflect the findings of local storm water studies by changing the Code where necessary to insure that the deleterious effects of runoff on water quality are minimized. The increased use of soil filtration and vegetation nutrient uptake should be an effective means of beginning to cope with the problem.

Relative to the incorporation of seepage drainage in place of or in conjunction with positive drainage, the issue of flood criteria must be addressed. It is possible that the present flood criteria may not be applicable to areas where flood protection is not presently adequate and where development without additional flood protection through positive drainage is to be permitted. In such cases it is anticipated that the required undisturbed open space will be adequate for on site retention. If, however, the water table rises with the contour of the land where fill is needed on the portion of the tract to be disturbed, then revised fill requirements based on a study of the site may be necessary.

Building Code

Building Code regulations might be considered of little importance in terms of their potential for providing any protection of the natural environment. However, in certain areas the adoption and enforcement of new regulations could be a useful implementation tool. Perhaps the adoption of more restrictive regulations on the development that can take place on Dade County soils is the most important issue relative to the Environmental Protection Guide. The appropriate place for such changes would be Chapter 24 of the South Florida Building Code. Guidelines should be determined and ordinances amending Chapter 24 should be adopted to control development on marl soils and organic-peat or muck soils. Specifically, the code should state the alterations that must accompany development on marl soils to insure that adequate drainage is provided at the same time that maximum possible percolation of rainfall is guaranteed.

Changes in the code may also be necessary to provide adequate hurricane flood protection in some areas. Presently the County is attempting to conform to federal flood insurance regulations which will necessitate drastic building code change in flood prone areas. Requirements for stilting structures may be part of such regulations.

Taxation

At the heart of existing inadequacies in the present tax structure is the fact that Florida law requires that structures and land be taxed at the same rate. The net effect is that relatively close-in land can be held at low tax cost while the community produced value of the land continues to rise. Thus, speculators and developers continue to have the speculation impetus for leap-frog development that characterizes urban sprawl. So long as these incentives exist controls such as subdivision controls or environmental regulations may not be effective.

A number of modifications in the tax structure could be undertaken, but discussion here will be limited to a few alternatives. One taxing method which would encourage the maintenance of open space is "annual value taxation". Under this tax policy land is taxed according to its annual value which is equal to the annual gross rental value of the property. Thus the tax is placed on the existing use of the property and not on the most profitable use of the property. Since such a tax system would not levy tax on vacant property the creation of greenbelts, or the maintenance of open space "pockets" would be more economical than is presently the case.

A second tool to be considered is "land value increment taxation". In such a system taxes are levied only on the increased value of the land. This tax would encourage more intensive use of land by reducing the return from land speculation. Since the tool has the potential of encouraging efficient land use, particularly in the central city, it could have the indirect effect of providing more open space.

Land Banking

Another implementation tool which could assure the realization of the goal to restrict development in the Conservation and Preservation Zones delineated in this study is land banking. Land banking by the County could be accomplished through the use of general obligation bonds and is the tool which in the long run has the greatest potential for preserving natural areas. Immediate investigation into the possibility of floating bonds for the purchase of lands in designated Preservation Zones and in some Conservation Zones should be pursued. Precedent for land banking is common, particularly in Canada and Europe. The extent to which the government in Dade County can become involved in land banking depends on powers granted by the State enabling legislation. However, if the powers are available, a program should be developed which would provide for the return of some purchased lands in the Conservation Zones to the private sector with restrictive covenants or deed restrictions accompanying the sales. The resale of land by the government would serve a two-fold purpose. First, it would avoid the legal complications involved in zoning where the restriction of an individual's use of his property may conflict with the constitutional rights of the individual to use that land. Second, through the use of covenants or deed restrictions, it would provide the County with an effective method of restricting the use of land to appropriate intensities of development. If implementing a land banking program proved to be time consuming and required drastic changes in governmental policy and responsibility, it could be preceded in the interim by zoning changes or other implementation tools. Ultimately, the consideration of public purchase may be necessary in the Preservation Zones.