DOE/RA/50316--T1
Attachment III

METHANOL PRODUCTION FROM EUCALYPTUS WOOD CHIPS

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Florida's Eucalyptus Energy Farm and Methanol Refinery
The Background Environment

April 1982

MASTER

Prepared by
Biomass Energy Systems, Inc.
Lakeland, Florida

For the
U.S. Department of Energy
Office of Alcohol Fuels
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METHANOL PRODUCTION FROM EUCALYPTUS WOOD CHIPS

Working Document 3

Florida's Eucalyptus Energy Farm and Methanol Refinery - The Background Environment

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April 1982

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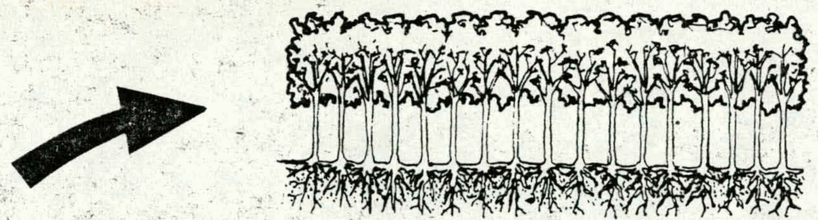
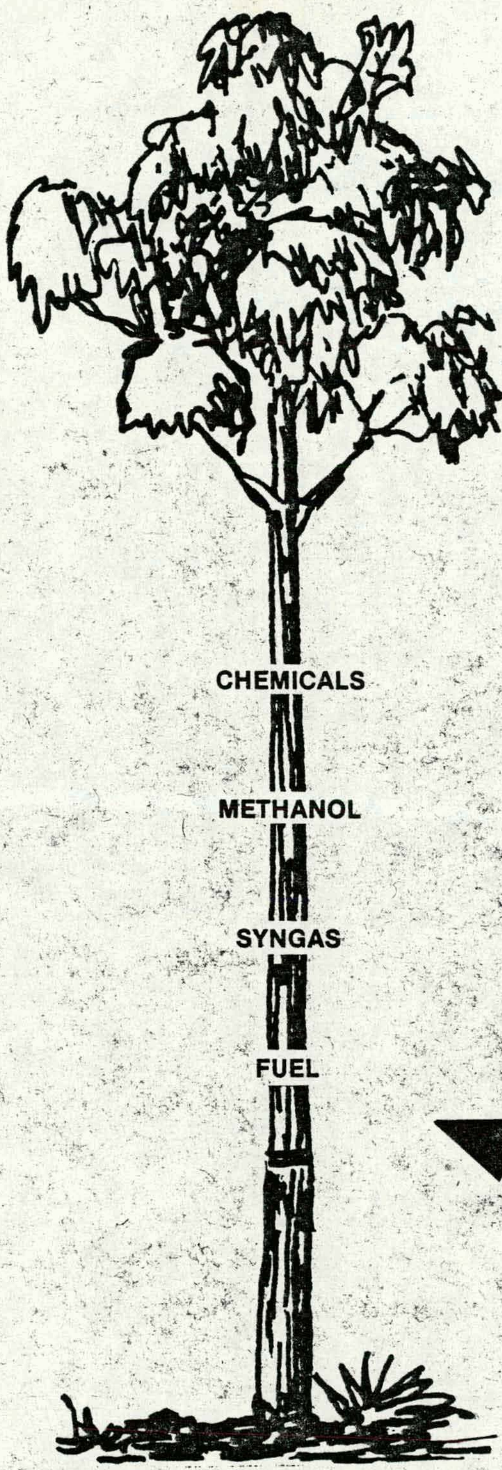
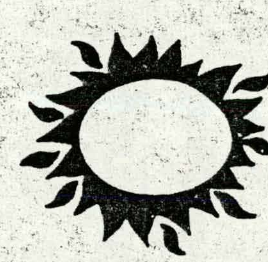
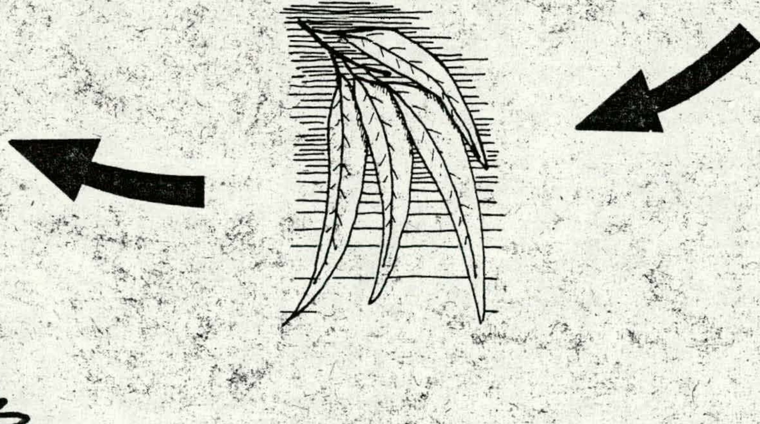


FLORIDA'S EUCALYPTUS ENERGY FARM AND METHANOL REFINERY-- THE BACKGROUND ENVIRONMENT







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"HARVESTING RENEWABLE ENERGY RESOURCES NOW"

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1.0 INTRODUCTION

This document presents a wide array of general background information on the Central Florida area in which the Eucalyptus energy plantation and methanol refinery will be located. Five counties in Central Florida may be affected by the project, DeSoto, Hardee, Hillsborough, Manatee, and Polk. This document along with Working Document No. 4: Health and Safety of the Florida Eucalypt Biomass to Methanol System, Working Document No. 5: Florida's Eucalyptus Energy Farm and Methanol Refinery--Environmental Impact Assessment, and Working Document No. 6: The Florida Eucalyptus Energy Farm Interface with Natural EcoSystems constitute our environmental analysis for the whole Eucalyptus-to-methanol project.

This background document reviews the human resources of the area in Section 2. Included are overviews of population demographic and economic trends. Land use patterns and the transportation are system described, and the region's archeological and recreational resources are evaluated. Section 3 focuses on the region's air quality. The overall climate is described along with noise and air shed properties.

Section 4 turns to an analysis of the region's water resources. Ground water is discussed first followed by an analysis of surface water. Then the overall quality and water supply/demand balance for the area is evaluated.

Section 5 presents an overview of the region's biota. Included here are discussions of the general ecosystems in Central Florida, and an analysis of areas with important biological significance. Finally, land resources are examined in Section 6.

2.0 HUMAN RESOURCES

This section provides an overview of population, demography, and economics of the region. Existing land uses are discussed along with transportation. Background information is provided on archeological, historical, recreational, and sensory resources. The eucalyptus energy farm must be compatible with the regional community and existing man-made and man-dominated elements of the earth's.

2.1 Population, Demography and Economics

The five county study area, DeSoto, Hardee, Hillsborough, Manatee, and Polk, is rather disparate group whose main connection is geography. The study area can be separated into two groups: the coastal counties—Hillsborough and Manatee, and the inland counties—Polk, Hardee and DeSoto. The coastal counties are urbanized and growing rapidly. The inland counties are more rural and growing more slowly. The counties also can be differentiated on the basis of their population characteristics—Manatee is a retirement haven while the others are not.

While the counties do have differences, they also share a lot of similarities. First, each of the five counties is affected by phosphate mining. Initially, the mines were in Polk County. As mining expanded and as the older mines became exhausted, mining spread—first to Hillsborough County and then to each of the others. Second, the counties share similar trade patterns with Tampa serving as the financial, transportation, and manufacturing hub of the region.

Table 2.1 displays recent trends in population for the five county region and for Florida. Over the last 20 years both Florida and the region have grown rapidly. Florida's population nearly doubled from 4.95 million in 1960 to 9.74 million by 1980. The five county region as a whole grew rapidly, but at a pace below the statewide average. Only in Manatee County did population growth exceed statewide totals.

Between 1970 and 19890 population growth accelerated in Florida and in the region. Florida posted a gain of 43.4 percent. In the region Manatee County grew most rapidly, 52.9 percent, followed by DeSoto's 45.6 percent gain. Hardee County grew at the slowest rate, 30.2 percent.

Hillsborough County is the region's most populous with 647,000 residents followed by Polk at 321,600. Manatee County had a population roughly one-half of Polk County's. DeSoto and Hardee counties are much smaller at about 19,000 each.

Table 2.2 examines the components of population change between 1970 and 1980. For Florida as a whole, over 90 percent of the population growth came as the result of net migration. Natural increase, the difference between births and deaths, accounted for less than 10 percent of population growth.

The five counties in the study area vary widely on the components of their population growth. For example, population growth in Manatee County depends entirely on net migration. Since almost 30 percent of Manatee County's population is over age 65, the county's number of deaths exceeded its number of births between 1970 and 1980. By contrast, in Hardee County natural increase accounted for over 37 percent of population growth. This indicates a youthful county population, and just over 11 percent of Hardee's citizens are over age 65.

Table 2.1.—Population trends
(in thousands)

	1960	1970	1980
DeSoto	11.7	13.1	19.0
% change	—	12.0	45.6
Hardee	12.4	14.9	19.4
% change	—	20.2	30.2
Hillsborough	397.8	490.3	647.0
% change	—	23.3	32.0
Manatee	69.2	97.1	148.4
% change	—	40.4	52.9
Polk	195.1	228.5	321.6
% change	—	17.1	40.8
Florida	4,951.6	6,791.4	9,740.0
% change	—	37.2	43.4

Table 2.2.—Components of population change 1970-1980

	Population change 1970-1980	Natural increase		Net migration	
		Number	Percent	Number	Percent
DeSoto	5,979	780	13.1	5,199	86.9
Hardee	4,490	1,672	37.2	2,818	62.8
Hillsborough	156,695	34,672	22.1	122,023	77.9
Manatee	51,327	-4,429	0.0	55,756	100.0
Polk	93,137	14,545	15.6	78,592	84.4
Florida	2,948,574	236,729	8.1	2,711,845	91.9

Table 2.3 outlines the composition of economic activity in the five county region and in Florida. As of March, 1981 there were over 3.7 million employed in nonagricultural industries in Florida. The trade sector dominates the employment total providing 26.1 percent of all jobs. The service sector constitutes 23.6 percent of all jobs with government at 18 percent and manufacturing at 12.6 percent also being important elements.

By and large the composition of economic activity in the region is similar to the state as a whole. However there are some important differences. These are most apparent in the data on manufacturing. Polk and Hillsborough county have significantly higher proportions of their workers engaged in manufacturing than is true statewide. By contrast, Hardee and DeSoto counties are much more rural and possess fewer manufacturing employees, 8.3 percent and 6.3 percent respectively.

Table 2.3.—Nonagricultural employment: March 1981
(in thousands unless noted)

	DeSoto	Hardee	Hills-borough	Manatee	Polk	Florida
Manufacturing	0.3	0.3	36.9	7.5	23.5	470.9
% of total	6.3	8.3	13.4	17.4	19.5	12.6
Construction	0.1	0.1	17.9	3.2	9.2	283.0
% of total	2.1	2.8	6.5	7.4	7.6	7.5
Transportation, communication, and utilities	0.2	0.1	20.2	1.5	4.9	225.4
% of total	4.2	2.8	7.4	3.5	4.1	6.0
Trade	0.9	1.0	74.2	12.0	29.7	980.3
% of total	18.0	27.8	27.0	27.9	24.6	26.1
Finance, insurance and real estate	0.2	0.2	18.3	2.9	6.7	266.3
% of total	4.2	5.6	6.7	6.7	5.6	7.1
Services	0.7	0.9	60.6	8.4	29.3	886.9
% of total	14.6	25.0	22.1	19.5	24.3	23.6
Government	2.4	1.1	46.7	7.5	17.4	673.4
% of total	50.0	30.6	17.0	17.4	14.5	18.0
Totals	4.8	3.6	274.8	43.0	120.7	3,750.2

2.2 Land Use

2.2.1 Land Use Categories. There is considerable variation in land cover and usage in West-central Florida. For the purpose of this study, only major land cover classes are discussed. Small scattered areas of differing land uses have been grouped according to the most appropriate land classifications discussed below.

2.2.1.1 Urban or built-up land. This land cover category comprises areas used for intensive activities such as cities, towns, industrial and commercial complexes, and highway strip development. These areas may or may not be contiguous to urban centers and are sometimes quite isolated. Urban areas cover about 9% of the land area of the region. The majority of this development lies in the counties of Hillsborough, Polk and Manatee.

2.2.1.2 Cropland and pasture. This heading encompasses several different land uses collectively referred to as "cropland and pasture." Specific land use trends are somewhat fluid. The land might be actively cultivated for crops, fallow between crops, used from cropland in rotation with pasture, or premanently utilized as pasture. Consequently, it is difficult to distinguish between cropland and pasture with accuracy. Cropland and pasture cover approximately 26% of the study area and can be distinguished from other cover types using remote sensing imagery (Level II). The lack of native vegetative cover separates these lands from native rangelands. Cropland and pasture frequently intergrades with both rangeland and urban or built-up land. Much of this land is edaphically well-suited for wood energy farms.

2.2.1.3 Orchards and groves. Citrus groves are the predominant use within this category. Oranges, grapefruits, and tangerines are the principal crops. About 11.6% of the Central Florida phosphate district is cultivated as groveland. The vast majority of these groves are in Polk County; others are scattered throughout the five county region. Groves are not likely to yield to eucalypt energy farms for economic reasons.

2.2.1.4 Rangeland. Historically, rangeland has been defined as land on which grasses, grasslike plants, forbs or shrubs and saw palmettos predominate. This category includes the "palmetto prairie" in South-central Florida. The major distinction between palmetto prairies and pine flatwoods is the absence of a naturally-occurring pine canopy. Thus, pine flatwoods areas that have been logged extensively and support little natural regeneration of pines (due primarily to fire management) also are considered rangeland and fall under this classification. Natural dry prairie rangelands are restricted to Southeastern DeSoto and Polk counties. Rangeland is the single most expansive land cover category comprising over 27% of the study area. The eucalyptus energy farm could become a dominant use of existing rangeland.

2.2.1.5 Forestland. Forests are identified as areas that have a treecrown areal density of 10% or more, are stocked with trees capable of producing timber or wood products, and influence the climate or water regime (USEPA, Vol. X, 1978). Forests in the study area are predominantly evergreen, consisting of pine flatwoods, xeric forests and hammocks. Of these, pine flatwoods continues to be the most extensive forest type. All existing forest types in the region, combined, cover less than 5% of the land area. About 47.6% of the remaining forestlands are located in Polk County. The eucalypts energy farm could add significantly to the forest cover of the region.

2.2.1.6 Water. All areas that are presistently covered with water fall under this classification. This includes streams, canals, lakes, reservoirs, bays and estauries. Water areas comprise about 3% of the study area. There are numerous streams coursing the region; however, most of the lakes are located in Polk County. Over 67% of the surface water areas of the region are located in Polk County.

2.2.1.7 Wetland. Areas where the water table is at, near, or above the land surface for a substantial portion of the year are considered wetlands. The begetatin responds to the moisture regime and usually consists fo hyrophytes (plants adapted to wet conditions). Wetlands occupy stream valleys and other topographic depressions and comprise about 13% of the Central Florida Phosphate District. Both forested and non-forested welands are common. Forested wetlands are dominated by woody vegetation and include seasonally flooded bottomland hardwoods, cypress swamps, byheads, mangrove swamps and shrub swamps. Non-forested wetlands are dominated by herbaceous vegetation and support freshwater marshes, wet prairies, and tidal marshes. Wetlands are not suitable for a eucalypt energy farm use.

2.2.1.8 Disturbed land. This category describes lands that have been mined or otherwise disturbed. Phosphate mining is primarily responsible for lands classified as disturbed. Portions of this category actively undergoing disturbance would be classified as barren land; however, no distinction was made to distinguish between transitional lands, solid waste disposal areas, active clearing and mining, and reclamation in process. As defined, about 4% of the study area is categorized as disturbed land. These lands are included in this category until other cover or use has been established. Woody biomass energy farms are one cf the most probable uses of disturbed land as i is newly reclaimed to a productive use.

2.2.2 Future Land Use Trends. Urbanization, primarily residential expandions, will continue to grow due to Florida's vast appeal to people for relocation and retirement. Urban or built-up areas generally will remain near the Gulf coast and along existing or planned transportation corridors (I-4, U.S. 92, U.S. 41, I-75, U.S. 17, etc.). By the year 2000, urban lands are expected to increase 375% in areal extent. Agricultural lands are rapidly being displaced by urban development. This trend may result in pressure to intensivy usage on the remaining uncultivated lands. However, the extent of agricultural lands are still expected to be reduced about 12%. Rangelands will fall prey to intensive agriculture, mining and urban development for a total reduction of 7%, but should still dominate over 25% of the region's land area. The most drastic change in land use will be in forestland. Forest cover will be reduced by over 20%; the major causes being urban development and phosphate mining (USEPA, Vol. X, 1978). There will also be a total reduction in wetlands, although it will be less than 2%. The area occupied by phosphate mining is projected to increase 13% and will progressively move southward toward undepleted ore deposits.

2.2.2.1 Polk County. The incorporated cities of northern Polk County will continue to grow, displacing citrus groves in the Lakeland vicinity. There will be an increase in pasture and agricultural uses of reclaimed phosphate lands; however, this increase is overshadowed by urbanization and mining. The forestland in Polk County is expected to be reduced by as much as 64% by the year 2000 (USEPA, Vol. X, 1978).

The establishment of large scale biomass energy plantations, as managed forestland, would offset and reverse this decline substantially.

2.2.2.2 Hillsborough County. Population and development will increase in the suburban areas northwest and east of Tampa. By the year 2000, mining activity will decline and reclamation of disturbed lands will be completed or in progress. Trends towards irrigated pastureland are projected to continue, placing further pressure on limited ground-water resources. Despite extensive urbanization, Southeastern Hillsborough County should retain its rural character.

2.2.2.3 Manatee County. Another major growth center, Manatee County, will experience major increases in urbanization along the coast. Urban expansion will be primarily restricted to the coastal portion west of Interstate 75. Salt water intrusion and contamination of freshwater will continue to be a major concern. An alternative to irrigated agriculture, such as dry land biomass farming, would help alleviate the aquifer contamination pressure in both Hillsborough and Manatee counties.

2.2.2.4 Hardee County. Major developments in Hardee County are expected to hinge upon transportation access to Polk and Manatee counties and the mining of extensive phosphate reserves. Most growth will be phosphate related as the industry moves southward towards the remaining deposits of the Bone Valley Formation. Wauchula will be the hub of this activity. Large tracts of rangeland and agricultural land will be devoted to mining in the Wauchula and Bowling Green area. Large acreages of newly reclaimed land could be committed to eucalypts energy plantations.

