



FLORIDA GEOLOGICAL SURVEY

## COPYRIGHT NOTICE

© [year of publication as printed] Florida Geological Survey [source text]

The Florida Geological Survey holds all rights to the source text of this electronic resource on behalf of the State of Florida. The Florida Geological Survey shall be considered the copyright holder for the text of this publication.

Under the Statutes of the State of Florida (FS 257.05; 257.105, and 377.075), the Florida Geologic Survey (Tallahassee, FL), publisher of the Florida Geologic Survey, as a division of state government, makes its documents public (i.e., *published*) and extends to the state's official agencies and libraries, including the University of Florida's Smathers Libraries, rights of reproduction.

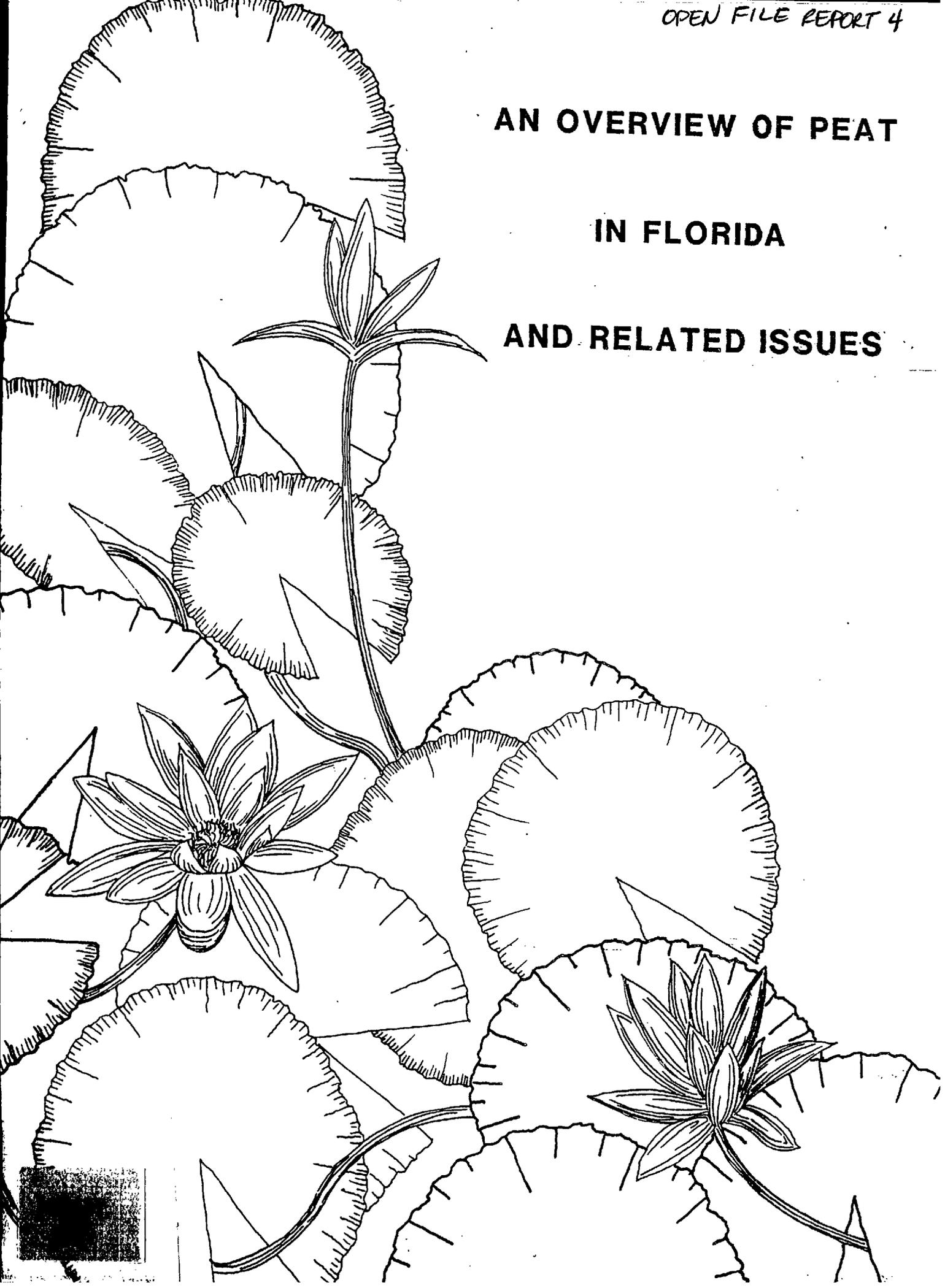
The Florida Geological Survey has made its publications available to the University of Florida, on behalf of the State University System of Florida, for the purpose of digitization and Internet distribution.