2.2.2.5 DeSoto County. Lying on the eastern edge of the stu region, DeSoto County will experience only small increases in population and will retain its rural character. The northwest corner of the county will be among the last areas in the Phosphate District to be mined. Substantial portions of native rangeland will be converted to agricultural uses, a 20% overall reduction by the year 2000 (USEPA, Vol. X, 1978). Similar areas in nearby Glades County have been developed as *Eucalyptus* plantations rather than improved pasture. The rangelands of DeSoto County are prime candidates for wood biomass energy farms.

2.3 Transportation

West-central Florida has a substantial network of highways and rail lines, and has good access to interstate throughways and Gulf ports. The most extensive transport systems are located in the northern and coastal sectors of the study area. In addition large international airports are located in Tampa and Orlando, as well as smaller regional air terminals throughout the study area.

2.3.1 Thoroughfares, Highways and Roads. The regional roadway systems can be broken down into the following hierarchy; (1) Federal (Interstate system), (2) Federal (U.S. system), (3) State, (4) County, and (5) Private. Interstate highways are limited-access thoroughfares and connect major cities and highways. Other Federal, State, and County highways range from single lane to multi-lane roadways. Many county roads are paved, while private roads are nearly always graded or ungraded unpaved surfaces.

Major north-south highways traversing the study area are Interstate 75, U.S. 41 and U.S. 301 along the coast, with U.S. 98 and U.S. 27

serving the interior portions of the region. Both U.S. 41 and U.S. 27 are multilane, divided highways. Parts of Interstate 75 are currently under construction and when finished will connect Tampa and the lower Gulf coast, thereby relieving the traffic congestion on U.S. 41. The central portion of the study area is serviced by only one north-south throughway (U.S. 17), which becomes a two lane roadway south of Ft. Meade in Polk County. Due to the rural nature of the central area, traffic congestion is not serious at this time. Although long-range goals call for widening of U.S. 17, no immediate plans for construction are under consideration.

Interstate 4, U.S. 92, S.R. 60, S.R. 64, and S.R. 70 are the major east-west highways traversing the study area. Interstate 4, most of S.R. 60 and portions of U.S. 92 are multi-lane, divided highways. These roadways serve some of the most populated areas in the region and are highly traveled. Both S.R. 64 and S.R. 70 are rural connector roads linking U.S. 27 with the coast.

Numerous locally important state and county roads connect rural areas with the major throughways. The preponderance of roadway access is associated with (1) urban and suburban areas, (2) lands owned by numerous small landowners, and (3) the mining areas of the phosphate district. Private roads are most common on large ranches and at phosphate mines.

2.3.2 Rail transportation. West-central Florida is well-served by major rail lines. The Seaboard Coast Line Railroad (SCL) is the only railroad that services the area. Major routes serve metropolitan areas. Because of geographical proximity and industrial needs, the vast majority of rail shipments are related to the Tampa-area ports.

Two lines connect Polk, Hardee and DeSoto counties with areas tc the north and south, as well as to the two major east-west routes converging in Tampa. Another major line extends along the west coast serving these growing metropolitan areas. A major concentration of spur lines and connector routes are located in Southwest Polk County in the phosphate mining areas. At present, Manatee County is most lacking in rail facilities; however, additional routes are being planned in this area in anticipation of future phosphate mining activities. Highway, rail, and ocean port resources are ideal for support of a large scale wood to methanol industry in the region.

2.4 Archeological, Historical and Recreational Resources

Most of the region's archeological and historical sites are associated with inland or coastal water features. These areas provided sites accessible to major transportation routes, abundant protein resources (e.g., fish, shellfish, etc.) or pottable water supplies necessary to support primitive habitation. Most recorded sites are classed as "prehistoric" because they predate the 16th century. Historic artifacts are rare, as most of the agricultural and urban development is intensive and recent in origin, and thus, has tended to obliterate existing sites. The region changed from wilderness to a major urban/agricultural complex in less than one century.

There are a variety of recreational areas, both public and private, within the study area. Major regional recreation areas are managed by the Florida Division of Recreation and Parks. Smaller parks and recreation areas are administered by city and county authorities. Portions of the Avon Park Bombing Range (Federal reserve) are managed as a wildlife management area for hunting, fishing and camping uses. Central Florida's numerous lakes and streams provide abundant recreational opportunities and many are easily accessible to the public. Private recreation areas such as golf courses, marinas and campgrounds are abundant and receive heavy use.

2.5 Sensory Resources

The sights, sounds, smells of an area are important components of it's total environment. The five county study area is composed of a variety of land forms, vegetation types, drainage systems and land uses. The interaction of these elements molds cultural and natural features and determines the region's sensory conditions. The way in which people perceive and respond to the landscape varies considerably. Value judgements should be avoided; rather, the landscape should be delineated and characterized as one of many commonly experienced environments. Due to the significantly large land area included for analysis, only general landscape types and regionally important features are discussed.

There are five major landscape types in the study area. Lands are grouped according to their dominant landscape features, which are prime determinants in classifying landscape types. There are several examples of each of these landscape types in the region. They differ according to site specific responses to particular environments. These can be referred to as landscape districts. Shift sin distribution are occurring in response to urban expansion. Slow long-term shifts are expected in the areas south of the current phosphate mining areas.

2.5.1 Tampa District (Urban). This region is the largest urban area within the study area. Tampa is equipped with deepwater port facilities on Tampa Bay and is a major commerce and shipping center for the Central Florida Gulf coast.

The enormous growth within the last 20 years has resulted in rapid expansion of outlying suburban areas and associated retail and service facilities. In addition, an urban skyline has been quickly developing Downtown, along the Bayshore, and in the Westshore area. Tampa is suffering the typical consequences of rapid, uncontrolled growth— destruction of natural areas, traffic congestion, overloading of public facilities. Air pollution, due primarily to automobiles, is chronic in some sectors.

The Hillsborough River and Tampa Bay are the major natural features of this region. Pollution is quite common in the area's waters, although water quality in Tampa Bay has been improving due to pollution control. Land marks include Bayshore Boulevard, Downtown, MacDill AFB, Ybor City, Tampa International Airport and the Sulphur Springs Tower. Suburban sprawl to the northwest around lakes and surrounding rangelands predominates, as well as to the east into the farmlands and hammocks of the Brandon area north of the Alafia River.

2.5.2 Coastal Lowlands (Rural). This district is situated along the eastern shores of Tampa Bay. The coastal lowlands are protected from harsh freezes due to their proximity to the warm waters of the Bay. This low, flat area is presently in transition from agriculture (vegetable crops) to commercial, residential and industrial uses.

Although vegetable cropping still occurs in the area, abandoned farmland is common. If not utilized as pastureland, these areas often are colonized by cabbage palms and Brazilian pepper. Strip commercial development occurs along U.S. 41, while major residential developments such as Sun City Center and Apollo Beach augment the existing towns of the district--Ruskin, Gibsonton, Adamsville, etc. A number of industrial plans and small ports are situated along the Bay. Loading yards and waste disposal areas are blunt visual landmarks along U.S. 41. Along undeveloped shorelines, mangrove swamps blanket the estuarine submerged lands and provide important fish and wildlife functions for the Bay.

2.5.3 Bradenton District (Urban). The urbanized area of Bradenton/Palmetto lies at the mouth of the Manatee River and is surrounded by the open waters of the Gulf, Sarasota Bay and numerous small bays and bayous. Natural systems parameters are similar to the Coastal Lowlands, the adjoining landscape district. Growth has been rapid in recent years resulting in expansive highway-oriented development. Unique features include Indian shell mounds along the coast, Braden Castle, Manatee Burying Grounds, the Bradenton municipal pier, and the Gulf beaches of Anna Maria Island.

2.5.4 Plant City District (Rural). This rural area lies between Tampa and Lakeland and comprises a multitude of small landownerships. Consequently, land utilization is diverse and includes citrus, ranching, dairy farming, vegetable cropping and rural residential uses. A substantial amount of vegetable farming occurs around Plant City, especially in the Seffner area. Tampa is expanding into the western portion of this district, resulting in higher land values and reduced agricultural activity.

2.5.5 Northern Rangelands (Pastoral). The Northern Rangelands encompass the lands lying across the northern portion of the study area. As a landscape type, it is interrupted by the upper Lake Wales Ridge.

The area is dominated by large ranch holdings with cattle grazing as th primary land use. Elevations are generally level and punctuated by numerous cypress domes, woody swamps, and strands.

The central portion of this district is referred to as the Green Swamp due to the predominance of small scattered swamplands composed mainly of cypress. Approaching the Lake Wales Ridge, several low parallel ridges rise from the lowlands and support several citrus groves that accent the landscape plain. The lands east of the Lake Wales Ridge are quite similar to the western portion of the Green Swamp and the Hillsborough River headwaters. In Northwest Hillsborough County, many of the natural depressions hold small lakes and ponds as well as cypress domes; and, a larger percentage of the native rangeland has been converted to improved pasture.

2.5.6 Lakeland District (Urban). The City of Lakeland lies along the highest portions of the Lakeland Ridge. Many lakes are located in depressional areas within and adjacent to the Ridge. Nearly the entire district is urbanized or rapidly developing. The Lakeland Highlands is one of the most important natural landforms in this district. Rolling hills with elevations up to 70 meters (230 feet) are covered with citrus groves, sandhill vegetation, and, most recently, suburban development.

The City of Lakeland, as an urban subdistrict, has been expanding into adjacent districts, as well as within the district. Numerous residential and industrial developments are located on old mined lands of the Bone Valley District. Florida Southern College on Lake Hollingsworth and the Colonnade facing Lake Mirror in downtown are the major cultural landmarks.

2.5.7 Bone Valley (Mining). The phosphate mining areas in Polk and Hillsborough counties are often referred to as the Bone Valley District. As a landscape district this area is characterized by the strip mining and processing of phosphatic ore. The pre-mining landscape is similar to the Central Rangelands. Newly disturbed areas are strongly evident, as are waste disposal sites such as clay settling areas and gypsum stacks.

Change is the most constant factor at work in this district. Topography and vegetative assemblages are severely altered. Large areas are occupied by natural revegetated spoils in various stages of natural succession ranging from ruderal weeds to impressive oak forests. Reclaimed land often is converted to improved pasture and leased to cattle interests. The post-mining lands can be distinguished by the presence of numerous ponds and lakes and a variety of slope gradients.

Air pollution is sometimes evident as fugitive dust and the acrid odor of sulfurous compounds from chemical plants. Chemical and benefication plants are constant landmarks and centers of activity that command wide visual attention.

2.5.8 Central Rangelands (Pastoral). The wide, expansive tablelands of the Polk Upland and Desoto Plain are typical of the Central Rangelands. Cattle grazing is very common, even to the exclusion of all other land uses other the majority of the district. Cut-over flatwoods are the predominant vegetative association. There are few pines remaining in the expanse of saw palmetto and wiregrass. Some areas have been converted to improved pasture and scattered citrus groves and oak scrub can be locally common. This district differs from the Northern Rangelands by its sparseness of cypress domes and strands. Wetlands are abundant, but are manifest as bayheads, sloughs, marshes and wet prairies. The spatial order of this district also is more open due to large, single-ownerships ranch holdings and low density land uses. There are significantly more cattle than people, with homesteads and residences few and far between. Many of these lands are owned by phosphate interests with obvious future intentions of mining the underlying ore when the richer deposits to the north are mined out.

2.5.9 Wauchula and Arcadia Districts (Rural). The towns of Wauchula and Arcadia are the county seats of Hardee and DeSoto counties, respectively. Patterns of growth and natural terrain are similar and the districts will be discussed together.

In certain ways, these districts resemble the Plant City district in land use and ownership trends. Many small farms and homesteads abound, resulting in a dramatic compartmentalization of spaces by hedgerows, swamps, forests, fences, etc. These areas tend to have more citrus and improved pasture than Plant City or the Coastal Lowlands District. Vegetable farming is not quite so common, since local farmers still prefer to move on to virgin land after several years of use as an alternative to soil fumigation for pathogen control. A deciding factor may be the generally poor nature of the soil when compared to areas near Ruskin and Plant City.

2.5.10 Lake Ridge (Highlands). The sandhill country of Central Polk County is speckled with numerous ponds and lakes, distinguishing this area from other ridges in the region. Lakes work very effectively at sight attractors and can be considered the major aesthetic resource in the district. Citrus groves overlay most of the surrounding hills. Citrus processing is common in the district, especially in and near towns such as Auburndale. Residential development continues to displace citrus near urban subdistricts such as Winter Haven. Nearby Cypress Gardens is a major tourist attraction in the area, featuring water-oriented shows and gardens.

2.5.11 Alturas District (Highlands). The ridge area is similar to the Lake Ridge district to the north, excepting the lack of lakes within the ridges themselves. However, several large lakes are situated at the base of the sandhills. The main contrast is the lack of urbanization. Most of this district remains in citrus and should continue to do so in the future.

2.5.12 Lake Wales District (Highlands). The Lake Wales Ridge is the natural surface feature that delineates the Lake Wales landscape district. Lowlands surround the ridge on both sides, emphasizing the elevation changes and local hydrology. Although the ridge rises abruptly in places, it appears as a series of rolling hills blanketed with citrus groves. Lakes are common and most prominent in the southern portion of the district. The Bok Tower Gardens overlook Crooked Lake and provide the most dramatic vistas in the district.

2.5.13 Peace Creek. The headwaters of the Peace River lie between the Lake Ridge, Alturas and Lake Wales districts. This lowland area was once covered by a series of marshes slowly draining into Peace Creek and thence into the Peace River. Channelization and agricultural conversion have significantly changed the function and character of this basin. Nearly all this lowland has been converted to improved pasture and now serves as highly productive, intensive grazing land.

2.5.14 Kissimmee Rangelands. This district is very similar to the Central Rangelands as it lies on a flat imperfectly drained terrace.

However, a line of swamps borders the Lake Wales Ridge and several large lakes dot the landscape. Several large residential developments located on Lake Weohyakapka contrast with the prevailing rural character of the district.

2.5.15 Kissimmee Prairie. Native dry prairie occupies the tablelands adjacent to the Central Rangelands in the south and the Kissimmee Rangelands in the east. Dry prairie is practically identical to pine flatwoods excepting the lack of pines. In fact, trees of any kind are rate, which allows a panoramic view of the expansive flat countryside. Vast areas of prairie have been converted to improved pasture. One large area in DeSoto County planted to citrus is particularly incongruous with the remainder of this landscape district. In addition, the Kissimmee River was channelized several years ago by the U.S. Army Corps of Engineers in conjunction with elimination of thousands of acres of wetlands and replacement by improved pasture.

2.5.16 Riverine Features. Major rivers in the study area sometimes cross several districts while maintaining their own unique character. Deeply incised river floodplains such as the Alafia, Little Manatee and Peace Rivers all have their origin in the imperfectly drained terraces of the Polk Upland (encompassed almost entirely by the Bone Valley landscape district) and cut through lower terraces on their course to the sea. The lands adjacent to these floodplains often display a disected topography as a result of tributary stream valleys intersecting the main river channel. Other rivers and major streams (e.g. Hillsborough River, Myakka River, Horse Creek, etc.) have a lesser effect on surrounding lands, yet provide aesthetic and natural systems values to the areas they traverse.

3.0 ATMOSPHERE

3.1 Climate

Climate is perhaps Florida's most valuable natural resource. It shapes tourism, industry, recreation, agriculture and the ecology of the peninsula. Chief factors that effect climatic conditions are latitude and proximity to the Gulf, ocean and numerous inland lakes (Bradley, 1972). Summers are long, warm and humid; winters are mild because of the southern latitude and warm adjacent ocean waters, although periodic invasions of cold fronts bring occasional frosts and freezes.

Florida lies between latitudes 24° 30' and 31°N and longitudes 80° and 87° 30'W, as a lowland peninsula between the Atlantic Ocean, the Gulf of Mexico and the Caribbean Sea. Central Florida is a sub-tropical environment. Ample sunshine and rainfall combined with a long growing season provide exceptional, near tropical conditions for plant growth. Plant species in Florida are typically adapted to the annual wet-dry season, occasional frosts, and periodic droughts. Native vegetation consists of species common to the Southeastern United States, as well as plants endemic to Florida and the Caribbean. Thousands of exotic plants have been introduced to Florida over the past few centuries. Many have found Florida's environment a favorable habitat, largely because of the climate.

3.1.2 Sunlight. Florida is often referred to as the "Sunshine State." Total annual sunshine hours range from 2,800-3,000 or about two-thirds of the possible sunlight hours (Landsberg, et. al., 1965). In addition, solar energy as radiation ranges from 140-160 $Kcal^{-1}$ cm^{-3}

yr^{-1}. The incidence and intensity of sunlight has a profound effect on temperature, and in turn wind patterns and other climatic factors.

As radiation passes through the earth's atmosphere a series of losses occur—incoming solar radiation is reflected by clouds, absorbed by atmospheric particles, and reflected by soil, water and vegetation. In arid zones a large percentage of the radiation reaches the ground, whereas in humid climates only about 40% reaches the ground (Konya, 1980). Potential biomass productivity is ultimately dependent upon the amount of usable solar insolation. However, biomass production is often limited by stress factors (e.g., mineral deficiencies/toxicities, temperature, moisture, etc.) rather than by inefficiency of photosynthesis. Florida is ideally located in terms of climate and edaphic factors for biomass production. Days of sunshine are the primary reason.

3.1.2 Temperature. The total effect of the warmth of air and radiation is recorded as the temperature, and as such is a primary influence upon weather. Annual temperature for the study area average 72-73°F (22.5°C) and monthly average range from 61°F (16°C) in January to 82°F (28°C) in July and August. Given the monthly mean maxima and minima, a good indication of diurnal variations can be made (Kinya, 1980). Estimated diurnal variation typically ranges from -8 to -7°C (17-19°F) for Polk County.

Seasonal and diurnal variations are more pronounced in inland areas, due to lack of the moderating effect of the ocean and Gulf stream. Coastal areas in the summer stay warmer on cool nights and cooler on hot days, as well as warmer on cool winter nights and cooler on warm winter days. Temperatures are usually higher in the cities, the greatest difference being in the morning and evening when buildings and pavement radiate stored heat.

Despite Florida's generally mild climate, winter cold fronts are responsible for periods punctuated by freezing temperatures. Winter minimum temperatures show a strong correlation with the angle of prevailing northwest cold frosts and moderating effect of the ocean. Incidence and duration of freezing temperatures increases dramatically in the upper portion of the peninsula. Cold waves typically last 2 to 3 days. Surface topography and proximity to water bodies results in a great variability of freezes, both locally and regionally. Cold tolerance is an important consideration in the selection of woody biomass species or varieties.

Temperature is a primary concern when cultivating plants intolerant of cold conditions. Prevailing temperatures during the period preceding a freeze event are critical in determining damage to cold sensitive plants. A "hardening-off" period will prepare the plant's physiological system for extreme cold stress (Burke, et. al., 1976). Winters with more than one severe cold period interspersed with warm weather can be particularly damaging to vegetation. Such freezes find plants in a tender stage of new growth and more susceptible to severe cold damage (Bradley, 1972).

3.1.3 <u>Humidity</u>. The absolute humidity is the quantity of water vapor present in the air. A measure of humidity that can be more useful is the relative humidity--the degrees of saturation of the air with water vapor. Since warm air can hold larger amounts of water, the relative humidity will drop with increased temperature despite a constant absolute humidity.

In Central Florida, relative humidity generally rises with the coolness of night and falls as mid-day high temperatures are approached. Humidities range from 40 to 65% in the afternoon to about 85 to 95% during the night and early morning (Bradley, 1972). In humid subtropical zones, such as Florida, summer mean values are between 70 and 80% in the summer and between 40-70% in the winter (Konya, 1980).

The relative amount of water vapor in the air has a profound effect on the rates of both evaporation from the soil and of transpiration. Water transfer is greatest when the air is the driest. Consequently, stress on vegetation is amplified during periods of drought when evapotranspiration exceeds rainfall.

Relative humidity also affects perspiration and consequently human comfort. It long has been know that temperature variations are felt more in humid climates than in dry areas (Hain, 1903). This is true of Florida, where summers are hot and sultry and winters sometimes chilly and frostprone.

3.1.4 Rainfall. Rainfall in the study area average 53 inches (135 cm) and is typical of most of Center and Southwest Florida. Rainfall is plentiful yet highly seasonal in distribution. During the summer rainy season, there is a 50-50 change that rain will fall on any day; whereas, during the rest of the year rain may be expected in 1 or 2 days each week. Additionally, dry spells with little or no rain may last weeks. When several dry periods occur in the course of 1 to 2 years, the result is lowered water tables and lake levels that can be responsible for water shortages, especially in coastal areas (Bradley, 1972).

Average rainfall ranges from a winter monthly low of 1.5 to 2.0 inches (4 to 5 cm) to a summer monthly high of 8.0 to 8.3 inches (20 to

21 cm). Due to exposure to trade winds, the maximum rainfall distribution along the Atlantic seaboard occurs during the warm season (Walter, 1973). Over half of Florida's percipitation falls in the summer "rainy" season (June-September). Most of the summer rainfall is derived from local showers and thunderstorms. Occasional hurricanes often result in record rainfall events. Figure 3.1.1 summarizes the seasonal rainfall patterns across the study area.

Low rainfall pockets occur in the Tampa area and Northern Polk County. Interestingly, this trend generally coincides with urbanized portions of the study area. Man's activities can directly and indirectly modify local weather patterns (Hare, 1977). Although the evidence is inconclusive, rainfall may be adversely affected by the lack of natural vegetative cover in urban areas due to reductions in evapotranspiration. Phosphate mining activities also destroy temporarily large areas of vegetation; however, the large acreage of settling ponds and rapid revegetation probably negate and negative effects.

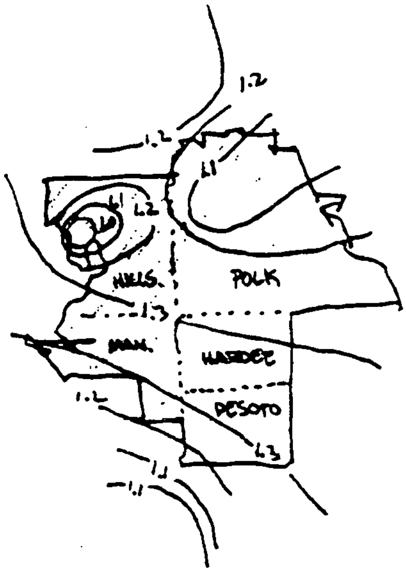
3.1.5 Evapotranspiration. The process by which a liquid is changed to a gas is evaporation; whereas transpiration implies that plant life has used the water just before it was vaporized. The combination of these concepts is defined as evapotranspiration and is responsible for returning moisture back into the atmosphere from plants, soil and water bodies. Consequently, precipitation less evapotranspiration is roughly equivalent to water available for runoff and aquifer recharge.

Transpiration from plants performs many functions including nutrient cycling and leaf temperature reduction. In arid climates, transpiration is an energy stress since water is a limiting factor.

However, in humid climates, transpiration is an energy subsidy, a mechanism which allows for rapid uptake of moisture and nutrients from the soil (Odum, 1971).

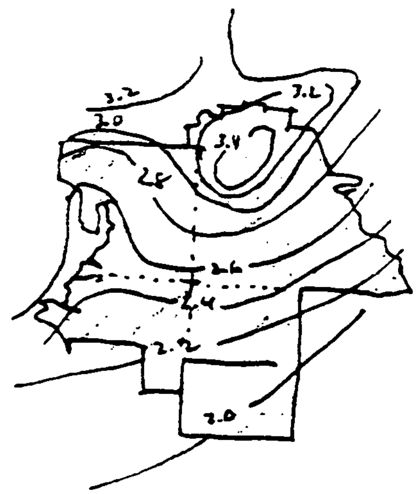
Transpiration of a short green cover cannot exceed the evaporation of a herbaceous cover. This is due to the large surface area of canopy exposed to transpiration by forest species and their deep root systems.

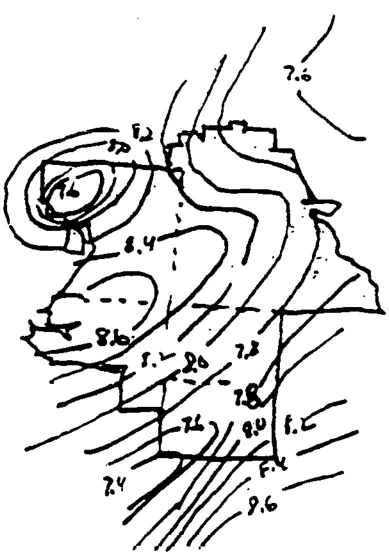
Transpiration is not necessarily a function of leaf surface alone. In some cases, a robust herbaceous cover (on a wet site) will transpire more than a forest system (on a dry site). Evapotranspiration from both forested and non-forested wetlands can exceed the evaporation rate of open water.



Median November Precipitation
November is the driest month for all stations. Median rainfall ranges from 3.0-3.3 cm (1.2 to 1.3 in) throughout the region. "Rainfall depressions" occur around Tampa Airport and Lakeland.

Median March Precipitation
The winter high occurs in March. Median rainfall ranges from 2.0 to 3.4 inches throughout the region. A high pocket occurs in the Green Swamp while Tampa Bay precipitation falls below the median.





Median July Precipitation
July is the wettest month for all stations. Occurrence and distribution are highly variable primarily due to convective storms. Upper Tampa Bay and Charlotte Harbor exhibit low values. A "ridge" or higher precipitation extends from Bradenton to Bartow.

Source: Hafer and Palmer (1978)

Figure 3.1.1 Seasonal rainfall patterns across the study area.

3.1.6 <u>Wind</u>. The location of the Bermuda high pressure area determines wind direction and air mass characteristics over Florida during the warmer season. Cold air masses from the north and northeast alternate during cooler weather with warm moist air from the Gulf. This controls the area's weather and can result in occasional extreme changes in temperature.

March and April are the windiest months. If associated with droughty weather, the winds can be undesirable since movement of air increases evaporation and dries the soil. High local winds occur in conjunction with summer thunder showers and winter cold fronts. Tornadoes average about 10-15 per year.

Florida is sometimes subject to gale force winds during tropical storms or hurricanes. From 1985 to 1971, 160 tropical storms of all intensities have entered or affected Florida (Bradley, 1972). Most originate in the Caribbean during August and early September and track into the Gulf of Mexico or the Atlantic Ocean. Torrential rain events are often associated with these storms. Damage due to wind and flooding can be substantial. Coastal areas are the most susceptible to the destructive effects of these storms, leaving the inland areas somewhat more protected.

3.2 Air Quality

The Central Florida Phosphate District presently has two significant sources of air pollutants, phosphate chemical plants and metropolitan areas (USEPA, 1978). Air pollutants include particulates; oxides of sulfur, nitrogen and carbon; hydrocarbons, and photochemical products (NAM, 1975). Most of these elements cause problems only at high concentrations within urban areas and dissipate rapidly. The automobile is the most common source of airborne pollutants in urban areas. The presence of sulfur dioxide and particulates is particularly critical due to their role in producing "acid" precipitation.

Table 3.2.1 summarizes important point and area source emissions in the five county region. Population-oriented area sources have increased. This trend is expected to continue in relation to increasing urban population densities. Conversely, declining levels of point source pollution are due to compliance with emission standards by local industries. Utilities are the only major exception and future increases can be expected as high sulfur fuels and additional facilities are utilized. In the rural areas, phosphate chemical plants are major point sources of dust, SO_2, and flouride. There are air quality standards for dust and SO_2 emission controls, ambient fluoride levels have steadily decreased in Polk County from 1965-1970. Sulfur dioxide and dust emissions have also decreased considerably. Other sources associated with transportation and agriculture are insignificant.

Table 3.2.1 SUMMARY OF POINT AND AREA SOURCE EMISSIONS IN STUDY AREA [1/]

DeSoto				
Area sources	1,644	65	1,656	67
Point sources	29	85	29	85
Hardee				
Area sources	2,556	72	2,572	73
Point sources	37	114	37	114
Hillsborough				
Area sources	12,382	2,559	12,865	2,695
Point sources	29,358	267,620	7,909	238,649
Manatee				
Area sources	3,091	326	3,121	348
Point sources	399	746	614	5,593
Polk				
Area sources	10,983	841	11,199	901
Point sources	31,125	119,010	8,127	45,080

[1/] Source: USEPA, 1978.

Climate affects the removal and dispersal of air pollutants. A stable positioning of a high pressure center permits stagnation and a subsequent buildup of pollution. When temperature decreases rapidly with height, air is unstable and pollution is carried aloft. Due to the generally flat terrain and steady winds, air over the study area is usually sufficiently unstable to prevent extreme air pollution. Occasional pollution problems are primarily centered around heavily population or industrialized areas such as Tampa. However, as Florida's population and fossil fuel consumption increases, the prospect of vegetation-damaging "acid" rain will increase. Otherwise, air quality is not expected to be a factor in the suitability of the region for wood energy plantations.

3.3 Noise Pollution

Noise has only recently been thought of in terms of a pollutant that can cause physical and psychological damage (Kavaler, 1975). Most sources of noise pollution are point-source oriented and related to specific industrial operations. Major hazards relate to employee health standards. Insignificant low level noises are widespread, primarily associated with automobiles and trucks along traffic arteries. Airports, particularly Tampa Airport and MacDill Air Force Base, create intense high level noises that can be a nuisance to surrounding land uses.

4.0 Water

The Lake Wales Ridge of Polk County is the primary drainage divide for the study area and most of peninsular Florida as well. Precipitation that falls west of the ridge flows to the Gulf, whereas rain falling to the east flows to the Atlantic. The majority of the study area lies in the watershed of the Gulf of Mexico. The study area is contained within two natural topographic regions: The Coastal Lowlands (comprising low, nearly level plains with high water table and abundant surface runoff; and gently undulating to rolling areas, with lakes, ponds, swamps and marches) and the Central Highlands (a ridge and sinkhole region with high infiltration rates and few surface streams, but numerous lakes; and interspersed with flatland basins).

Groundwater movement follows the same general pattern as surface runoff. Since the shallow water table aquifer is hydraulically connected to lakes and streams and discharges water to them, the groundwater resources of a watershed are closely interrelated to surface water resources (USEPA, 1978).

4.1 Groundwater

There are three major aquifer systems in the study area--the surficial or water table aquifer, the secondary artesian aquifer (Upper Unit Floridan Aquifer) and the Floridan Aquifer (Lower Unit). In some areas, additional aquifers may be identified lying above the Florida aquifer. Impermeable layers separate the aquifer systems resulting in artesian conditions in those underlying the surficial aquifer.

The surficial aquifer generally is present as the uppermost aquifer in the area. In a few places, such portions of the Peace River and the

Green Swamp, the limestone of the Floridian aquifer surfaces. When the Floridan aquifer surfaces, it either acts as a discharge or a recharge area.

In artesian aquifers, water that infiltrates from a recharge area is compressed between confining layers composed of clays and marls of several formations. If unconfined, the surface elevation of aquifer waters should be much closer to the surface. This imaginary water elevation is referred to as the potentiometric surface. Water moves in the direction of downward slope on the potentiometric surface and discharge of "rejected recharge" occurs in exposed seepage areas and springs that breach the confining layer.

4.1.1 Surficial Aquifer. The surface deposits of Pleistocene sands, silts and clays are the receptacle for the shall unconfined surficial aquifer. The surficial aquifer ranges in thickness from 8 meters (25 feet) in coastal Manatee County to more than 30 meters (100 feet) along the Lake Wales Ridge. The upper surface of this aquifer is the water table. In poorly drained areas, the water table is near of at the surface. The zone of saturation may be 1.5 to 15 meters (5 to 50 feet) below the land surface under better drainage conditions in the sandhill ridges.

Rainwater that percolates into the soil enters the surficial aquifer. The surficial aquifer stores water and transmits it when sufficient gradient exists. Local depressions, lakes, stream valleys, and swamps receive discharge from this aquifer and depend on it to maintain normal seasonal water levels. The surficial aquifer is crucial in maintaining dry weather stream flow in many rivers. The surficial aquifer may also receive water from or recharge water to underlying artesian aquifers, depending upon breaches in the confining layer and the potentiometric surface of the artesian system (Stewart, 1966). Sand deposits of the surficial aquifer grade downward to finer deposits (clay, clayey sand and interbedded sand and clay) as weathered portions of the Hawthorne formation (Wilson, 1977).

4.1.2 Secondary Artesian Aquifer. Underlying the surficial aquifer is a clayey unit composed of sediments of the Hawthorne and related formations. Within the permeable limestone and dolomite beds of the Hawthorne and Tampa formations lies the secondary artesian aquifer (Pride, et. al., 1966; Steward, 1966). In DeSoto and Hardee counties, the secondary artesian aquifer loses its identity and becomes the upper unit of the Floridan aquifer. The upper unit is considered equivalent to the secondary artesian aquifer (Wilson, 1977). Overlying this aquifer is a confining bed consisting of clay, marl, and soft clayey dolomite and limestone of the Hawthorne formation.

4.1.3 Floridan Aquifer. The Floridan aquifer underlies almost all of Florida in limestone formations 500 to 900 meters (1,500 to 3,000 feet) in thickness, and is the region's major artesian aquifer. It supplies water to Florida's many large springs as well as agricultural, industrial and municipal wells. The Floridan aquifer is entrained in limestone and dolomite beds of Avon Park, Ocala, Suwannee, and Tampa formations as well as parts of the Hawthorne that are in hydrologic contact. The aquiclude is comprised of mixtures of sand, clay and marl; primarily in the sand and clay unit of the Tampa limestone (Wilson, 1977).

The aquifer is replenished by rainfall in areas where the limestone lies at the surface and where is is not covered by impervious material

(Cooper, et. al., 1953), depending on the potentiometric surface. In the five county study area, substantial recharge occurs only in the Tampa and Green Swamp areas. Over most of the region, the Floridan aquifer is covered by an impermeable cap and is under artesian pressure. Most of Hillsborough County lacks a confining layer; however, water movement along faults, joints, and bedding planes induces artesian conditions despite abundant recharge (Menke, et. al., 1961).

Several low lying stream valleys exposing the aquifer receive seepage flow or rejected recharge (i.e., Kissimmee, Peace, Myakka, Alafia, and Manatee Rivers). The aquifer can also receive recharge in areas blanketed by watertight material where there are sinkholes that penetrate the blanket. This occurs in certain areas within Hillsborough and Polk counties.

4.2 Surface Water

When rain falls on the sandy upland terrain, water is quickly absorbed with little or no overland flow over hundred of square kilometers (Heath, 1961). Conversely, there is little absorption of precipitation in the flatland areas where the water table is high, resulting in substantial overland flow which is responsible for large peak flows in the major streams. As stated previously, the surface water resources are closely interrelated to the groundwater resources of the area, since the surficial aquifer is hydraulically connected to lakes, streams and swamps and may discharge water during both the wet and dry seasons.

4.2.1 Rivers and Streams. The Peace, Hillsborough, Myakka, Withlacoochee, Kissimmee, Manatee, Little Manatee, and Alafia River systems are the major drainage basins of the study area. Numerous tributaries feed these river systems and characterize the regional drainage system. Most streams are located in flatlands typified by poor internal soil drainage. High water tables are responsible for maintenance of base flows during dry weather.

Of the region's eight major drainage basins, the Hillsborough River is the only one that receives significant runoff from outside the study area. Others lie almost entirely within the region (i.e., Peace, Alafia, Manatee, and Little Manatee Rivers) and some border the area (i.e., Myakka, Kissimmee, and St. Johns Rivers). These latter encompass substantially more drainage area in the adjacent regions.

The Hillsborough and Peace Rivers have the largest drainage basin and are responsible for over half of the stream flow in the region. The major rivers and streams of the area receive enormous quantities of water during the rainy season. Consequently, overflow lands, or floodplain areas, are often associated with marsh or swamp vegetation tolerant of periodic flooding. Water flowing through swamps is primarily responsible for organic acids in the water which impart a coffee color and lower the pH.

Central Florida waterways are generally sluggish and meandering, flowing to the ocean with little topographic change. However, portions of several rivers cut through limestone or other impervious materials. Limestone is exposed in sections of the Peace and Hillsborough rivers, the most prominent being the "rapids" in Hillsborough River State Park. In addition, several streams leaving the Polk Upland have relatively steep stream gradients.

4.2.2 Lakes. Most Florida lakes are found in depressions where the water level of the surficial aquifer exceeds the elevation of the land surface. Water fluctuations generally correspond with those of the local water table, although lakes connected with the Floridan aquifer may fluctuate in accordance with the potentiometric surface (USACE, 1977). Most lakes of significance in the region are in Polk County and can be found in depressional pockets of the well-drained sandhills. Lakes are also created by phosphate mining and can be highly valued resources depending upon lake design and management policies (EcoImpact, 1981).

Lakes in West-central Florida typically are shallow, ranging in depth from 3 to 10 meters (10-35 feet). Coupled with Florida's warm climate and high potential biological productivity, these lakes are particularly susceptible t the negative consequences of eutrophication or "lake-enrichment." Many lakes receive agricultural runoff high in nutrients, treated sewage effluent, and septic tank seepage. Lakes respond by converting excess nutrients into sediments and/or aquatic plant biomass, eventually filling the basin. In addition, water quality and biological diversity also suffers.

4.2.3 Wetlands. Low areas in which the water table is at, near or above the land surface for a significant part of most years is classified as a wetland (Cowardin, et. al., 1979). Hydrophytic or "water-loving" plants dominate the vegetative assemblage and include marshes, swamps, mudflats, wet prairies and other seasonally wet basins. Wetlands cover 12.8% of the study area and are discussed in greater detail in Section 5.2.