The Florida Geological Survey reserves all rights to its publications. All uses, excluding those made under "fair use" provisions of U.S. copyright legislation (U.S. Code, Title 17, Section 107), are restricted. Contact the Florida Geological Survey for additional information and permissions.

**AN OVERVIEW OF PEAT**

**IN FLORIDA**

**AND RELATED ISSUES**



DEPARTMENT  
OF  
NATURAL RESOURCES

ROBERT GRAHAM  
Governor

GEORGE FIRESTONE  
Secretary of State

JIM SMITH  
Attorney General

BILL GUNTER  
Treasurer

GERALD E. LEWIS  
Comptroller

RALPH D. TURLINGTON  
Commissioner of Education

DOYLE CONNER  
Commissioner of Agriculture

ELTON J. GISSENDANNER  
Executive Director

Cover Drawing:

The cover drawing shows Water Lilly (Nymphaea), the living plant from which Water Lilly Peat forms, characteristic of relatively deep, open waters.

STATE OF FLORIDA  
DEPARTMENT OF NATURAL RESOURCES  
Elton Gissendanner, Executive Director

DIVISION OF RESOURCE MANAGEMENT  
Charles W. Hendry, Jr., Director

BUREAU OF GEOLOGY  
Steve R. Windham, Chief

AN OVERVIEW OF PEAT  
IN FLORIDA  
AND RELATED ISSUES

Prepared by  
staff  
Bureau of Geology  
Paulette Bond, Principal Investigator

at the  
direction of  
THE FLORIDA LEGISLATURE  
1984



# TABLE OF CONTENTS

	Page
Executive Summary.....	x
Acknowledgements.....	xviii
Purpose and Scope of the Study.....	1
Historical Perspective of Peat Research in Florida.....	1
Definition of Peat and the Significance of This	
Definition.....	4
Terminology Relating to the Peat Forming Environment..	7
Peat: Agricultural or Mineral Resource?.....	9
Harvesting or Mining.....	14
Classification Systems Applied to Peat.....	16
The Accumulation of Peat.....	20
The Process of Peat Formation.....	20
Geologic Conditions Associated with Peat	
Accumulation.....	21
Mining Technology.....	23
Mining Methodology Associated with the Use of	
Peat for Fuel.....	23
Mining Methodology Associated with the	
Agricultural Use of Peat.....	26
The Accumulation of Peat in Florida.....	27
Rates of Peat Accumulation in Florida.....	27

Geologic Settings of Peat Accumulation in Florida.....	30
Inventory of Peat in Florida.....	40
Mapping and Evaluating the Peat Resource.....	40
Current Estimates of Peat in Florida.....	42
The Everglades Agricultural Area.....	49
History of the Everglades Agricultural Area.....	49
Crops and Soils of the Everglades Agricultural Area...	51
Subsidence.....	54
Conservation Measures.....	60
The Near Future of the Everglades Agricultural Area...	61
Industrial Uses of Peat.....	65
Preparation of Peat for Industrial Utilization.....	65
Fuel Uses.....	67
Direct Combustion.....	67
Gasification.....	68
Biogasification.....	69
Industrial Chemicals.....	70
Bitumens.....	70
Carbohydrates.....	72
Humic Acids.....	73
Peat Coke, Peat Tar and Activated Carbon.....	74
Use of Peat as a Growth Medium.....	75
Horticulture.....	75
Agriculture.....	76
Energy Crops.....	76
Sewage Treatment.....	77

Economic Impact.....	78
Production, Value, and Price of Peat.....	78
Location of Peat Producers.....	80
Location of Markets.....	82
Use of Peat.....	82
Permitting.....	83
County Level Permits.....	83
State Level Permitting.....	86
Department of Environmental Regulation.....	86
Water Management Districts.....	87
Suwannee River Water Management District....	87
St. Johns River Water Management District...	87
Southwest Florida Water Management	
District.....	93
South Florida Water Management District.....	94
Department of Community Affairs.....	94
Federal Level Permitting.....	95
Army Corps of Engineers.....	95
The Environmental Protection Agency.....	96
Peat Revenue and Taxation.....	96
Potential Environmental Impacts of Peat Mining.....	98
The Effects of Peat Mining on Wetlands.....	98
The Effects of Peat Mining on Water Quality.....	102
The Effects of Peat Mining on Water Resources.....	107
Water Resources in an Undisturbed System.....	107
Water Resource Parameters Affected by Peat	

Mining.....	109
The Effects of Peat Mining on Air Quality.....	114
The Effects of Peat Mining on Topography.....	118
Endangered Species Associated with Areas of Potential	
Peat Mining.....	125
Reclamation of Mined Peatlands.....	136
Peatland Reclamation in Minnesota.....	137
Peatland Reclamation in North Carolina.....	141
Peatland Reclamation in Finland.....	143
Peatland Reclamation in New Brunswick.....	145
Reclamation in Peatlands of Florida.....	146
Summary and Conclusions.....	147
References.....	151
Glossary of Technical Terms.....	158
Appendices.....	170
Appendix A. Federal Environmental Legislation.....	170
Appendix B. Classification of Wetlands in Florida....	174
Appendix C. Florida Statutes Concerning Wetlands.....	180
Appendix D. Water Quality.....	195
Appendix E. Peatland Management.....	200

## ILLUSTRATIONS

### Figure

1	The process of coal formation.....	13
2	The relationship of peat types to fuel grade.....	17
3	A comparison of moisture content and heating value for peat, wood and various coal types....	22

4	Peat provinces of southern Florida.....	31
5	SW-NE cross-section from Cape Sable to vicinity of Tamiami Trail.....	32
6	Cross-section through a cypress hammock.....	33
7	Cross-section through a "Bay Head".....	34
8	Cross-section through bay swamp and titi swamp...	35
9	Peat deposits bordering lakes.....	36
10	Cross-section showing peat filling lake.....	37
11	Cross-section using cores to show buried peat layers at Eureka Dam site, Oklawaha River, Marion County, Florida.....	38
12	Isopach map of the Everglades region showing thickness of peat and some muck areas.....	41
13	Peat deposits in Florida.....	45
14	Fuel grade peat deposits in Florida.....	46
15	Peat deposits in Florida.....	47
16	Location map of the Everglades Agricultural Area.....	53
17	Map of the Everglades Agricultural Area showing the locations of profiles A-A' and B-B'.....	57
18	Profile A-A' across the upper Everglades showing the original surface elevations and the ground elevation in 1940 as shown by topographical survey. Profiles for the years 1970 and 2000 are estimated.....	58

19	Profile B-B' through the lower part of the Everglades Agricultural Area show the original surface elevation and the surface elevation as determined in 1940 by topographic surveys. Profiles for the years 1970 and 2000 are estimated.....	59
20	Soil depths predicted (Stephens and Johnson, 1951) for the year 1980. Compare with figure 17:.....	62
21	Thicknesses of soils from the Everglades Agricultural Area as determined in a recent study.....	63
22	Location of current peat producers.....	79
23	Production and value of peat in Florida.....	81
24	Topographic profile of a karst basin peat deposit in north Florida.....	119
25	Topographic profile of St. Johns River Marsh peat deposit in southern Brevard County.....	120
26	Topographic profile of the Oklawaha River peat deposit in northern Lake-southern Marion counties.....	121
27	Topographic profile of the Santa Fe Swamp peat deposit in Alachua and Bradford counties.....	122
28	Topographic profile of the Everglades in Collier and Dade counties.....	124

Table

1	Estimated rates of peat accumulation in Florida.....	28
2	Proportions of the organic soils of the Everglades Agricultural Area falling into categories based on thickness.....	64
3	Summary of county level permitting requirements.....	84
4	Water quality issues associated with peat mining.....	104
5	Water resources issues associated with peat mining.....	110
6	Air quality issues associated with peat mining...	115
7	Plant communities of concern.....	128
8	Endangered, threatened, and rare species associated with areas of potential peat accumulation.....	129
9	Independent factors governing site specific reclamation programs.....	138

## EXECUTIVE SUMMARY

Peat is a deposit of partially decayed plant remains which accumulates in a waterlogged environment. It may contain some proportion of inorganic material which is referred to as ash. Ash content is a critical parameter if peat is to be used as a fuel and may not exceed 25 percent of the material by dry weight. In addition, fuel grade deposits must be at least four feet thick with a surface area of at least 80 contiguous acres per square mile. Fuel grade peat must yield at least 8000 BTU per moisture-free pound.

Peat is removed from the ground in an excavation process. The procedure is alternatively referred to as harvesting or mining. "Harvesting" when used in conjunction with peat correctly refers to the nearly obsolete practice of harvesting living Sphagnum from the surface of a bog. In this process, the Sphagnum was allowed to grow back so that repeated harvests were possible in a given area. Very little or no true harvesting occurs today. Thus, the extraction of peat is properly termed mining.

An important implication of the definition of peat is its classification as an agricultural resource as opposed to a mineral resource. This classification may have ramifications with respect to the sorts of regulations which are applied to peat mining. Peat does not comply with the conditions set forth in the academic definition of the term mineral. It is, however,

considered a mineral resource by the United States Geological Survey and the United States Bureau of Mines. Peat is an ancestor of the mineral graphite and is also viewed by earth science professionals as nonrenewable. Thus it is considered appropriate to term peat a mineral resource.