4.2.4 Springs. A spring is located in an area of artesian flow where there is a natural discharge of water through openings or channels from the underlying aquifer. The Floridan aquifer is the source of Florida's many large springs, although several minor springs are associated with other aquifers. Spring discharge varies naturally as a result of withdrawals and seasonal fluctuations in the aquifer.

Sulfur Springs and Lithia Springs are two major springs located in Hillsborough County. Kissengen Springs, near Bartow, was the first of the large artesian springs of Florida to cease flowing completely (Peek, 1961). Other springs of lesser importance are located in the region, although many of these also have ceased flowing in recent years. Reduced flow in Florida springs is directly attributable to increases in water withdrawals for agricultural, industrial and urban uses (Cooper, et. al., 1953), as well as long-term declines in rainfall.

4.3 Water Quality

4.3.1 Surface Water. The quality of surface water is highly dependent upon (1) discharge patterns of streams and rivers, (2) morphometry of the water body and (3) characteristics of land use within the watershed. During the dry season, mineral content is generally higher due to higher dissolved solids and higher specific ion concentrations. Groundwater and sewage effluent are major water sources during dry periods and have a substantial effect on surface water quality. Increased river discharges are usually accompanied by organic detrital inputs and concommitant lower dissolved oxygen and higher biological oxygen demand (Dragovich, et. al., 1968). Lakes are particularly susceptible to water quality degradation if they are isolated, shallow, and receive high nutrient runoff (EcoImpact, 1981). As flowing systems, rivers and streams have a greater capacity for buffering natural and man-induced chemical inputs.

Surface waters of Florida are naturally high in organic color and low in hardness. Swamps along rivers and lakes are responsible for the characteristically tea-colored water in many surface waters. Springs are exceptions, having crystal clear water and relatively high hardness (Cooper, et. al., 1953).

Since the streams and rivers of the region cut through the phosphate-bearing strata, most natural surface water in Central Florida exceed recommended criteria for phosphorus concentrations. Under these conditions, additional nutrient inputs, especially phosphorus and nitrogen, add to primary productivity and aquatic plant growth, thus encouraging water quality degradation in receiving waters (EcoImpact, 1981).

4.3.2 Groundwater. Precipitation is relatively clean and free of dissolved minerals except for small quantities of air pollutants (atmospheric gases, smoke and dust) washed from the atmosphere. Consequently, the chemical characteristics of groundwater will depend upon the composition and solubility of the soil and rocks through which the water passes and the length of contact with those formations (Peek, 1958). Local contamination of groundwater can occur from waste disposal and saltwater intrusion.

4.3.2.1 Surficial aquifer water is generally soft and has a low dissolved-solids content (less than 100 milligrams per liter) except in shoreline areas where chloride concentrations exceed 250 milligrams per liter due to natural or man-induced saltwater intrusion (USEPA, 1978).

Since the surficial aquifer is unconfined, it is subject to direct contamination from agricultural nutrients, septic tanks, sewers, landfills, etc. Localized contamination has occurred in some areas as evidenced by increased concentrations of dissolved constituents such as chloride, nitrate, fluoride, phosphate, sulfate as well as bacteria and viruses in some areas (USACE, 1977). In southern DeSoto County and some coastal areas where the underlying Floridan aquifer is highly mineralized, poorly cased free-flowing wells are contaminating the shallow surficial aquifer (Wilson, 1977). Many of these wells have been plugged since the problem was identified early in the decade.

4.3.2.2 The Floridan aquifer consists of moderately hard to hard water of a calcium bicarbonate type. The water is slightly to moderately mineralized, having a dissolved solids content of 150 to 350 milligrams per liter. Although saltwater intrusion has threatened coastal portions of the study area, widespread contamination of the Floridan aquifer has not been promoted thus far by man's activities (USEPA, 1978).

Under most portions of the study area, the potentiometric surface of the Floridan aquifer system is higher than the bottom of the surficial aquifer (Stewart, 1966; USEPA, 1978). Consequently, there is upward leakance of water from the lower aquifers to the surface. The pressure exerted by freshwater in the aquifer maintains a barrier between saltwater and freshwater in the aquifer along coastal areas. Under these conditions, man-induced contamination tends to occur in areas of substantial recharge. However, cones of depression created by groundwater pumping can lower the artesian aquifer to such an extent that downward leakance occurs from shallow aquifers. Under such conditions, contamination can occur from a variety of sources. This is considered critically important where agriculture and phosphate interest pump huge amounts of water from deep wells (USEPA, 1978). In addition, ground water withdrawals along the coast can cause invasion of saltwater into formerly potable water reserves.

4.4 Water Supply and Utilization

Water demands can be supplied by surface impoundments, shallow wells, and deep well fields. About 70 percent of the water used for municipal, industrial, agricultural, and domestic supplies in Florida is drawn from the ground. In inland areas, water has been and will continue to be abundantly available from the Floridan aquifer (USEPA, 1978). In fact, the potentiometric surface in southwestern Polk and southeastern Hillsborough is expected to rise and return to normal levels as pumpage from mined areas decreases.

Coastal areas suffer from high natural mineralization of deep aquifers and saltwater intrusion into shallow aquifers when withdrawing groundwater. Surface water impoundments, such as the Hillsborough River and Lake Manatee Reservoirs provide sufficient water to coastal communities during most years; however, periodic droughts and associated reservoir drawdowns suggest that water reserves are limited. As water demands increase, the availability of potable water will be a critical land use issue.

5.0 BIOTA

5.1 Ecosystems, Community, and the Florida Environment

5.1.1 The Importance of Biological Systems. The ability to transform solar energy into chemical energy (food) is the basis for life on this planet. Biomas energy production capitalizes on this photosynthetic process. Any unit that includes all of the organisms in a given area (i.e., the community), interacting with the physical environment, is an ecosystem. The boundary or area of an ecosystem is less important than the internal processes within the system and external exchanges with its surroundings. Although primary emphasis in this section concerns specific bilogical communities of the region, these communities are viewed in the context of several ecosystem process, including the interaction with the physical environment, self-maintenance, and cultural modification.

Plants are the key component of both communities and ecosystems, and perform many roles vital to an ecosystem's maintenance and function. The most important is the assimilation of solar energy and its conversion to chemical energy through photosynthesis. Organisms that have this ability are collectively called primary producers. Consumer organisms depend on the energy bound in the chemical compounds of the food they eat and are limited in their ability to utilize directly radiant energy. Respiration is the mechanism by which carbohydrates are utilized for growth and maintenance of both plant and animal life. While most plants synthesize their own carbohydrates, animals consume carbon compounds produced by plants. Consumption of producers by consumers is necessary to insure that vast quantities of organic products do not accumulate, nor is the system depleted of the mineral nutrients necessary for organic production. By removing the "excess" production, consumers recycle mineral nutrients to the producer and thereby maintain the functioning of the ecosystem.

The flora and fauna of Florida, both natural and managed systems, provide many valuable resources. Direct economic values include commercial fishing, ranching, farming, forestry, citrus production and tourist attractions. Other indirect values can be attributed to plant communities: converting solar energy into plant growth, cycling carbon and oxygen, absorbing wastes, protecting soil and water resources, modifying the climate and sustaining aesthetic and recreational values; and to animal communities: redistributing and recycling nutrients, indicating environmental health, propagating vegetation, providing protein sources, enhancing aesthetic and recreational values (FDNR, 1975). Under agricultural regimes, man increases net primary productivity through energy subsidies that reduce internal consumption, thereby increasing the harvest for himself (Odum, 1971). The diversity of values received from biological systems is reduced by the same factor that increases direct harvestable benefits for man.

There is significant difference in the costs of providing these direct and indirect services, according to the specific management plan in use. Intensive management requires heavy subsidies from outside the system in order to increase net yields of desirable products, whereas nature provides many services free of charge (Snedaker and Lugo, 1972). On Central Florida soils, high level management is necessary to maintain the productivity of traditional agricultural crops. As energy becomes increasingly limited and costly, agricultural production will have to concentrate on less energy-intensive crops to efficiently utilize the land resources.

5.1.2 Environmental Factors Determining Community Composition. The flora of an area is determined by the interaction of soil, hydrologic, topographic, climatic, fire and biotic parameters. In Florida, water and fire are the most pervasive factors determining plant community structure. The response of vegetation to variable environmental parameters produces distinct recognizable groups or plant communities. In turn, the fauna of an area is dependent upon many factors, vegetation being of foremost importance. The combination of animal and plant communities is the bilogical community. When discussed in the context of it's physical environment, a biological community can be termed an ecosystem.

Moisture is one of the most important environmental factors determining the natural distribution of Florida's vegetation. In fact, inorganic characteristics and fertility of the soil is of little importance compared to its role in maintaining suitable moisture characteristics (Snedaker and Lugo, 1972). A proper balance between soil and moisture and soil aeration is necessary, since plant growth is limited by saturated conditions that reduce oxygen availability, as well as insufficient moisture regimes that limit water uptake (EcoImpact, 1980). The water balance in the soil is dependent upon soil texture and depth to the water table. Elevation and topography play a key role in determining water table levels and fluctuations. The diversity of Florida's plant communities is strongly associated with the diversity of soil moisture conditions, since specific plants are well adapted to specific moisture regimes.

The frequency of fire is another important environmental determinant and is responsible for maintaining certain vegetative assemblages at a "fire-climax" successional level, or sere. The plant composition in a community is directly related to fire frequency and soil moisture. Factors such as soil fertility are more important in determining variations within a community type and the direction of succession than as a limiting factor maintaining communities in a successional stage (Monk, 1968).

Agricultural crops are also maintained by the forces of climate, soil, hydrology, etc.; but, usually only with inputs and subsidies by man. Although forestry generally tracks the natural system more closely than agriculture, nonetheless, silvicultural practices are required for optimum productivity. In all managed ecosystem, the degree to which management services are provided free or a low costs, depends upon the intensity of cultural practices. Managed ecosystems, as biological communities, are only as persistent as man's will and ability to maintain them. Since some agricultural and forestry uses are more energy efficient than others, these will likely become major man-induced biological systems as fossil fuel resources decline or grow more costly. However, some forms of energy intensive agriculture will continue to persist as long as demand for food and fiber products supports the necessary subsidy.

5.1.3 The West-central Florida Ecosystem. Florida is in a unique position within the United States, biologically speaking. It lies within a subtropical zone that supports species of both North American and the Caribbean. A number of species are endemic to Florida and are rare of absent elsewhere in the world. Florida's climate provides a long growing season and is characterized by mild winters, rainy summers and unpredictable spring and fall droughts. The soils are predominantly sandy and poor in terms of natural productivity. The land varies from very wet (swamps, marshes, bogs, etc.) to very dry (sandhills, scrub), depending on soil, elevation and hydrology. The native vegetation is well adapted to this environment and introduced crops perform well if provided with the proper nutrient and moisture conditions. Estimated annual primary productivity equals about $25.5^{+} \times ha^{-1} \times yr^{-1}$ ($11.4^{+} \times ac^{-1} \times yr^{-1}$) (Walter, 1973).

The natural ecosystems of the study area are quite diverse in composition and ecological function. Many of the biological communities extend over vast areas or developed into intricate patterns prior to urban and agricultural development. Section 5.3 describes the biological communities of West-central Florida in greater detail. These communities can be found in particular associations or vegetative complexes. In West-central Florida, the communities can be aggregated into the (1) flatwoods/pond cypress complex; (2) flatwood/prairie complex; (3) ridge/lake complex; or (4) riverine/estuarine complex. These vegetative complexes are described below as they would have been described in their near-pristine state, 100 years ago:

> The flatwoods/pond cypress complex is characteristic of the flat imperfectly drained lands of Hillsborough, Western Polk and Northern Manatee and Hardee counties. Longleaf pine flatwoods occupy the higher portions and slash pine flatwoods occupy the lower areas. Occasionally, excessively drained sandy hilltops support scrubby flatwoods, sand pine scrub or sandhill vegetation. The complex is dotted by numerous low, seasonally flooded depressions dominated by pond cypress. The highest density of cypress "domes" occurs in North Hillsborough and Polk counties. In addition, slash pine flatwoods are also more common. Fire is an important component in preventing succession in flatwoods (relatively frequent fires) and cypress domes (infrequent fires). Surface streams are common, but floodplains are shallow with low storage capacity

and soils of the complex are typified by hardpans that restrict soil percolation; consequently flooding often occurs during the rainy season.

The flatwoods/prairie complex is similar to the flatwoods/pond cypress complex; however, fires are much more frequent. Flatwoods land forms subject to frequent fires have few, if any, pine trees. In general, this complex has a lower density of pines than the more northern flatwoods. Certain areas along the Kissimmee River, Southeast DeSoto County and scattered areas in Manatee County are vast treeless plains known locally as "dry prairie." Marshes and wet prairies are much more common in this complex, again, because of the high frequency of fire. Threeless or nearly treeless floodplains are common in this area. Hammocks occur sporadically and are composed primarily of cabbage palm and live oak, both somewhat fire tolerant trees. Hammocks not subject to fire typically have a more diverse assemblage of species.

The Ridge/Lake complex is entirely restricted to Polk County, primarily Eastern Polk County. This is the most topographically diverse complex in the study area. The major ridges of the area (Lakeland Ridge, Lake Hendry Ridge, Lake Wales Ridge) are composed of wind and wave washed sands of the Pliestocene epoch. The rolling hills are covered by sandhill vegetation (primarily longleaf pine, turkey oak, wiregrass, etc.). Excessively well drained sands support sand pine scrub vegetation. Depressions hold numerous lakes, ponds and swamps fed by subsurface seepage from the hillsides. There is little surface runoff and consequently few streams. Surface runoff is primarily restricted to low lying flatwood valleys between the ridges.

The riverine complex is the most intricate association of communities in West-central Florida. Major river systems have cut relatively deep channels through the various flatwoods complexes. The deepest flood-plains of these rivers tend to lie on loamier soil substrates buried below the elevation of the surrounding flatlands and support diverse hardwood hammocks and swamp forests. The increased availability of dependable soil moisture is the major factor that creates favorable conditions for swamp hardwoods regardless of the soil substrate. Floodplain vegetation is adapted to seasonal flooding, alluvial deposition, and erosional scouring. Nutrients and fresh water are transported downstream and mix with seawater in estuaries creating productive breeding grounds for coastal fish and wildlife. Whereas the stream valleys receive excess water runoff and bank seepage, the surrounding bluffs and dissected landscape are predominantly well drained and support sandhill, and scrub vegetation. Scattered areas of loamier soil support hardwood hammocks. Phosphatic loamy soils in Polk County along the Peace River and smaller areas near the Alafia River support the largest upland hammocks in the area.

Changes in the floral and fauna composition within the last one hundred years have been substantial. First logging, then citrus and vegetable farming and finally urban development and mining became forces that disrupt the original ecological status. In some cases, these changes will last only as long as man modifies and controls land uses; in others, the changes have irreparably altered the supporting system, for better or for worse.

5.1.4 Seral Trends. Natural succession in Florida plant communities lead to development of Southern Mixed Hardwood Forest (Laessle, 1942; Monk, 1968; Quarterman and Keever, 1962). The forest is the climax community when released from fire. Fire plays a key role in plant succession by selecting for fire-tolerant species. These species comprise the major components of serveral important Florida plant communities. Fire frequency, soils and moisture regimes differentiate the various fire dependent communities. For example, the sand pine scrub occupies the dry, infertile, white sands and are infrequently affected by fire, but require periodic fires to avoid succession to a xeric hammock (Laessle, 1967; Snedaker and Lugo, 1972). Other plant communities like the sandhill (dry), wet prairie (wet), and flatwoods (imperfectly drained) all require frequent fires yet have different species composition due to variations in soil consistency and moisture regimes.

Prior to the advent of settlement, the ecology of Florida was maintained at somewhat of an equilibrium. The forests of the Southeastern Coastal Plain, whether pine or hardwood, have been disturbed so extensively that practically all are assumed to be at least second growth (Quarterman and Keever, 1962). Such disturbances encourage the spread of and domination of pioneer species at the expense of a more diverse assemblage of plants and animals. Logging and subsequent controlled burning of rangelands have converted much of the former flatwoods into a dry prairie community (FDNR, 1975). The incidence of fire has substantially increased dramatically within the last 40 years, often resulting in complete elimination of sand pine in Florida's scrubs (Richardson, pers. comm.). Nearly all the sandhill country was devastated by logging and replaced with citrus groves.

Much of the flatwoods, rangeland, and hardwoods forests have been turned into cropland and improve pasture. In the absence of fire, abandoned agricultural land and rangeland typically develop into hardwood forests rather than the original plant community. In addition, wetlands have been indiscriminantly drained for many agricultural and urban uses. Consequently, today's landscape is vastly different and "pristine" biological communities are limited in areal extent. Fortunately, natural systems have excellent resiliency if not irreparably disturbed. Thus, many forested wetlands and floodplain forests have become naturally revegetated and continue to perform valuable ecosystem functions.

The most threatened natural systems in West-central Florida are fresh and saltwater wetlands and xeric forests, hammocks, and coastal stands. The extent of wetlands as well as all terrestrial habitat types is expected to decline in the five county region. Habitat types of greatest decline have been predicted to be those of greatest importance to wildlife (USEPA, 1978). Large acreages of rangeland are being replaced with cropland and pasture, but the total inventory of this land type in Florida is so high that these are low priority areas of environmental concern.

Cattle and farming interests typically drain freshwater wetlands and cultivate the land if adequate profits can be realized. Currently, the Department of Natural Resources requires dredge and fill permits for wetland disturbance within submerged wetlands adjacent or contiguous to waters of the State of Florida. However, many wetlands do not fall under state jurisdiction, nor is logging regulated. The few remaining xeric forests (sand pine scrub, sandhill, xeric oak) are continually under pressure to be brought into citrus cultivation. The sand pine scrub is slightly more resistant to cultural change due to the quality of the soil; however, urban development is capable of eliminating any or all natural communities in its path.

Phosphate mining not only removes the vegetative cover and change surface hydrology, but actually inverts the soil profile. In many cases, the reclaimed soils are better suited for vegetative growth and a variety of land uses than was the native land (EcoImpact, 1980). However, while much of the cropland lost to mining will be restored, little wildlife habitat will be restored (Shnoes and Humphrey, 1980). The inflexibility of the reclamation regulatory agencies and the reluctance of the phosphate companies to commit to natural systems restoration have contributed to the current trend in reclamation exclusively toward improved pasture.

5.2 Biological Communities of West-central Florida

The local biological communities are described in greater detail below. Each community is introduced with a brief description of its identifying characteristics and environmental parameters. This includes a discussion of the animal and plant communities and the types of organisms found there. In addition, specific seral trends will be addressed, including natural succession and cultural disturbances and modifications. Major categories of biotic communities include agricultural lands, flatwoods, dry prairie, xeric forests, disturbed lands, hammocks, wetlands, and aquatic habitats.