Peat accumulates and is preserved in wetlands, such as the Everglades, marshes and mangrove swamps, river-valley marshes (St. Johns river-valley marsh), and in sinkhole lakes. This strong association of peat with wetlands occurs because the presence of water serves to inhibit the activity of decomposing organisms which would normally metabolize plant matter and prevent its accumulation.

Earth science professionals consider peat to be nonrenewable. In Florida an average rate of peat accumulation is 3.62 inches per 100 years. Using this average rate, a deposit 4 feet thick (minimum thickness of a fuel grade deposit) could accumulate in approximately 1,326 years or approximately 18 human lifetimes (average lifetime of 72 years).

Florida is estimated as having 677,688 acres of fuel grade peat or 606 million tons. This estimate is based on material thought to contain no more than 25 percent ash. Other estimates are much greater (1.75 billion tons and 6.9 billion tons). These estimates include organic soils whose ash content exceeds ASTM standards for material defined as peat and U.S. Department of Energy standards for fuel grade peat.

The Everglades Agricultural Area was delineated based on

scientific analysis of soils to determine their suitability as a growth medium. The drainage necessary for successful agriculture has been accompanied by subsidence primarily because soils are no longer protected from decomposing organisms which require oxygen for their metabolism. Soil loss continues to occur at about 1 inch each year. It is predicted that by the year 2000 approximately 250,000 acres in the Agricultural Area will have subsided to depths of less than one foot. The fate of soils less than one foot thick is uncertain. They may be used for pasture land or abandoned for agricultural purposes.

Peat currently is used in Florida for a variety of horticultural and agricultural purposes. The United States Bureau of Mines reports that in 1982, 120 thousand short tons was produced at a value estimated at 1.575 million dollars. These data reflect voluntary information supplied to the Bureau of Mines and do not include responses from all of Florida's peat producers. Most peat sales in Florida are currently wholesale and for agricultural purposes and are thus exempt from sales tax. Records are not maintained which detail sales tax on retail sale of peat products specifically, and thus there is no way of estimating the current tax income derived from the exploitation of peat resources in the State of Florida.

The peat permitting process as it applies to peat mining is complex. County level permits may be required, although in many cases zoning regulations are the only regulations which apply to opening a peat mine. At the state level, the Department of

Environmental Regulation and Water Management Districts containing peat may require permits. The Department of Community Affairs has jurisdiction over Developments of Regional Impact (DRI). Certain peat mining operations could come under federal jurisdiction. The agencies concerned would include the Environmental Protection Agency and the Army Corps of Engineers.

The environmental impacts associated with peat mining for energy purposes depend strongly on the size of the prospective operation. Environmental impacts are also extremely site specific. Small operations would consume 26 acres of peat mined to a depth of 6 feet, over 4 years, moderate operations - 3500 acres mined to a depth of 6 feet, over a 20 year period and a large operation would require 125,000 acres of peat, mined to a depth of 6 feet to operate for 20 years. Peat mining will occur largely in wetlands and the functions of each individual wetland must be weighed against the value of peat to be removed. The wetland habitat will be severely affected. Fauna will be displaced and possibly destroyed and flora will be destroyed when the peatland is cleared for mining. Water quality impacts may be major, even for small operations and are related to chemical characteristics of the discharge waters. Water resource parameters are not expected to be severely affected by small scale operations but may be more seriously impacted by larger scale development. The impacts of mining on air quality arise from mining, processing, and utilizing peat as a fuel. They are specific to an operation's size, mining method, and the intended

use for the product. Endangered species, both plant and animal, may inhabit peatlands. The change in habitat brought about by peat mining might lead to the destruction of members of stressed species associated with a mined area.

Research in Minnesota, North Carolina, Finland and New Brunswick, Canada, show that reclamation techniques can be successfully applied to peatlands. Reclamation techniques are specific to those areas and do not address difficulties inherent to Florida peatlands. Reclamation of Florida's peatlands will involve a change from wetland systems to other systems (probably aquatic systems). Restoration of mined peatlands (for the most part wetlands) will, in all probability, be financially unfeasible.

## SUMMARY AND CONCLUSIONS

### Mineral Versus Non-Mineral

Peat, like coal, petroleum and natural gas, does not comply with the principal conditions set forth in the academic definition of the term mineral. Peat represents an early stage in a series of products resulting in the conversion of vegetable matter to pure carbon (peat-lignite-coal-graphite), the end product of which fits all the requirements of a true mineral. In classifying peat as a mineral or non-mineral, there has been a tendency toward allowing use to play an important role in the

classification, that is, if used as an agricultural product peat would be treated as a non-mineral or if used as an energy source or fossil fuel peat would be treated as a mineral. Classification based on use can create considerable confusion especially with mineral products used as fertilizers. Peat has been historically classified by the U.S. Bureau of Mines and the U.S. Geological Survey as a mineral resource, a somewhat broader category than just "mineral," along with coal, oil and natural gas. Peat is generally regarded as nonrenewable by earth science professionals, requiring in excess of 1,000 years to generate a commercially extractable deposit of fuel grade peat.

This study would conclude that because of peat's genetic relationship to the mineral graphite, its general classification by the U.S. Bureau of Mines and the U.S. Geological Survey as a mineral resource, and emphasizing its nonrenewability, peat should be classed as a mineral, mineral resource, or mineral product. Consequently, any classification based on use should be discouraged.

#### Harvesting versus Mining

Harvesting and mining have been used synonymously to refer to the extraction of peat. Literature searches reveal the term harvesting correctly refers to the nearly obsolete practice of selectively removing living Sphagnum from the surface of the bog. In this practice, Sphagnum was allowed to grow back, permitting successive harvests in a single location. Peat (unlike living

Sphagnum) is considered nonrenewable and the term harvesting is inappropriate when applied to peat extraction. Additionally, the method and equipment utilized in peat extraction and the environmental impacts of peat extraction are synonymous with those commonly attributed to mining, not harvesting.

This study would conclude that harvesting should be applied only to the removal of living Sphagnum or other living plants and that the extraction of peat should be categorized as mining.

### Environmental Impacts of Peat Mining

Peat occurrence in Florida is, in nearly every case examined, coexistent in and beneath a current wetland area. For this reason, peat mining and wetland mining are virtually synonymous terms in Florida. The environmental impacts associated with peat mining may vary widely depending on the type of wetland, the location of the wetland, the function of the wetland, the extent of mining, the type of mining, and other physical parameters of the site.

This study would conclude that an accurate assessment of the environmental impacts of peat extraction will be site specific and can be anticipated to range from minor to severe.

### Reclamation of Peat Mining

Reclamation or the return of mined land to a beneficial use is applicable to most mining operations and would be so with peat mining. Restoration or the return of mined land to the pre-

mining function is only partially applicable to most mining operations and would not be practical with peat mining. The higher the ratio of overburden to the mined product, the higher the percentage of original landform and contour that can be achieved in reclamation. In peat mining, where the mined product typically has no overburden, the extraction leaves a void space with no material available for filling, and therefore, no original landform and contour can be achieved in reclamation.

This study would conclude that reclamation of mined peatlands to a beneficial use as an aquatic or uplands system is achievable, however, the restoration of mined peatlands to pre-mining contour and function is not feasible.

#### Agricultural Use of Peat

The in-place use of peat and related organics for agricultural purposes such as the Everglades Agricultural Area appear to be a nonconsumptive use of peat. In fact, the exposure of peat to air allows aerobic bacteria to oxidize the peat causing a gradual loss of peat accompanied by subsidence of the land surface. It is predicted that by the year 2000, approximately 250,000 acres in the Everglades Agricultural Area will have subsided to depths of less than one foot.

This report would conclude that agricultural uses of in-place peat be viewed as a consumptive use of peat and that companion to the use, research and planning be carried out to determine the systems impact resulting from peat loss and land subsidence for management to better transition into future land uses.

## ACKNOWLEDGMENTS

The initial outline for this study was read and improved by David Gluckman, representing the Florida Chapter of the Sierra Club; Charles Lee, representing the Florida Audubon Society; and Katherine Ewel, Helen Hood, John Kaufmann, and Marjorie Carr, representing the Florida Defenders of the Environment.

Richard P. Lee, Florida Department of Environmental Regulation offered helpful comments on the outline and sent valuable references concerning wetlands. Irwin Kantrowitz, United State Geological Survey read the outline and offered assistance.

Ronnie Best of the Center for Wetlands, University of Florida provided an excellent perspective on the values attributed to wetlands and proved to be a most useful reference. Roy Ingram, Professor of Geology at the University of North Carolina, Chapel Hill, provided work space, access to his personal collection of peat reference works and the benefit of his research experience through numerous informal conversations concerning various aspects of peat.

## PURPOSE AND SCOPE OF THE STUDY

This study was undertaken in response to a directive from the Florida Legislature originating in the Natural Resources Committee of the Florida House of Representatives. Florida is currently faced with immediate expanding industrial interest in the exploitation of its peat resources for fuel use. The study is primarily a compilation of literature pertinent to peats of Florida and their use for agriculture and energy applications. It is conceived as providing an information base for decisions concerning both the utilization and conservation of Florida's extensive peat resource.