5.2.1 Agricultural Lands. Farmland in the study area include cropland, improved pasture, and citrus groves. Depending upon the intensity of management, these habitats support comparatively few native plant species and have somewhat limited wildlife value.

Cropland and improved pasture dominate. Due to the cyclic nature of these agricultural activities, vegetative cover and cultivation may differ at various times. Tomatoes, watermelons, cucumbers, green peppers, and strawberries are among the important crops of the region. Much of the native rangeland in the outlying agricultural areas that is converted to cropland is, in turn, developed as improved pasture following a few years of continuous row cropping. Pathogen control costs often become prohibitive after intensive cultivation. Consequently, improved pastures are becoming increasingly important landscape elements of the region. Typical vegetation includes Bahia grass, carpet grass and clover. Management usually involves drainage, irrigation, and fertilization.

Pine flatwoods, rangeland, and prairies are the native plant associations that pastureland replaces. Pastures with interspersed areas of marsh and forest have higher wildlife values. Species that frequent pastures include Burrowing Owl, Audubon's Caracara, American

Kestrel, Eastern Cottontail, Striped Skunk, and Whitetailed Deer. Pastures are also heavily used by the Florida and Greater Sandhill Cranes.

Citrus is the major vegetative cover of orchards and groves of the region. Polk County is one of the larges citrus producing areas of the state. Xeric forests, sand pine scrub, sandhills, and xeric oak habitats are displaced by citrus groves throughout the region. Most of the groves are intensively managed through irrigation, fertilization, pest control, pruning, and cultivation/mowing.

Prime agricultural lands (productive vegetable farming areas and citrus groves) are rapidly being displaced near urban areas by new residential development. When land is converted to urban uses, the farmer is encouraged to move out and develop formerly uncultivated lands. Thus, there are both direct and indirect impacts of urban expansions on the natural biota of the region.

5.2.2 Pine Flatwoods, Rangeland, and Dry Prairie. These lands occupy the nearly level, poorly drained soils of the coastal flatlands. Soils are imperfectly drained spodosols. The sandy surface soil is typically underlain by organic hardpans at varying depths which impede drainage.

5.2.2.1 Pine flatwoods are evergreen forests dominated by pine. Two major types of flatwoods are generally recognized. Longleaf pine flatwoods are typified by a longleaf pine canopy on the drier sites, where as slash pine flatwoods occupy the wetter soils. Understory composition is similar for both forest types, yet varies from site to site. Typical ground cover vegetation includes wiregrass, runner oak, and bunchgrasses. Gallberry, fetterbush, saw palmetto, and wax myrtle are common shrubs. Maintenance of the natural vegetative composition is highly dependant upon fire (Laessle, 1942; Monk, 1968). Longleaf pine is more fire-tolerant than slash pine, although both forest types depend on fire to arrest natural succession. Without fire, longleaf pine flatwoods would be replaced by xerophytic hardwoods. Respectively, the drier slash pine sites typically develop into mesic forests while the wettest sites, often associated with pond pine, are succeeded by a bayhead association. Of Florida's natural plant communities, flatwoods are the least resistant to successional change and rapidly succeed to a hardwood forest condition (Monk, 1965).

Flatwoods are home for the boxturtle, pinewoods snake, Brownheaded Nuthatch, Red-cockaded Woodpecker, Bachman's Sparrow, and Sherman's fox squirrel. Other indigenous wildlife species include pinewoods tree frog, oak toad, eastern diamondback rattlesnake, Great-horned Own, Pine Warbler, least shrew, cotton rat, and gray fox.

The pine flatwoods association was once the most widespread of Florida's plant communities, covering over half the state prior to 1900 (USEPA, 1978). As previously discussed, most of the flatwoods have been logged repeatedly, stumped, managed as grazing land or coverted to cropland and pasture. Pines may persist in pastureland, or understory vegetation may remain as nonforested native range; but, undisturbed pine forests are rarely found in today's Florida.

5.2.2.2 Rangelands are extensive and cover over 27 percent of the study area. This category encompasses lands dominated by naturally-occurring grasses and forbs and their principle cover. Most of the rangeland is former flatwoods, modified by the removal of pines and periodic burning to maintain forage production. Although some pines may remain, the landscape is predominantly prairie-like.

Rangeland is a short grass and forb association with scattered palmetto and low shrubs. A small amount of rangeland is considered natural dry prairie, or palmetto prairie, due to the historic absence of a pine canopy. These areas are virtually indistinguishable from cutover flatwoods in all respects, except for the absence of pine stumps, knots, and roots. A major portion of the District's natural palmetto prairie is located in southeastern DeSoto and Polk counties.

Several distinctive species, such as Audubon's Caracara, Florida Burrowing Owl, and Florida Sandhill Crane, can be found in these habitats. Other wildlife species include boxturtle, black racer, Turkey Vulture, Black Vulture, Common Nighthawk, Eastern Meadowlark, least shrew, hispid cotton rat, eastern cotton rate, eastern harvest mouse, and eastern spotted skunk.

Overgrazing with frequent fire causes gradual replacement of wiregrass by carpet grass, which contains a lower nutritive value for grazing animals. When these habitats are intensively managed for cattle forage, they are of comparatively little wildlife value. Large expanses of rangeland and dry prairie have been converted to improved pasture. This trend is expected to continue under the present economic climate. Due to existing wildlife populations and land management practices, loss of the natural dry prairies of the Kissimmee basin appears to be ecologically more significant than the loss of other native rangelands.

5.2.3 Xeric Forests. Xeric forests are typically found growing in the excessive to well-drained, deep sandy, acid soils of Florida's sand ridges (Monk, 1968, Snedaker and Lugo, 1972). These communities, with their deep loose sands, are valuable aquifer recharge areas. Primary xeric forests are the sand pine scrub, sandhill association and variations of each. However, origin and relationship between sandhill and scrub vegetation is unclear (Laessle, 1958; Veno, 1976).

5.2.3.1 The sand pine scrub is typified by an overstory of sand pine and a well developed shrub layer consisting largely of evergreen species (Laessle, 1968). Scrub live oak, Chapman's oak, and myrtle oak are typical co-dominants. Other Shrubs are saw palmetto, rosemary, silkbay, staggerbush, and scrub palmetto. Wildlife species include Florida scrub lizard, bluetailed skink, sand skink, short-tailed snake, Florida Scrub Jay, and Florida mouse.

The scrub is a fire-maintaining community. Periodic fires are essential to the ecological balance of the scrub community. Scrubs subjected to more frequent fires are characterized by low dense clumps of oaks and shrubs with only scattered pines (Laessle, 1958; Snedaker and Lugo, 1972). Conversely, fire-protected scrubs develop a closed canopy with a well developed litter layer. In the absence of fire, succession is toward a xeric oak woodland and ultimately a mesic hammock association (Monk, 1968). The scrub is unique to Florida and limited in area within the five county region. Scrubs occur locally on the ridges of Polk County and on bluffs bordering stream valleys. Fire frequency has increased substantially within the last 40 years, contributing to an overall reduction of pine cover in scrub stands.

5.2.3.2 The sandhill association is endemic to Florida's gently rolling uplands. The soils are well drained, deep acid sands overlying loamy subsoils. Longleaf pine, turkey oak and bluejack oak are typical trees. Ground cover is well-developed and consists of wiregrass, silkgrass, milkpea, partridge pea, and gopher apple. Shrubs are noticeably inconspicuous. Fire is also an important controlling parameter determining the vegetative composition of the association. Unlike the scrub, sandhill vegetation requires more frequent fires to maintain the open character of the forest (Snedaker and Lugo, 1972; Veno, 1976). Some important wildlife species include gopher tortoise, gopher frog, Southeastern pocket gopher, fence lizard, pine snake, Florida mouse, and Sherman's fox squirrel.

The sandhill association was once the dominant plant community in Florida's Central Highlands. Its preferred habitat in the study area is the sandy ridges of Polk County and Central Hillsborough County east of Tampa, as well as along the Peace River in Hardee and DeSoto counties. Most sandhill communities have been destroyed by urban development and citrus interests. The remaining acreage also has been extensively modified, mainly as the result of intensive logging of longleaf pine.

All xeric forest types are subject to real estate development because of their ideal, well-drained upland situation. In Central Florida, these areas are often cleared and planted to citrus or converted into improved pasture.

5.2.4 <u>Disturbed Lands</u>. Transitional communities are typical of the disturbed lands of Central Florida. Changes in soil, topography, and hydrology determine the direction and composition of plant community development.

5.2.4.1 <u>Mineland communities</u> occupy a significant portion of southwest Polk and southeast Hillsborough counties. A variety of ecotypes occupy unreclaimed phosphate lands. Vegetative composition is dependent upon the particular mine soil, relation to the water table, and successional status. Consequently, a patchy mosaic of cover types is the typical landscape composition. Although some impressive near-climax forests can be found, most lands are in an early successional stage due to their young age. Wetlands consisting of marshes, swamp thickets, and swamps are common, as well as upland cover types of grassy, brushy, and woodland associations.

Modern mining leaves a barren ridge and valley topography, vast clay settling areas, and deep lakes. Prior to the 1975 reclamation regulations, few of these areas were reclaimed (PLRC, 1978). Without reclamation, many of these abandoned areas have naturally revegetated and serve as important wilderness areas in the man-dominated environment.

Overburden spoils are rapidly colonized by grasses and weeds, followed by shrubs and eventually trees. Sweetgum, water oak, live oak, American elm, and red maple are typical forest species. Succession will lead to the Southern mixed-hardwood forest as a climax community (Schnoes and Humphrey, 1980). Variable site conditions and seed sources are important factors determining the rate of revegetation.

The expansive clay settling areas develop into marshes and eventually into swamps. Cattail and willow are important colonizers of settling pond wetlands. Depending upon water level management, these ponds can serve impressive wildlife functions (Cornwell and Atkins, 1980).

Among the wildlife species that frequent minelands are the Carolina Wren, White Pelican, Great Blue Heron, Wood Duck, Pileated Woodpecker, cotton mouse, greentree frog, bobcat, opposum, gopher tortoise, and gray squirrels.

Land mined after July, 1975 must be reclaimed in accordance with the Florida Department of Natural Resources' reclamation regulations (Chapter 16C-16, Florida Administrative Code). In addition, efforts are being made to encourage reclamation of abandoned lands as well. Consequently, the land is being converted to productive agricultural uses, as opposed to wildland usage. The exception is clay settling areas, which can maintain a wetland function for over 20 years prior to mandatory reclamation.

5.2.4.2 Other transitional lands include brushlands, swamp thickets, and newly cleared and cleared land. Brushland is unburned rangeland or prairie and usually consists of wax myrtle and/or gallberry. These areas provide habitat for black racer, Eastern diamondback rattlesnake, Red-tailed Hawk, hispid cotton rat, and Eastern cottontail. Swamp thickets composed of wax myrtle, willow, red maple or buttonbush are natural successional stages of drying marshlands. Agricultural drainage and groundwater pumping are primarily responsible for the rapid increase of swamp thickets around ponds, lakes, marshes, streams, etc. The marsh rice rat, cotton rat, and marsh rabbit are often abundant.

In some areas, land has been cleared for agriculture or urban development; but, it has been abandoned and consequently colonized by a ruderal, early successional community of grasses, weeds, and shrubs.

5.2.5 Hammocks. Harwood forests in Florida are typically referred to as "hammocks." Hammocks can be categorized according to soil moisture conditions and dominant vegetative cover. These areas can be important in flood control on a watershed basis. Wildlife values are exceptionally high, especially where different stages of succession are adjacent to each other.

5.2.5.1 Live oak hammocks occupy the driest sites and are sometimes referred to as xeric hammocks (Laessle, 1942). Subdominant trees include laurel oak, cabbage palm, and bluejack oak. These are characteristically open woodlands with scattered shrubs and little ground cover. Chapman's oak, beautyberry, and shining sumac are typical shrubs. Live oak hammocks support populations of squirrel, tree frog, Southern toad, green anole, black racer, Screech Owl, Blue Jay, eastern mole, cotton mouse, and Southern flying squirrel. Live oak hammocks are of relatively local occurrence as slightly elevated "islands" in pine flatwoods or pastureland. Fire is an important factor that restricts invasion of fire-intolerant species of the mesic hammock.

5.2.5.2 Mesic hammocks occupy a variety of sites between the driest live oak hammocks and the moist hydric hammocks (Quarterman and Keever, 1962). The soils are usually rich in organics. Laurel oak, pignut hickory, water oak, red bay, and sweetgum are dominant tree species in the Central Florida phosphate district. Shrubs include saw palmetto, beautyberry, and sparkleberry. Common vertebrates are southern toad, green anole, pileated woodpecker, great-crested flycatcher, red-eyed vireo, gray squirrel, and cotton mouse. The mesic hammock, as the Southern mixed hardwood forest, is considered to be the climax vegetation in North-central Florida (Laessle, 1942, Veno, 1976). It is usually restricted to floodplains, fire-protected areas and loamy soils where it can develop into a diverse forest community.

5.2.5.3 Hydric hammocks occur primarily along rivers and streams or other lands with a high water table. Typical trees include water oak, sweetgum, laurel oak, swampbay, and Florida elm. Wax myrtle and saw palmetto are frequent understory species. Ground cover is sparse but includes lizard's tail and a variety of ferns. The green tree frog, Southern leopard frog, Red-bellied Woodpecker, and cotton mouse are common wildlife species. Hydric hammocks often occupy the ecotone between wetlands and mesic hammocks and are common floodplain forests (Laessle, 1942). In the southern portion of the study area, cabbage palm hammocks occur on moist, highly organic soils. Live oak is sometimes a component; but, for the most part, cabbage palm is the predominant canopy species.

Past cultural disturbance of hammocks has been extensive in areas near the Peace, Alafia and Manatee Rivers. Nearly all have been logged (Veno, 1976) and many have been converted to farmland. Although common components of floodplain forests, mesic and hydric hammocks are often not protected by current wetland regulations. When the trees are left intact, hammocks often are subject to grazing or housing development.

5.2.6 Wetlands (Forested). Swamps, or forested wetlands, occur along rivers and the edges of lakes and basins that are seasonally or periodically flooded. There are a number of different types of forested wetlands that vary according to hydroperiod and soil conditions. Swamps function as natural waste treatment plants by absorbing nutrients and trapping sediments. These areas are well known as valuable wildlife habitat.

5.2.6.1 Mixed hardwood swamps occur along rivers and streams and overflow areas of lakes. The transition from a hydric hammock to a mixed hardwood swamp is difficult to distinguish where elevation changes are gradual (Laessle, 1942). The mixed hardwood swamp is subjected to inundation for only short periods during the growing season. Floodwaters typically range from 25 to 83 centimeters (10 to 35 inches) in depth (Monk, 1966). Soils are poorly drained and have a higher percentage of silts, clays and organics than most upland soils.

Red maple, water oak, black gum, water hickory, pop ash, and bald cypress are common arboreal components. Understory species include buttonbush, wax myrtle and sweet sprie. Ground cover is sparse and mud and/or sand is frequently exposed during the dry season. Smartweed, lizard's tail, pennywort as well as grasses and sedges can be found in the less inundated portions.

5.2.6.2 Cypress swamps are forested wetlands that typically occupy deep, freshwater habitats containing surface water throughout most of the season. Cypress communities have a characteristically zoned arrangement. Larger trees are located in the permanently flooded zones. Tree size progressively declines towards the edge of the community. Due to this configuration, cypress ponds are often referred to as cypress "domes."

Either bald cypress or pond cypress dominate the stand. Pond cypress are found in depressions called cypress "domes." These swamps tend to be isolated and more acidic than other cypress swamps (Monk, 1966). Associated species of a typical cypress swamp include black gum, red maple, pop ash, and willow. Pickerel weed, arrowhead and sawgrass are common herbs. Mixed cypress-hardwood swamps can also be found in the study area and consist of both cypress and hardwoods.

5.2.6.3 Bay forest often are flooded seasonally but fluctuate less frequently than other swamp types (Monk, 1966). Soils are wet, acidic and highly organic. Canopy trees such as loblolly bay, red bay, and sweet bay characterize bay forests or bayheads. Bay heads usually develop from flatwoods depressions, swamps and marshes via an accumulation of organic matter (Laessle, 1942). Continued organic matter deposition and concommitant improved drainage in conjunction with protection from fire will result in succession towards a mixed hardwood forest (Monk, 1968).

Freshwater forested wetlands are one of the most important habitat types in the study area. Swamps are typically linear and therefore create substantial interface zones (ecotones) with upland systems. This "edge effect" provides many animals and plants with food and cover. Typical animal species include the green tree frog, ground skunk, American alligator, Barred Owl, Limpkin, Wood Duck, Red-shouldered Hawk, river otter, gray squirrel, raccoon and opposum.

Bayheads and mixed swamps both may represent climax stages in wet areas (Monk, 1966). Fires are uncommon in swamps, but when they occur, the community is destroyed and usually reverts to marshland or shrub swamp. Cypress communities are considered sub-climax. If they become drier through organic accumulation or a lower water table, they will be succeeded by a bayhead or mixed hardwood swamp community. If cypress trees remain rooted in sand or unburned much, they will be resistant to fire damage and persist as a pure stand, whereas competing hardwoods are destroyed. Drainage and channelization projects threaten large numbers of smaller river swamps. These "reclamation" projects have long-term negative effects on downstream water quality and quantity. Destruction of small isolated swamps eliminates wildlife habitat and increases runoff, but seldom carries regional consequences.

5.2.6.4 Mangrove swamps occupy the land-water interface in low-energy coasts of the study area. Three types of mangrove trees can be found in a characteristic zonation according to specific water fluctuation regimes. Mangroves collect sediment and are effective land builders in coastal areas. Red mangroves occupy the deepest waters, black mangroves occupy intermediate areas, and white mangroves colonize the shallowest waters. Saltwater wetlands perform vital functions as breeding grounds for fish and water fowl. The majority of the saltwater wetlands occur along the shores of Tampa Bay. Dredging and landfill operations are continuing threats to the remaining coastal wetlands of the area.

5.2.7 Wetlands (Non-forested). Marshes are continually or periodically flooded wetlands dominated by non-woody plants such as grasses, sedges, rushes and other herbs. These wetlands are located along or in rivers, streams, canals, ditches, standing water bodies or depressions. Marshes vary in size and occur on all kinds of soil ranging from sand to muck. They are most numerous in the prairies and flatwoods int he southern portion of the study area. Saltwater marshes are best developed north of Tampa Bay.

5.2.7.1 Deep freshwater marshes are wetlands in which the soil is covered by water throughout most of all of the growing season (Cowardin, et. al., 1979). Deep marshes along the margins of ponds, lakes and inopen sloughs. Inundation is generally permanent with fluctuations ranging from 0.1 to 2.5 meters (4 inches to 8 feet). Maidencain, cordgrass, pickerel weed, cattail, smartweed, arrow leaf, fire flag, sawgrass, rushes, and water lilies are common deep marsh plants. Floating and submerged aquatics are found in the deeper portions. Deep marshes will succeed to shallow marshes if conditions become drier, either by artificial drainage or organic accumulation. Deep marshes naturally collect detritus and fill up with organic matter. Occasional fires help control natural succession and maintain the deep marsh environment.

5.2.7.2 Wet prairies support herbaceous communities on seasonally wet soils, less subject to inundation and more prone to fire than deep marshes. Broomsedge, bullrush, maidencain, panic grass, rushes, and cordgrass are typical herbaceous species. In wet prairies, fire is an important factor since the ground may be dry for extended periods of time. Consequently, organic matter usually does not build up in appreciable quantities.

Marshes are very productive wildlife areas. Characteristic vertebrates include the greater siren, Southern cricket frog, pig frog, American alligator, banded water snake, Red-winged Blackbird, Common Snipe, marsh rice rat, and round-tailed muskrat. Marshes also are critical habitat for the Sandhill Crane. Non-forested wetlands serve as nutrient filtration systems and are particularly valuable when connected to the regional drainage system.

Unfortunately, marshes are highly susceptible to environmental degradation. Marshes are dependent on certain patterns of water level fluctuation and fire occurrence. Thus, the exclusion of fire or adequate water levels permits succession to a woody community (FDNR, 1975). Drainage projects have converted many marsh habitats into agricultural lands. Where proper conditions for wetland vegetation have been inadvertently created, marshes develop in man-made lakes, ditches, and clay settling areas of the phosphate district.

5.2.8 Aquatic Habitat. Freshwater aquatic habitats can be classified as either standing water, or lentic habitats (lake, pond, reservoir) or running water or lotic habitats (spring, stream, river)

(Odum, 1971). The major rivers and lakes of the study area are of considerable aesthetic and recreational importance, serve as sources of water supply and support sport and commercial fisheries (USEPA, 1978).

5.2.8.1 Lakes are most abundant in Polk County in the Central Highlands. These lakes generally occur in areas of little or no surface runoff. Some of the region's lakes in Hillsborough and Polk were formed by phosphate mining. The majority of the large water bodies have permanent water, are naturally shallow (less than 20 feet), have wide littoral (shore) zones, and maintain moderate to luxuriant algal and vascular plant communities that support comparatively large populations of zoo plankton, macroinvertebrates and fish (USEPA, Vol. X, 1978).

Largemouth bass, lake chubsucker, bluegill, and black crappie are important fishes. Lakes with marshy areas are frequented by the cooter, American alligator, banded water snake, Purple Gallinule, and American Coot. Ponds are smaller and shallower than lakes and are home for the mosquito fish, golden topminnow, least killifish, lake chubsucker, and warmouth. Shallow Florida lakes are particularly susceptible to the processes of eutrophication due to cultural pollution.

5.2.8.2 Rivers and streams commonly occur in the incised or shallow valleys of the flatwoods terraces within the study area. There is considerable variation as to size, bottom characteristics, flows and other factors. Streams can be continuous or intermittent. However, aquatic habitat is severely limited in streams with unreliable water supplies (Reid and Wood, 1976).

Pondweeds, niads, eelgrass and water hyacinths can be found in permanently wet aquatic systems. Common fishes include coastal shiner, golden shiner, spotted sunfish, largemouth bass and brook silverside.

When streams and rivers are used as disposal systems for sewage and industrial wastes, the aesthetic, recreational and bilogical resources can be severely degraded.

5.2.8.3 Seagrass meadows are marine ecosystems of the Caribbean and Gulf of Mexico. Two seagrass species form dominant growths in coastal waters, *Thalassia* and *Halodule*. These aquatic marine communities have great value in stabilizing and protecting shorelines and are essential to the growth of many species of marine life. Dredging and subsequent sedimentation is the major cause of losses in marine meadow cover in estuaries.

5.3 Areas of Important Biological Significance

5.3.1 Important Natural Areas. Natural ecosystems perform well-documented biological and hyrological functions beneficial to man. In particular, local and regional significance can be attributed to the ecological functioning of riverine floodplains and associated wetlands. These natural systems provide substantial stormwater detention, biological filtering, nutrient assimilation, and diverse wildlife habitats. In addition, both upland and lowland forests promote soil and water conservation, provide a wide range of air pollution control functions, and support substantial wildlife resources. Rangelands, as modified and managed ecosystems, are of secondary importance. Open pastures, rangeland or prairies interspersed with wetlands and woodlands can provide impressive natural systems values, depending upon the particular land management regimen.

Central regions of Florida have distinctive assemblages of plants and animals. Within the study area, the Lake Wales Ridge and the

Kissimmee Prairie are two such natural regions that occur within the study area. Xeric forests with particularly diverse flora and fauna populations are endemic to the Lake Wales Ridge. The Kissimmee Prairie is characterized by vast treeless plains consisting of dry prairie, wet prairie and marshes. Few of these regions have adequate natural system portions preserved in public ownership. Much has already been lost to agricultural development.

Natural biological communities of the study area vary in their value, scarcity, vulnerability and endangerment. The Florida Game and Freshwater Fish Commission has evaluated natural Florida communities and given them priority ranking, indicating those most deserving of protection (FDNR, 1975). First priority communities over most of the study area include cypress swamp, mixed hardwood swamp, wet prairie and hardwood hammock. Eastern Polk County and Southeastern DeSoto County lie within the Kissimmee River Basin in which wet prairie, dry prairie, and sandpine scrub are the first priority communities. The sandhill association is considered a second priority community in both areas. However, since much of the sandhill community within the study area has been converted to several forms of agriculture, the remaining parcels are considered highly endangered and approaching unique status (USEPA, Vol. VI, 1978).

Scarce flora, fauna or geological resources characteristics of the original natural Florida environment are considered unique and outstanding natural areas. The Department of Natural Resources has instituted the Environmentally Endangered Lands Program to conserve and protect these lands (FDNR, 1975).

5.3.2 Important Agricultural Areas. The development of agricultural systems is the most pervasive cause of the extensive reduction of acreage of natural systems in Central Florida. However, the production of food can provide a net increase in total benefits to man. The efficiency, profitability, and uniqueness of a particular agricultural system are the major criteria upon which to rate its beneficial value to society. Citrus can be rated the most valuable agricultural system due to its adaptability to the Florida environment, as well as the existing high value of investment in citrus production. Vegetable and dairy farming also require a high investment/high return scenario. The widespread importance of cattle ranching as a land use cover type overshadows its subdued economic importance as the least profitable agricultural use on a per acre basis. These major agricultural land uses are interspersed with the remaining natural systems of the area.

Initially, the Florida pioneers ventured into the Central Florida wilderness only for longleaf and slash pine. The sandhills and flatwoods were scoured for any and all marketable timber. The hard freezes of 1894-95 convinced citrus growers of northern Florida that a warmer climate was necessary. Consequently, the heart of the citrus industry moved southward, accelerating the conversion of sandhill rough and sandpine scrub of Central Florida into groves. Today, Central Florida is one of the largest citrus producing areas in the world. As a cash crop, citrus is one of the most valuable commodities grown in Florida.

Bartow and Ft. Meade were among the earliest vegetable farming areas in the study area. Today, the major farming areas in the region are located in and around Plant City, Ruskin, Bradenton and Wauchula. The coastal areas near Tampa Bay are particularly favorable in this regard due, primarily, to mild winter weather conditions. Marketing and distribution facilities are other factors affecting the distribution of vegetable production. Many areas are only cultivated for several years before conversion to improved pasture. Consequently, prime farmlands are difficult to identify unless monitored over the long-term.

Cattle ranching covers a large percentage of the land area of the Central Florida Phosphate District. Surprisingly, it contributes a relatively small percentage to total agricultural income. Native rangeland may support a cow/calf unit on 20-40 acres of land. On improved pasture only 3-4 acres are needed, along with intensive management (Blue, 1979).

The most valuable agricultural lands are also the most susceptible to destructive change. While Polk County has the distinction of being the largest citrus producing county in the state, it also lost more citrus acreage to development than any other Florida county. Urban development not only reduces the area's agricultural income, but also increases pressures to convert the remaining natural sandhill and scrub communities into citrus groves.

5.3.3 Threatened and Endangered Species. Numerous plant and animal species around the world are are or becoming extinct. By the year 2000, it has been estimated that more than half a million species will be extinct—15 to 20% of the earth's plants and animals.

In Florida, there are more than 500 species and subspecies of vertebrates (excluding fishes) in West-central Florida supported by a variety of different habitat types(USEPA, Vol. VI, 1978). The Central Highlands comprises a number of diverse habitats. The highest elevations in the study area are located here. Within the Central Highlands, the Lakeland and Lake Wales ridges contain unique habitat. The Coastal Lowlands associated with marine and estuarine habitats support a variety of wildlife species exclusively associated with the coastal environment. The intermediate terraces between the Central Highlands and the Coastal Lowlands support a number of species common to both zones.

The local loss of wildlife habitat due to urban, agricultural and industrial development has been significant. This trend is expected to continue, much to the detriment of the wildlife community. A number of species have already been eliminated from this region and others are threatened or endangered statewide. Table 5.2 and 5.3 lists the endangered and threatened species that may be found in West-central Florida.

Table 5.2 ENDANGERED AND THREATENED FAUNA OF THE STUDY AREA 1/

Scientific Binomial (Common Name)	Status 2/	Preferred Habitat
MAMMALS		
Sciurus niger shermani (Sherman's for squirrel)	T^2, T^3	Sandhill and xeric oak association, margins of flatwoods, cypress ponds
Peromyscus floridanus (Florida mouse)	T^2, T^3	Sandhill, scrub and other xeric associations
Trichechus mantus latirostris (Manatee)	E^1, T^2, T^3	Shallow estuaries, saline bays and sluggish rivers
Ursus americans floridanus (Florida black bear)	T^2, T^3	Dense thickets and vine-choked bays
Felis concolor coryi (Florida Panther)	E^1, E^2, E^3	Variety of forest habitats
BIRDS		
Pelecanus occidentalis (Brown Pelican)	T^1, T^2, T^3	Shallow clear waters of bays, islands and inlets
Fegata magnificens rothschildi (Magnificent Frigatebird)	T^2, T^3	Coastal areas
Ardea Herodis (Great White Heron)	T^2	Mangross islands in estaurine or coastal areas
Mycteria americana (Wood Stork)	E^2, E^3	Freshwater and brackish marshes
Ajaia ajaja (Roseate Spoonbill)	T^2	Coastal bays, brackish ponds and mangrove swamps
Rostrhamus sociabilis plumbeus (Everglades Kite)	E^1, E^2, E^3	Freshwater marshes of the Kissimmee basin
Pandion Haliaetus (Osprey)	T^2, T^3	Habitat near large streams, lakes, seashores, etc.
Buteo brachyurus (Short-tailed hawk)	T^2	Cypress, hardwood, mangrove or pine stands in association with open marsh or prairie

continued . . .

Table 5.2 ENDANGERED AND THREATENED FAUNA OF THE STUDY AREA 1/ (cont.)

Scientific Binomial (Common Name)	Status 2/	Preferred Habitat
BIRDS (cont.)		
Haliaeetus leucocephalus (Bald Eagle)	E^1, T^2, T^3	Habitat near large streams, lakes, seashores, etc.
Caracara Cheriway (Caracara)	T^2, T^3	Dry prairies and other low growth habitats
Peregrine Falcon (Falco peregrinus)	E^1, E^2, E^3	Coastal areas
Falco Sparverius paulus (Southeastern American Kestrel)	T^2, T^3	Openwoods, pastures, old fields and prairies
Haematopus palliatus (American Oystercatcher)	T^2, T^3	Marine coasts, tidal marshes, dredged spoils and beaches
Grus canadensis pratensis (Florida Sandhill Crane)	T^2, T^3	Open wet prarie, low lying pasture, lake borders and shallow marshes
Charadrius alexandrinus tenuirostris (Cuban Snowy Plover)	E^2, E^3	Dry sandy beaches and tidal flats
Sterna dougallie (Roseate Tern)	T^2, T^3	Coastal beaches
Sterna albifrons (Least Tern)	T^2, T^3	Beaches, estuaries, lagoons, lakes, large streams and all types of marine habitat
Coccyzus minor (Mangrove Cuckoo)	T^2	Mangrove swamps
Picoides borealis (Red-cockaded Woodpecker)	E^1, E^2, E^3	Old-growth pine stands
Campephilus principalis (Ivory-billed Woodpecker)	E^1, E^2, E^3	Dead cypress in swamp forests
Aphelocoma coerulescens coerulescens (Florida Scrub Jay)	T^2, T^3	Scrub oak

continued . . .

Table 5.2 ENDANGERED AND THREATENED FAUNA OF THE STUDY AREA 1/ (cont.)

Scientific Binomial (Common Name)	Status 2/	Preferred Habitat
BIRDS (cont.)		
Vermivora bachmanii (Bachman's Warbler)	E^1, E^2, E^3	River bottoms and lowland swamps
Dentroica kittlandii (Kirtlands Warbler)	E^1, E^2, E^3	Variety of forest habitats
Ammodramus savannarum floridanus (Florida Grasshopper Sparrow)	E^2, E^3	Pastures, meadows and dry prairies of the Kissimmee basin
HERPETILES		
Rana areolata aesopus (Florida Gopher Frog)	T^2, T^3	Coastal xeric areas and Lake Wales Ridge
Alligator mississippienus (American Alligator)	T^2, T^3	Lakes, streams, marshes and swamps
Chrysemys concinna suwanniensis (Suwannee Cooter)	T^2, T^3	Rivers and spring runs
Gopherus polyphemus (Gopher Tortoise)	T^2, T^3	Sandhill, scrub and live oak hammocks
Dermochelys coriacea (Atlantic Leatherback Turtle)	E^1	Offshore marine waters
Lepidochelys kempi (Atlantic Ridley Turtle)	E^1, E^2, E^3	Offshore marine waters
Caretta caretta caretta (Atlantic Loggerhead Turtle)	T^2, T^3	Offshore marine waters
Chelonia mydas (Atlantic Green Turtle)	E^2	Marine shoals, lagoons, and beaches
Eumeces egregius lividus (Blue-tailed Mole Skink)	T^2, T^3	Sand pine scrub and scrub oak of the Lake Wales Ridge
Neoseps reynaldsi (Sand Skink)	T^2, T^3	Sand pine and scrub forests of the central highlands

continued . . .

Table 5.2. ENDANGERED AND THREATENED FAUNA OF THE STUDY AREA 1/ (cont.)

Scientific Binomial (Common Name)	Status 2/	Preferred Habitat
HERPETILES (cont.)		
Drymarchon corais couperi (Eastern Indigo Snake)	T[2]	Variety of wet to dry habitats
Stilosoma extenautum (Short-tailed Snake)	E[2], E[3]	Sandhills, upland hammocks and sand pine scrub
FISHES		
Goniopsis cruentata (Mangrove Crab)	T[3]	Mangrove swamps and estuaries
Acipenser oxyrhynchus (Atlantic Sturgeon)	T[3]	Marine aquatic habitats
Rivulus marmoratus (Rivulus)	T[3]	Marine aquatic habitats

1/ Source: USEPA, Vol. IV, 1978.

2/ 1. Listed as endangered or threatened by the U.S. Department of Interior.
2. Listed as endangered or threatened in the Wildlife Code, Florida Game and Freshwater Fish Commission.
3. Listed as endangered or threatened by the Florida Committee on Rare and Endangered Plants and Animals.

Table 5.3 ENDANGERED AND THREATENED PLANTS OF THE STUDY AREA

Scientific Binomial (Common Name)	Status	Preferred Habitat
Hypericum cumicola (Highlands scrub hypericum)	E^3	Sand pine scrub of the Lake Wales Ridge
Polygala lewtonii (Lewton's polygala)	E^3	Sand pine scrub of the Lake Wales Ridge
Prunus geniculata (scrub plum)	E^3	Sand pine scrub of the Lake Wales Ridge
Chionanthus pygmaeus (pygmy fringe-tree)	E^3	Sand pine scrub of the Lake Wales Ridge
Asplenium auriturn (auricled speenwort)	E^3	Live oaks of the Hillsborough River
Asclepias curtissii (curtiss milkweed)	T^3	Endemic to scrub and other xeric habitats
Bonamia grandiflora (Florida bonamia)	T^3	Endemic to scrub fringes
Cereus gracilia (Prickly apple)	T^3	Coastal shell mounds and hammocks in Manatee County
Clitoria fragrans (Pigeon-wing)	T^3	Sandhills along the ridges of Polk County
Erioganum floridanum (Scrub buckwheat)	T^3	Sandhills
Ernodea Littoralis (Beach creeper)	T^3	Coastal dunes
Rhapidophyllum hystrix (Needle Palm)	T^3	Hammocks and stream bottoms
Smilax Smallii (Jackson vine)	T^3	Hammocks, ravines and stream-sides

6.0 LAND

6.1 Geology

The geology of the Central Florida phosphate district has been described by Cooke (1945) and others (Alshuler, et. al., 1964; White, 1970). The major formations of parent material rocks are located in Figure 6.1.1 and stratigraphically depicted in Figure 6.1.2, with accompanying descriptions in Table 6.1.1. Differential uplift deposition, erosion, and dissolution of underlying rock formations are responsible for the existing physical environment of the Florida peninsula.