## HISTORICAL PERSPECTIVE OF PEAT RESEARCH IN FLORIDA

Interest in Florida's peat deposits has fluctuated since the Florida Geological Survey published a "Preliminary Report on the Peat Deposits of Florida" in its Third Annual Report (Harper, 1910). This early work was basically a reconnaissance study of peat resources in the state. The author acknowledged that as population density in the state increased a detailed report would be required. In light of current environmental awareness, it is especially interesting that Harper (1910) recommended studies by both an engineer and an ecologist.

The historical perspective of peat use in Florida is not

complete without mention of the work of Robert Ransom, a civil engineer, who came to Florida from Ipswich, England in 1884. Ransom viewed Florida's peat deposits as a readily exploitable resource and was especially interested in energy production from peat. For thirty-five years Ransom experimented with peat, eventually even opening a test plant near Canal Point (Palm Beach County) which produced power gas, tars, oils, methyl alcohol and various by-products. He was not able to gain acceptance for his radical projects within his lifetime (Davis, 1946).

In 1946, John H. Davis published The Peat Deposits of Florida, Their Occurrence, Development and Uses. This study categorized peat-forming environments in the state and treated individual deposits in detail. It extended Harper's work and included chemical characterization of various Florida peats. Chemical characteristics were related to the use of peat for agricultural purposes and also to its use as a fuel source.

A number of studies treating the peats of south Florida have been prepared by W. Spackman in conjunction with co-workers. Spackman and others (1964) presented a summary of various coal forming environments associated with the Everglades. This work includes a large number of geologic cross sections which document the relationship of peats to bedrock and surrounding materials. The plant communities currently associated with peats in the various coal forming environments are also carefully documented. Cohen and Spackman (1977, 1980) present detailed descriptions of peats from southern Florida along with discussions of their ori-

gin, classifications and consideration of the alteration of plant material. Spackman and others (1976) present an updated and augmented edition of the original guidebook. The format of these works (Spackman, et. al., 1964 and Spackman, et. al., 1976) makes them particularly useful to scientists in various disciplines whose interests converge on the various wetland environments of south Florida.

In 1979, the U. S. Department of Energy began its "Peat Development Program." The assessment of fuel grade peat deposits was part of an effort to define energy resources in the United States exclusive of petroleum. The Florida Governor's Energy Office subcontracted with the University of Florida's Institute of Food and Agricultural Sciences to survey the peat resources of Florida. This study resulted in a literature survey of peat deposits of Florida combined with detailed work in the Everglades Agricultural Area (Griffin, et al., 1982).

The current study was undertaken in response to a directive from the Florida Legislature originating in the Natural Resources Committee of the Florida House of Representatives. It provides a compilation of information concerning the location and amount of Florida's peat resources. In addition, the various aspects of the Everglades Agricultural Area are described in some detail and implications of subsidence of peats in this region are considered. Emphasis is also placed on existing information relative to potential effects of peat mining on Florida's environment. Legislation which may be applied to peat mining, water quality parameters monitored in conjunction with various

phases of peat mining and methods of regulation applied to the peat resource by Minnesota, New Brunswick and North Carolina are included as appendices to this report.

#### DEFINITION OF PEAT AND THE SIGNIFICANCE OF THIS DEFINITION

Peat is defined by workers in a variety of disciplines (geology, botany, soil science, and horticulture among others). These definitions proliferate in response to the specific interest of researchers and also in response to the multiple uses of peat. The American Geological Institute defines peat as, "An unconsolidated deposit of semicarbonized plant remains of a watersaturated environment, such as a bog or fen and of persistently high moisture content (at least 75 percent). It is considered an early stage or rank in the development of coal..." (Gary, et al., eds., 1974). This extremely general definition notes several essential points. Peat is composed of plant remains which accumulate in a wet environment. It is considered to be an early product of the coal-forming process.

In a definition which will be published in an upcoming volume (A. Cohen, personal communication, 1984), the American Society for Testing and Materials (ASTM) defines peat as a naturally occurring substance derived primarily from plant materials. Peat is distinguished from other organic soil materials by its lower ash content (less than 25 percent ash by dry weight [ASTM Standards D2974]) and from other phytogetic

material of higher rank (i.e. lignite coal) by its lower BTU value on a water saturated basis. This very specific definition is designed so that peats may be classified objectively and distinguished from both organic soils and also coals.

Griffin and others (1982) note the definition of fuel grade peat which is used by the United States Department of Energy. Fuel grade peat is defined as an organic soil consisting of greater than 75 percent organic matter in the dry state. In order for a peat deposit to be classified as fuel grade, the deposit must be at least 4 feet thick, with a surface area of not less than 80 contiguous acres per square mile and yield not less than 8000 BTU per pound (moisture free). The definition for fuel grade peat establishes minimum standards for organic matter content and also for heating value (BTU per pound). It further comments on the deposits itself, stipulating minimum thickness and contiguous acreage requirements.