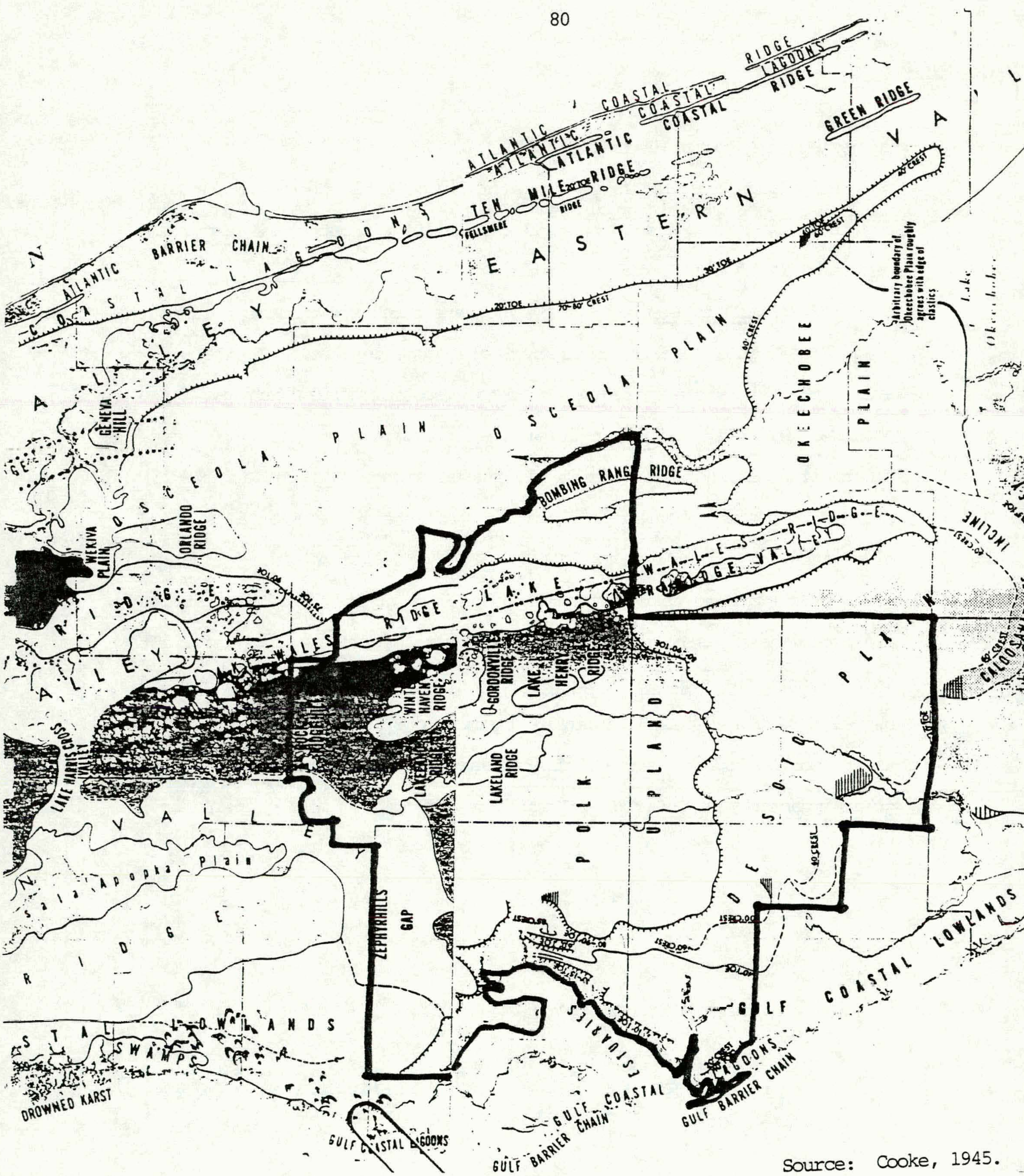
6.1.1 General Lithology. The Floridan Plateau consists of the present Florida peninsula and a broad, submerged shelf of equivalent size projecting between the Gulf of Mexico and the Atlantic Ocean. A number of large structural domes have been superimposed on the North-central Florida peninsula. A broad elongate dome, the Ocala Uplift, lies immediately north of the study area and greatly influences surface and subsurface conditions. Formations of Oligocene and Miocene age flank the Ocala Uplift, receding in all directions and thickening to the south and east (Altshuler, et. al., 1964). The Pliocene and younger formations, in contrast to the older strata, are thin blankets of material deposited in the lowland areas of peninsular Florida.

Of primary interest to the Central Florida phosphate industry is the Bone Valley formation, the major source of pebble rock phosphate deposits. The origin of these rich deposits is generally believed to be deposition in shallow marine environments with subsequent reworking and alteration (Blakey, 1973), although dissolution and reprecipitation of the phosphate limestone of the older Hawthorne Formation has also been suggested as a source (Farmer and Blue, 1978).

Principle minerals in the commercially valuable phosphate deposits are those of the apatite group and the aluminum phosphates. Important minerals of the study area are listed in Table 6.1.2.

6.1.2 Surface Geology. The immediate surface sediments, at most places in Florida, are underlain by Pleistocene deposits. In the study area, the Pleistocene sediments were deposited as "terraces" and occurred in seven different intervals, corresponding with sea level fluctuations during interglacial and glacial stages. These terraces are defined by their topographic elevation with the higher terraces being older than the lower ones.

The surface to near-surface deposits vary greatly in character but are predominantly sandy. Within the phosphate district, it is important to note that the surface deposits are composed not only of quartz sand but also of clay lenses (kaolinite and montmorilinite), associated with the primary phosphate-bearing mineral apatite. These constituents have great impact on the "overburden" soils resulting from mining operations.



Source: Cooke, 1945.

Figure 6.1.1 Surface Formations of Study Area

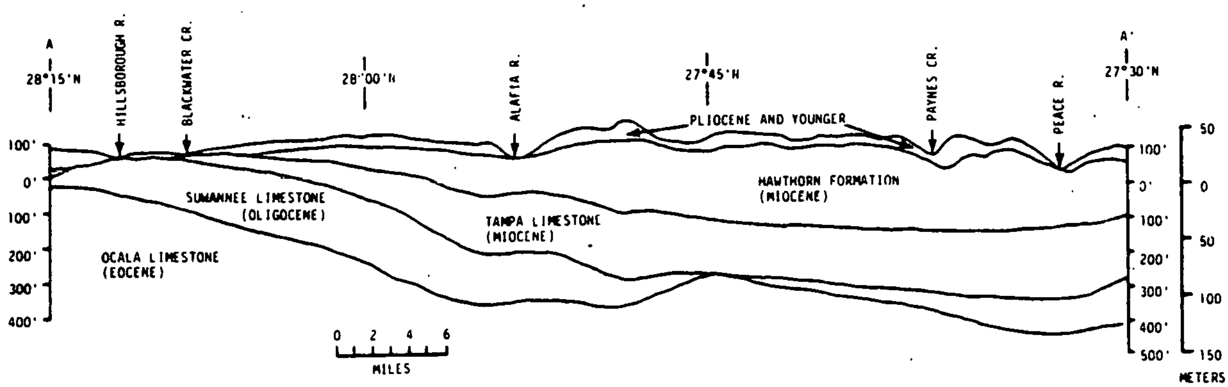


Figure 6.1.2 Cross Section of General Structure and Stratigraphy Through Portion of Study Area

Source: USEPA, Vol. VI, 1978.

Table 6.1.1 SURFACE FORMATIONS OF STUDY AREA

Series	Formation	Description
Pleistocene	Late Pleistocene deposits (Q1)	Marine and estuarine terrace deposits less than 30 meters (100 feet) above sea level; includes Anastasia, Wicomico, Penholoway, Talbot, and Pamlico formations
	Fort Thompson formation (Qf)	Three thin beds of marine shell marl separated disconformably by freshwater limestone; includes Coffee Mill hammock marl member at top
Pliocene	Bone Valley formation (pb)	Marine and estuarine phosphatic sand, clay, gravel
	Citronelle formation (Pc)	Chiefly sand and white or iron-stained clay; some deposits so mapped are early Pleistocene
Miocene	Hawthorne formation (Mh)	Sandy phosphatic limestone weathering into vesicular sandstone or sand; in Gadsden County, includes large deposits of fuller's earth
	Tampa limestone (Mt)	Marine, very fine sandy limestone of early Miocene age; commonly chalky
Oligocene	Suwannee limestone (Os)	Hard white or cream-colored limestone commonly containing pockets of green residual clay

Source: Cooke, 1945.

Table 6.1.2 CHEMICAL COMPOSITION OF IMPORTANT MINERALS IN STUDY AREA

Mineral Name	Chemical Composition
Apatite	$Ca_5(F,Cl,OH)(PO_4)_3$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Quartz	SiO_2
Vivianite	$Fe_3(POh4)_2 \cdot 8H_2O$
Montmorillonite	$(Al,Mg)_8(Si_4O_{10})_3(OH)_{10} \cdot 12H_2O$
Millisite	$(NaK)CaAl_6(PO_4)_4(OH)_9 \cdot 3H_2O$
Crandallite	$CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$
Wavellite	$Al_3(OH)_3(PO_4)_2 \cdot 5H_2O$
Chert	S10
Calcite	$CaCO_3$
Attapulgite	$(Mg,Al,Fe)_5(Al,Si)_6O_{20}(OH)_2 \cdot 8H_2O$
Dolomite	$CaMg(CO_3)_2$

Source: USEPA, Vol. VI, 1978.

6.1.3 Karst Features. The limestones of the Ocala, Suwannee, Tampa and related formations are highly susceptible to solution weathering along lines of deposition and lines of fracturing. As rainwater passes through the soil overlying these deposits, it becomes weakly acidic and acts as a natural solvent to the limestone. When the water enters the rock, it follows interconnected channels that are continually being enlarged and developed. These caverns are critical storage and transport mechanisms for Florida's freshwater aquifer system. Groundwater resources are discussed in more detail in Section 4.0.

When sediments overlying cavernous limestone can no longer be supported, they subside or collapse and a sinkhole is formed. Sinkholes are sometimes referred to as "sinks" or "karsts." Solution sinkholes differ from collapse sinkholes in that the surface gradually subsides due to slow dissolution rather than abrupt rupture of the limestone (Wright, 1974). Sinkhole collapse is dependent upon overburden thickness and level of water table. Sinkhole occurrence is highest in Hillsborough and Polk counties, decreasing as the overburden thickens in the southern portions of the study area.

Florida's freshwater springs are intimately related to the underground system of sinks and caverns. Stable prehistoric sinkholes that have surface cavities lying below the potentiometric surface of an artesian aquifer act as vents for many large springs (Cooke, 1939). Lands dominated by limestone solution features are considered to have a "karsted topography."

6.2 Geomorphology

Florida can be divided into five topographic divisions (Cooke, 1945), two of which occur in Central Florida--the Coastal Lowlands and the Central Highlands. In the study area, the principal terrain of the Coastal Lowlands consists of poorly drained and virtually undissected plains (i.e., DeSoto Plain, Osceola Plain, Gulf Coastal Lowlands), whereas the Central Highlands consist of relatively flat yet elevated uplands (i.e., Polk Upland, Lake Upland) punctuated by north-south elongated ridges (i.e., Lake Wales Ridge, Lakeland Ridge, Winter Haven Ridge, etc.) as well as lowland areas (i.e., Western Valley).

The Wicomico shoreline of the Pleistocene epoch appears to be the most important dividing line between different types of terrain in the Florida peninsula (White, 1970).

6.2.1 Lake Wales Ridge. The ridge and other ridges to the west of similar structure and origin are located within the study area in Polk County. The highest elevations of the study area are found here. The Lake Wales Ridge is the most prominent topographic feature in peninsular Florida and extends from Clermont in mid-Lake County to Venus in southern Highlands County.

Other smaller ridges to the west (i.e, Lakeland, Winter Haven, Lake Hendry, etc.) rise from Polk Upland and roughly parallel the Lake Wales Ridge. Contours of the highland ridges typically range from 40 to 60 meters (130-200 feet). Elevations are the highest in the Lake Wales Ridge, at times in excess of 80 meters (250 feet).

Most sand ridges in interior Florida are considered to be barrier islands, beach ridges or spits formed along ancient shorelines (Pirkle, et. al., 1970). White (1970) suggests that these ridges are intricately dissected remnants of a former broad plain that have resisted reduction, with their formation controlled by certain relict beach ridges or other Atlantic littoral features. The presence of the course, claybound, gravelly sand of the Citronelle Formation underlying the surface sands likely was instrumental in preserving the higher portions of the present ridges.

6.2.2 Polk Upland. This surface feature occupies much of the eastern half of Polk County and is surrounded by lower ground on three sides--the Gulf Coastal Lowlands to the west, the DeSoto Plain to the south and the Zephyrhills Gap to the north (encompassing the valley of the Hillsborough and upper Withlacoochee Rivers). It is bounded on the east by the toe of the Lake Wales Ridge and is punctuated by the higher elevations of the Winter Haven and Lakeland Ridges. Northeast of the Polk Upland, the land surface blends into the Lake Upland, the boundary being arbitrarily drawn between the Western Valley and the Lake Wales Ridge (White, 1970).

Aside from the ridges and stream valleys, the topography of the Polk Upland is relatively flat, ranging in elevation from 30 to 40 meters (100 to 130 feet); due, perhaps to the lack of extensive solution features. Topographic dissection by surface features approaches 15 meters (50 feet) in places.

The Bone Valley Formation, rich in phosphatic minerals, underlies most of the Polk Upland and portions of the DeSoto Plain to the south. Mining more thoroughly impacts the landscape than any of man's previous activities int he area. Topography following mining ranges from a steep ridge and valley effect of spoil piles, to large above-ground terraces of settling areas. Reclaimed land usually is slightly rolling in character with numerous lakes.

The Peace, Manatee, Little Manatee, and Alafia Rivers all have their headwaters in the Polk Upland. the impermeable beds of the Hawthorne and Bone Valley Formations that underlie the Polk Upland are responsible primarily for the extensive surface drainage system over the area. Where the overlying beds are thin, the incidence of sinkhole occurrence is high, although historically more common on the ridges of the area.

6.2.3 Lake Upland. The Lake Upland occupies the northern portion of Polk County and is somewhat continuous with the elevations in the Polk Upland. The Lake Upland is dominated by relict beach ridges, similar to the ridges of the Polk Upland, differentially reduced by subsidence caused by solution of the underlying limestone. It is underlain by portions of the Citronelle and Bone Valley Formations. The mean elevations of these relict beach ridges lessens gradually towards the north, primary consideration in separating the Polk and the Lake Upland.

The Green Swamp encompasses most of the Lake Upland in Polk County. Although the area is designated as the Green Swamp, it is not a continuous swamp; rather, it is a composite of numerous swamps distributed rather uniformly throughout the area. Prominent topographic features of the eastern part of the Green Swamp are the low north-northwest ridges and swales in the Lake Upland of Polk County (Pride, et. al., 1966). These low ridges result in parallel drainage flows to the north, the majority of which break off to the west forming the Withlacoochee River at the northern edge of Polk County.

6.2.4 Western Valley. This "valley" is an extensive, north-south oriented lowland that grades into the Gulf Coastal Lowlands within the study area from North-eastern Hillsborough County. In the differential reduction which left the ridges, uplands and hill areas as residual remnants of a former region upland, the unprotected soluable areas such as the Western Valley were reduced to lower elevations. The Zephyrhills Gap is the southernmost drainage egess of the Western Valley and is connected to the Tampa Bay estuaries via the Hillsborough River. The common headwaters of the Hillsborough and Withlacoochee Rivers is in the Zephyrhills Gap, both originating from the upper Withlacoochee River.

The western portion of the Green Swamp is located in the Western Valley. In the western part of the Green Swamp area, there is little evidence of the elongated ridges typical of the Lake Upland (Pride, et. al., 1966). The main surface features are large swamps, flatlands and rolling hills. There are many small swamps and strands scattered throughout the area. The largest continuous expanse of swampland lies within the Withlacoochee River Floodplain. Limestone of the Suwannee Formation is exposed in this area, resulting in substantial recharge to the Floridian Aquifer.

6.2.5 DeSoto Plain. The DeSoto Plain is one of the largest and flattest plains in Florida. From its northern edge at the Polk Upland to the southern scarp in Charlotte and Glades counties, elevations drop a mere 5 to 8 meters (15 to 25 feet). Topographic dissection is greatest along water courses. The scarps that separate the DeSoto Plain from the Polk Upland and the Lake Wales Ridge are the most definitive boundary between the Central Highlands and the Coastal Lowlands. The transition from DeSoto Plain to the Gulf Coastal Lowlands is poorly defined by gentle depositional slopes. The DeSoto Plain is submarine in origin as evidenced by the lack of lineral features of relict beach ridges or shorelines. The northern two thirds of the DeSoto Plain is underlain by the Bone Valley and Hawthorne Formations, and is expected to support future phosphate mining as the rich reserves to the north are depleted.

6.2.6 Osceola Plain. This topographic features of the study area is similarly submarine in origin, as the DeSoto Plain, but is separated from it by the Lake Wales Ridge. It is bounded on part of its periphery by marine scarps which rise above it (e.g., Lake Wales Ridge) and lower marine scarps which fall away below it. The Kissimmee River bisects the plain and drains it to the south into the Okeechobee.

A conspicuous ridge, referred to as Bombing Range Ridge, separates Arbuckle Creek and the Kissimmee River, Rising an additional 20 meters (65 feet) above the surrounding 18 to 22 meter (60 to 70 feet) elevation of the Osceola Plain. It appears to be a large, marine sand bar made by the Atlantic Ocean and is similar in morphology to the Lake Wales Ridge (White, 1970).

6.2.7 Gulf Coastal Lowlands. This area is among the most recent to have risen from the sea and consists of poorly defined marine terraces. Most of the lower Gulf Coastal Lowlands lies below 12 meters (40 feet), except for the areas in Hillsborough County abutting the Polk Upland. As the slope narrows and steepens between the Polk Upland and Tampa Bay, a strong development of terraces is evident, especially between the Alafia and Little Manatee Rivers. This area is one of the most conspicuously terraced parts of the coatal plain, showing four flats and three intervening scarps (White, 1970). Prominent terraces are rare, both north and south of this area.

6.3 Soils

For satisfactory growth of plants, the soil environment must supply three major ingredients: water, nutrients, and physical support. Critical to accomplishing these tasks are certain physical, chemical, and biological characteristics which the soil must possess. There must be means for retaining rainwater or other moisture and making it available to the plants. There must also be a steady supply of nutrients and mechanisms for storing them for future uses. Toxic metals and salts must not be present in quantities which would inhibit plant growth. Soils are active bodies; many dynamic processes must occur for them to be continually productive.

6.3.1 Native Soils. The native soils of the study area were formed from unconsolidated and generally uncemented marine sands deposited on the limestone bedrock during the Pleistocene epoch. This cap of sandy material exhibits a terrace effect resulting from different shorelines of the Pleistocene ice ages (Cooke, 1939; Leighty, et. al., 1958).

On lower terraces, poorly drained soils formed on the generally flat landscape. "Flatwoods" soils, termed Spodosols, include Myakka (formerly Leon), Immokalee, and Ona. They are the dominant soils present in this area. These "flatwoods" soils have a sandy, acidic upper profile, with about a 15 centimeter (6 inch) thick topsoil. In terms of agricultural production, these soils are naturally infertile and intensive management is necessary to being them into a productive condition (Blue, 1979). Indurated spodic horizons in these soils occur at shallow depths (within one meter, or 40 inches). These relatively impervious horizons (hardpans) are the major factor in determining land use capability ratings. Consequently, these soils have severe limitations on building site development, water management; recreation development and other uses due to surface wetness.

Areas within the flatwoods zone, with local higher elevations, may be occupied by well-drained Ultisol soils typified by the Millhop Series (formerly Blanton). These soils show an argillic horizon (clay) at about 120 centimeters (50 inches); but they lack the shallow, restrictive spodic horizon noted in the previous soils. Because of better drainage, the Millhop Series has a wider range of suitability for various developmental purposes and is considered to be better agricultural land.

The highest elevations indicate greater marine and deposition in the landscape and are occupied by well-drained to excessively well-drained soils. The Astatula Series is a common example of this type. This sandy soil is characterized by very little subsurface horizonation. It is droughty and excessively drained. The free drainage conditions limit the use of this soil for water management and impose restrictions on building site development.

The five soil series described above, especially the Spodosoils, are the most impacted by phosphate mining (Farmer and Blue, 1978). Obviously, many other soils occur in this region. For a general overview, soils can be grouped into soil associations.

A soil association is a fairly well-defined pattern of geographically associated soils. Soil series with a particular association do not necessarily have similar properties. The overall rating is based on the rating for the dominant soil (soil that makes up the greatest percentage of the association) or soils if more than one soil has the same rating (USEPA, Vol. VI, 1978).

6.3.2 Phosphate Mine Soils. Modern mining operations remove the phosphate matrix with huge, electric-powered draglines. The soil body overlying the matrix is referred to as overburden. Overburden thickness ranges from 1.5 to 12 meters (5 to 40 feet) (Boyle, 1969). The phosphate matrix is hydraulically pumped to the water and benefication plant for separation of the phosphate product from the waste clays and sands, each of which comprise approximately one-third of the matrix by weight. The phosphate product is further refined for commercial use, while the sand and clay are returned to the land.

Overburden generally consists of Pleistocene deposits which overlie the Bone Valley Formation. Quartz, montmorillonite, apatite, kaolinite and vivianite are its primary mineral constituents. Kaolinite is the principal clay in this zone and is rich in oxides of iron (FeO_3), magnesium (MgO) and potassium (K_2O) (USEPA, Vol. VI, 1978). In the Polk County area, the overburden usually includes the leached zone, which is acutally the upper Bone Valley Formation. This zone is mineral rich, having a higher uranium content than its overlying deposits.

Overburden soils have been classified as Arents (Ohlsen, et. al., 1980) or Udalfic Arents (USDS-SCS, 1975a; Thomas, et. al., 1979) by various researcher. In the 1970s, overburden accounted for about 72 percent of the reclaimed land surface (Schnoes and Humphrey, 1980). The quality of the resulting soil depends on the depth of surface sands and its mixture with the finer clay-sized materials (Farmer and Blue, 1978).

The sand "tailings" are generally pumped back into old mine cuts and capped with overburden. Tailings consist of quartz sand with no organic matter, low nutrient content, and very low cation exchange capacity (Farmer and Blue, 1978). Sometimes the tailings cannot be capped, thus offering a harsher substrate for revegetation. Discing phosphate clay into the surface of the sands improves the physical and chemical composition of the tailings substantially.

Sand tailings covered about 12 percent of the lands reclaimed in the 1970s (Schnoes and Humphrey, 1980). Unlike tailings from copper or heavy metal mining, ground cover vegetation can be established quickly and easily on phosphate-mined tailings. A number of viable pastures have been established on this sandy mine soil; but they require more intensive management to be very productive. According to the water table elevation and moisture regime, sand tailings have been tentatively classified as Aquic or Typic Quartzipsamments by the Soil Conservation Service (Ohlsen, et. al., 1980). Uncapped tailings have the potential for restoration to xeric forests, since this mine soil closely resembles the St. Lucie fine sands common to sand pine scrub forests.

Phosphatic clays are deposited in large, above ground settling ponds. These areas hold clays for years until settling and consolidation occur. Historically, these ponds have covered 65 percent of the total mined land area (USEPA, Vol. II, 1978). An excessive amount of fine, clay-sized particles impart excellent chemical properties but exceptionally poor structure and stability to this soil. Due to shrinkage, the clays tend to harden, crack, and flake when drying. They are fluid or slick, and very poorly drained and aerated when wet. While these areas make excellent pasture, they are not easily cultivated due to the limited periods of optimal moisture for the operation of farm equipment (W. Hawkins, pers. comm.). Preliminary findings from cropping these soils suggest that the clay settling areas could be prime agronomic soils if the moisture conditions were acceptable. Clay settling ponds have exceptional fish and wildlife values when active or reclaimed as permanent wetland and aquatic ecosystems (Montalbono, et. al., 1978; Cornwell and Atkins, 1980). Depending upon water level management both during and after active waste disposal, the settling ponds are a poorly recognized wetland resources that has been undervalued in the past. Soil conditions are similar to those typically found in Vertisols (W. Blue, pers. comm.).

Recent research on sand tailings and clay mixtures indicates that the most desirable characteristics of both soils can be optimized in this combination, depending on the ratio of sand to clay in the matrix and in the mix. Homogenous sand-clay mixes, based on preliminary findings, may well become some of the most productive soils in Florida. Techniques of advanced reclamation will vary according to site-specific conditions at each min, since there are no universal reclamation solutions. A variety of techniques involving flocculating, layering, or mixing clays with tailings are being developed to meet the variety of needs and limitations. At present, this is a topic of great interest in the phosphate mining industry.

6.3.3 Location and Extent of Various Soils. Table 6.3.2 describes the soil associations and groups them into characteristic soil areas. Areas 1 and 2 are dominated by the Entisols and are typically droughty. These areas are the principle citrus lands of the region. Sandhill and scrub are the major vegetation types. Area 3 comprises the great flatwoods zone dominated by the somewhat poorly drained Spodosols. This area covers about 57 percent of the study region and supports cattle grazing and truck crops. The wetter soils, subject to flooding are located in Areas 4 and 5. Although wetlands are the typical cover type, many of the Area 4 lands have been and will continue to be drained and converted into cropland and pasture. With proper drainage these lands can be highly productive, agriculturally. Area 6 consists of the lands mined for phosphate. Reclaimed land can be highly productive, depending upon the amount of silt, clay and residual phosphate. Presently, over 78 percent of the existing mined lands remain unreclaimed. By law, all lands mined after 1975 must be reclaimed. Of the pre-1975 abandoned lands, about 75 percent is salted for future reclamation. Older unreclaimed and naturally revegetated lands provide impressive natural systems values (Breedlove and Adams, 1977; Edscorn, 1977; Kangas, 1979; Shnoes and Humphrey, 1980) and the most valuable natural areas may be left unreclaimed.

Area 1 soils are primarily located long the sand ridges of Polk County. Area 2 soils follow the major river and stream valleys in the region. These valley provide the necessary relief for good internal drainage as well as surface drainage routes. In general, there is a great diversity of soils in these areas. Area 3 soils comprise the vast flat plateaus of the region (i.e., Manatee, DeSoto, Hardee). A substantial portion of Area 3 soils has been mined for phosphate in Polk County and now are designated as Area 6 soils. Area 5 soils are associated with riverine wetlands and floodplains in all five counties. Area 4, although often associated with watercourses, includes low areas dominated by isolated wetlands that may experience only temporary flooding.

6.3.4 Physical and Chemical Properties of Native and Mine Soils. Comparisons of the physical and chemical properties of a selected number of native soils and mine soils reveal significant differences in their inherent qualities for producing vegetation (EcoImpact, 1980). The most basic and important characteristics of a soil is the relative amounts of various sized inorganic particles. Most other qualities are influenced by this distribution. Phosphate overburden and clays have significantly higher quantities of fine particles (silts and clays). This finer texture, in concert with high phosphorus and calcium levels, imparts to these soils a higher nutrient and moisture retention than the native soils. The coarse texture of sand tailings results in a soil drier and less fertile than the native soils. Conversely, phosphatic clay soils retain excessive amounts of moisture and are physically unstable due to the high quantities of montmorillinite clay. Initially, mine soils have no organic matter and little soil biotic activity. However, equilibrium levels for overburden and phosphatic clay eventually may exceed the native soils, again, due to texture.

The native soils of the mining region are naturally low in productivity and have a number of management problems. They are acidic, sandy soils with poor particle size distributions and weak aggregations. With few colloidalsized components, the capacities for nutrient exchange and water absorption are low. Regular programs of liming and fertilization of major elements are essential agricultural practices. In addition, intensive drainage schemes must be used on the poorly drained Spodosols.

The native soils are almost universally regarded as agriculturally poor soils, since the moisture capacity and nutrient regimes are low.

Management considerations for mine soils relate mainly to establishing vegetation. They are all young soils and have had little time for soil forming factors to operate on them. With vegetative growth, genesis of the upper layers of soil occurs. Sand tailings tend to be excessively drained and need consideration additions of colloidal material to improve their texture and structure for ordinary agricultural uses. This serves to increase the moisture and nutrient retention of the soils.

Over burden soils possess many favorable characteristics. With improved texture, these have an excellent capability for accumulating organic matter. They tend to form a surface crust; but, when vegetated, this can be alleviated by root activity and the deposition and accumulation of an organic litter layer. Overburden is generally well-drained and amenable to agricultural uses.

Phosphatic clay soils have a very high colloidal content with a concomitant high potential productivity when managed properly. Because of the tendency of the clays to become plastic when wet, the soils could be easily puddled if worked under saturated conditions. The unstable condition of phosphate clay soils is a severe limitation to most uses, even agricultural. However, with nitrogen fertilization, the clay mine soils have produced dry matter yields of grasses and native shrubs as high as 7.7 metric tons/hectare (17.5 tons/acre) (W. Blue, pers. comm.). Experimental squash planting on these clays also has been encouraging (W. Hawkins, unpub. data). Outstanding crops of green beans and milo have been grown but not harvested (M. Moorman, pers. comm.). The agronomic and silvic potential of reclaimed clay settling ponds is enormous, once the proper production methods are identified by future research.

Table 6.3.1.—Soil Associations of the Five County Study Area

Particule Size Distribution

Soil type	Horizon	Sand %	Silt %	Clay %	0.1 Bar moisture % by weight	15 Bar moisture % by weight
Myakka	A1	93.8	4.1	2.2	12.0	8.5
	A2	97.5	1.8	0.7	5.1	4.1
Ona	A1	92.2	5.9	1.9	20.5	NA
	B_2H	90.6	5.4	4.0	19.3	NA
Immokalee	A1	95.4	3.1	1.5	9.3	1.7
	A2	98.0	1.3	0.8	3.4	1.2
Astatula	A1	96.3	2.2	1.5	6.6	2.0
	A2	96.9	1.6	1.4	3.5	1.3
Millhop	A1	88.8	8.6	2.6	14.3	10.7
	A2	90.1	6.6	3.3	9.6	7.3
Phosphate Sand Tailings	*	98.5	0.0	1.4	2.2	1.9
Phosphate Over-burden	*	76.1	3.8	20.1	13.7	6.4
Phospate Clays	*	4.9	14.5	80.5	NA	NA

*0-6" sample in mine soils.
NA Not available.
Source: EcoImpact, 1980.

Table 6.3.2 SOILS OF THE FIVE-COUNTY STUDY REGION

Area Definition	Percent of Study Region	Extent Within Study Region (hectares/acres)	Soil Association Description
AREA 1 - dominated by sandy, droughty soils not subject to flooding	13.4	15,721/388,467	Astatula-Arredondo association (14.1%): Nearly level to sloping, excessively drained soils sandy throughout and well drained soils with very thick, sandy layers over loamy subsoil. Astatula-Tavares-Basinger association (81.5%): Nearly level to sloping, excessively and moderately well drained soils sandy throughout and poorly drained soils sandy throughout. Candler-Tavares association (4.4%): Nearly level to sloping, excessively drained soils with very thick. sandy layers over thin loamy or sand loam lamella and moderately well drained soils sandy throughout.
AREA 2 - dominated by well drained to moderately well drained soils not subject to flooding	11.3	13,257/327/588	Arredondo-Ft. Meade-Astatula association (7.0%): Nearly level to sloping, well-drained soils with very thick, sandy layers over thin loamy subsoil and excessively drained soils sandy throughout. Tavares-Adamsville association (21.9%): Nearly level to gently sloping, moderately well and somewhat poorly drained soils sandy throughout. Tavares-Myakka association (29.8%): Nearly level to gently sloping, moderately well-drained soils sand throughout and poorly drained sandy soils with weakly cemented sandy subsoil. Pomello-St. Lucie association (6.1%): Nearly level to sloping moderately well-drained, sandy soils with weakly cemented sandy subsoil and excessively drained soils sandy throughout.

Table 6.3.2 SOILS OF THE FIVE-COUNTY STUDY REGION (continued)

Area Definition	Percent of Study Region	Extend Within Study Region (hectares/acres)	Soil Association Description
AREA 2 (continued)			Pomello-Myakka-Tavares association (1.8%): Nearly level to gently sloping, moderately well and poorly drained, sand soils with weakly cemented sandy subsoil and moderately well drained soils, sand throughout.
			Pomello-Basinger-St. Lucie association (21.1%): Nearly level to gently sloping, moderately well drained, sandy soils with weakly cemented sandy subsoil; poorly drained soils, sandy throughout; and excessively drained soils sandy throughout.
AREA 3 - dominated by somewhat poorly to poorly drained soils not subject to flooding	57.1	66,991/1,655,335	Sunniland-Bradenton association (1.9%): Nearly level, somewhat poorly and poorly drained soils with thin, sandy layers over loamy subsoil underlain by marly material.
			Myakka-Pomello-Basinger association (30.1%): Nearly level, poorly and moderately well drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils sandy throughout.
			Myakka-Immokalee-Basinger association (50.2%): Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils sandy throughout.
			Ona-Myakka association (3.3%): Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil.
			Wabasso-Elred-Oldsmar association (0.2%): Nearly level, poorly drained, sandy soils with a

Table 6.3.2 SOILS OF THE FIVE-COUNTY STUDY REGION (continued)

Area Definition	Percent of Study Region	Extend Within Study Region (hectares/acres)	Soil Association Description
AREA 3 (continued)			weakly cemented sandy subsoil layer over loamy subsoil and poorly drained sandy soils with loamy subsoil.
			Myakka-Placid-Swamp association (0.5%): Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil; very poorly drained soils, sandy throughout; and very poorly drained soils subject to prolonged flooding.
			Felda-Pompano-Wabasso association (0.2%): Nearly level, poorly drained, sandy soils with loamy subsoil; poorly drained sandy throughout; and poorly drained, sandy soils with a weakly cemented sandy subsoil layer over loamy subsoil.
			Paisley-Bushnell association (0.2%): Nearly level to gently sloping, poorly and somewhat poorly drained soils with thin sandy layers over a clayey subsoil.
			Immokalee-Pomello association (8.1%): Nearly level to gently sloping, poorly and moderately well drained, sandy soils with weakly cemented sandy subsoil.
			Wabasso-Felda association (1.2%): Nearly level poorly drained, sandy soils with a weakly cemented sandy subsoil layer underlain by loamy subsoil.
			Broward-Bradenton-Manatee association (0.5%): Nearly level, poorly drained, sandy soils, underlain by limestone; poorly drained soils

Table 6.3.2 SOILS OF THE FIVE-COUNTY STUDY REGION (continued)

Area Definition	Percent of Study Region	Extend Within Study Region (hectares/acres)	Soil Association Description
AREA 3 (continued)			with thin, sandy layers over loamy subsoil underlain by marly material; and very poorly drained, sandy soils with loamy subsoil.
			Wabasso-Bradenton-Myakka association (1.6%): Nearly level, poorly drained, sandy soils with a weakly cemented sandy subsoil layer underlain by loamy subsoil; poorly drained soils with thin, sandy layers over loamy subsoil; poorly drained soils with weakly cemented sandy subsoil.
			Immokalee-Myakka-Pompano association (0.2%): Nearly level, poorly drained, sandy soils with weakly cemented sandy subsoil and poorly drained soils, sandy throughout.
			Pompano, high-Felda association (1.6%): Nearly level, poorly drained, soils, sandy throughout and poorly drained, sandy soils with loamy subsoil.
			Pompano, high-Pompano association (0.2%): Nearly level, poorly drained soils, sandy throughout.
AREA 4 - dominated by poorly drained soils subject to flooding	6.0	7,039/173,941	Chobee-Delray association (1.6%): Nearly level, very poorly drained soils with thick, sandy layers over loamy subsoil.
			Brighton-Placid association (11.5%): Nearly level, very poorly drained, poorly decomposed organic soils 130-203 cm (51-80 inches) or more thick, and very poorly drained soils, sandy throughout

Table 6.3.2 SOILS OF THE FIVE-COUNTY STUDY REGION (continued)

Area Definition	Percent of Study Region	Extend Within Study Region (hectares/acres)	Soil Association Description
AREA 4 (continued)			Pompano-Charlotte-Delray association (14.8%): Nearly level, poorly drained soils, sandy throughout and very poorly drained soils with thick, sandy layers over loamy subsoil.
			Placid-Basinger association (16.4%): Nearly level, very poorly and poorly drained soils, sandy throughout.
			Delray-Manatee-Pompano association (1.6%): Nearly level, very poorly drained soils with thick, sandy layers over loamy subsoil; very poorly drained, sandy soils with loamy subsoil and poorly drained soils, sandy throughout.
			Basinger-Placid association (6.6%): Nearly level, poorly drained soils, sandy throughout and very poorly drained soils subject to prolonged flooding.
			Placid-Swamp association (4.9%): Nearly level, very poorly drained soils, sandy throughout and very poorly drained soils subject to prolonged flooding.
			Brighton-Terra Ceia association (3.3%): Nearly level, very poorly drained, poorly decomposed, organic soils 132 cm (52 inches) or more thick and well decomposed, organic soils 132 cm (52 inches) or more thick.

Table 6.3.2 SOILS OF THE FIVE-COUNTY STUDY REGION (continued)

Area Definition	Percent of Study Region	Extend Within Study Region (hectares/acres)	Soil Association Description
AREA 5 - dominated by very poorly drained soils subject to flooding	6.5	7,626/188,436	Fresh Water Swamp association (77.3%): Nearly level, very poorly drained soils subject to prolonged flooding. Salt Water Swamp and Marsh association (6.1%): Nearly level, very poorly drained soils. Fresh Water Swamp and Marsh association (9.1%): Nearly level, very poorly drained soils subject to prolonged flooding. Tidal Marsh and Swamp-Coastal Beach/Ridges Dune association (7.6%): Nearly level, very poorly drained soils subject to frequent tidal flooding, high lying coastal dune-like ridges and deep droughty sands.
AREA 6 - dominated by soils resulting from the severance of phosphate rock	5.7	6,708/165,753	Udalfic Arents (16.1%): Cast and reshaped overburden, well drained, loamy surface soils, miminal horizon development. Typic and Aquic Quartzipsamments (2.6%): Hydraulically pumped and graded tailings, excessively drained to well drained, sandy throughout. Entic Vertisols (3.6%): Semi-consolidated phosphatic clay, very poorly drained, clayey throughout. Unreclaimed Land Types (78.6%): Cleared or disturbed areas, unreclaimed overburden spoils, tailings dumps, and clay settling areas.

Source: USEPA, Vol. VI, 1978.

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