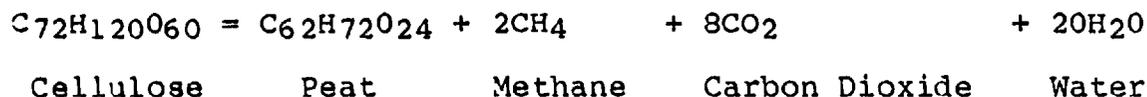
The three definitions of peat presented here respond to the specific purposes of individuals and agencies who prepared them. Varied user groups and professionals who work with peat may formulate additional definitions directly suited to their needs. It is thus necessary to determine the way in which an author defines peat in order to fully understand the implications of his work.

In the state of Florida, the definition of peat may take on special significance if it is used as criteria for classification of peat as either a mineral resource or an agricultural (vegetable) resource. It has been argued that if peat is not

classified as a mineral then its excavation might constitute a harvesting process. Harvesting may not be subject to the regulatory procedures that govern mining of a legally-defined mineral material.

The usage of the term harvesting to describe the mining of peat follows Kopstein (1979). "Harvesting" when used in conjunction with peat correctly refers to the nearly obsolete practice of harvesting living Sphagnum (peat moss) from the surface of a bog. In this process, the Sphagnum was allowed to grow back so that repeated harvests were possible in a given area. Thus, a crop was in actuality "harvested." Very little or no true harvesting occurs today (A. Cohen, personal communication, 1984).

In the carbonization process, the carbon content of the plants' cellulose is proportionally increased as water, carbon dioxide and methane are evolved. Carbonization can be generally described by the following equation:



The expressions for cellulose and peat were taken from U.S. Geological Survey Bulletin 728 (Soper and Osbon, 1922).

Two major considerations arise from the definition of peat. One of these considerations involves the classification of peat as a vegetable or mineral and the second consideration follows from the first. If peat is viewed as being a vegetable material,

then its excavation might be termed a harvesting process. Harvesting practices would not be subject to the regulatory procedures that govern mining of a legally-defined mineral material.

#### TERMINOLOGY RELATING TO THE PEAT FORMING ENVIRONMENT

Peat can only accumulate in a waterlogged environment. The terms which refer to these environments take on different definitions according to author preference. The American Geological Institute distinguishes between bogs and fens on the basis of chemistry. Bogs and fens are both characterized as waterlogged, spongy groundmasses. Bogs, however, contain acidic, decaying vegetation consisting mainly of mosses while fens contain alkaline, decaying vegetation, mainly reeds (Gary, et al., eds., 1974). The terms "bog" and "fen" are not usually applied to peatlands in the southeastern United States. They are included in this discussion because they occur frequently in the literature associated with peatlands extraneous to Florida. Although a significant body of research specific to the peats of Florida exists (Cohen and Sparkman, 1980; Cohen and Spackman, 1977; Griffin et al., 1982 Spackman et al., 1976), much information concerning mining techniques, reclamation methods and hydrologic aspects of peatlands pertains directly to areas remote to Florida where the terms "bog" and "fen" may be used.

The concepts of minerotrophy and ombrotrophy are based on the quality of water feeding a peatland (Heikurainen, 1976) and

are perceived as separate from the series eutrophy, mesotrophy and oligotrophy. The latter series describes nutrient resources of peatlands using plant composition with eutrophy being richer in nutrients and oligotrophy being poorer. The eutrophy - oligotrophy series is difficult to apply since it may be expanded to include additional extreme and transitional groups. The boundaries between these various groups are not clear (Heikurainen, 1976) and they will not be considered further in this document.

Bogs are said to be ombrotrophic, which implies that the bog is isolated from the regional groundwater system and receives its moisture mainly from precipitation. Minerotrophic peatlands, or fens, are defined as being connected with the regional groundwater system and are nourished both by precipitation and groundwater flow (Brooks and Predmore, 1978).

The U.S. Department of Energy in its Peat Prospectus avoids the usage of fen and characterizes peat as forming in swamps, bogs and saltwater and freshwater marshes (Kopstein, 1979). The extent of this confusion becomes clear on examination of the American Geological Institute's definition of swamp (Gary, et al., eds., 1974) which is characterized as "A water saturated area..., essentially without peatlike accumulation." It should be noted that most workers in the field do not concur with the portion of the American Geological Institute's definition that addresses the accumulation of peat in swamps (A. Cohen, personal communication, 1984). Moore and Bellamy (1974, p. 84) use the term "mire" to cover all wetland ecosystems in which peat

accumulates in the same area where its parent plant material lived and grew. Thus, the meaning of specific names assigned to the peat-forming environment must be derived from an author's context.

In the southeastern United States, the most commonly used terms for peat-forming environments are swamps and marshes. Swamps refer to forested wetlands and marshes refer to aquatic, herbaceous wetlands (A. Cohen, personal communication, 1984).

#### PEAT: AGRICULTURAL OR MINERAL RESOURCE?

In Florida, peat may eventually be viewed as a mineral resource or an agricultural resource. The United States Bureau of Mines has long considered peat a mineral resource for the reporting of commodity statistics. In deference to the formal definition of the term "mineral," the greatest majority of earth science professionals would not classify peat as a mineral. Peat more properly might be likened to a rock in that it contains a number of minerals (quartz, pyrite, and clay minerals among others) as well as macerals which are the organic equivalents of minerals.

If, however, the formal and most restricted definition of mineral is compared with a definition of mineral that reflects current usage, it is noted that "minerals" adhere to the specifications of the formal definition in varying degrees. The intent of this discussion is not to establish that peat is a mineral,

but rather to illustrate the extent to which the formal definition has been expanded in the realm of common usage.

A standard mineralogy textbook for university students, Elements of Mineralogy (Mason and Berry, 1968), gives the following definition of a mineral: "A mineral is a naturally occurring, homogeneous solid, inorganically formed, with a definite chemical composition and an ordered atomic arrangement." This definition is useful because its authors continue by expanding on each part of their definition, taking into account the complexity of the group of compounds classified as minerals.

According to this definition, a mineral must be naturally occurring. This eliminates materials which are synthesized in the laboratory or are formed as by-products of various manufacturing processes. Since peat is indisputably naturally occurring, this aspect of the definition will not be considered further.

A mineral must also be a homogeneous solid. This qualification eliminates liquids and gases from consideration and implies that a mineral cannot be separated into simpler compounds by any physical means (Mason and Berry, 1968). In the coalification process by which plant material (i.e., cellulose) becomes peat, water, carbon dioxide and methane are evolved with time (Kopstein, 1979). Kopstein (1979) is referring to a generalization of the peat-forming process in which all initial plant material is referred to as cellulose. In actuality, peat contains many types of plant material and may possibly contain no

cellulose at all. It is important here to note that many mineral substances evolve water or gaseous by-products when subjected to changed conditions of pressure or temperature. Gypsum dehydrates (evolves water) forming anhydrite. The mineral talc evolves water and forms enstatite and quartz at elevated temperatures. Thus, minerals commonly contain water as an integral part of their crystal structures.

The term mineral is restricted by definition (Mason and Berry, 1968) to refer to inorganically formed substances. It eliminates homogeneous solids formed by plants and animals such as oyster shells, pearls and gallstones. Ostensibly, this qualification could eliminate peat from consideration.

The American Geological Institute in its Glossary of Geology (Gary, et al., eds., 1974) includes the following reference in its definition of the term mineral: "A mineral is generally considered to be inorganic, though organic compounds are classified by some as minerals." Thus, organic compounds are not automatically eliminated from consideration as minerals. This suggests that the term mineral has come to be used in a sense that is less restricted than might be supposed from examination of the definition presented to beginning students of mineralogy.

Minerals are defined as having definite chemical composition (Mason and Berry, 1968). This implies that their composition must be readily expressible using a chemical formula. It does not preclude variation in chemical composition. Variation within definite limits is allowed, thus, the composition is definite but

not fixed (Mason and Berry, 1968). The compositions of cellulose and the peat derived from it are frequently cited using the appropriate chemical formulae (Soper and Osbon, 1922, pp. 6-7; Kopstein, 1979, pp. 5-6; Cameron, 1973, p. 506). (As noted previously, the formulae cited here are based on a generalization of the peat-forming process in which peat is derived from a starting material of cellulose. For most peats, this simplified approximation is not realistic.)

The last criterion in the definition of a mineral is that of an ordered atomic arrangement; that is, a mineral should be a crystalline solid. Mason and Berry (1968) note a group of compounds which are considered minerals even though the crystalline state is not initially attained: "A few minerals, the commonest being opal, are formed by the solidification of a colloidal gel and are noncrystalline initially; many such minerals become crystalline during geologic time." The mineral opal may attain an ordered atomic arrangement only in the course of geologic time.

The coal-forming process is illustrated in figure 1. As organic matter (originally deposited as peat) is subjected to conditions of increasing temperature and pressure it undergoes the changes associated with coalification. The end-product of this process is the mineral graphite (Press and Siever, 1974, p. 468). Graphite crystallizes in the hexagonal system and its formula is simply carbon (C). It is found in a number of occurrences including metamorphosed coal beds (Quinn and Glass,

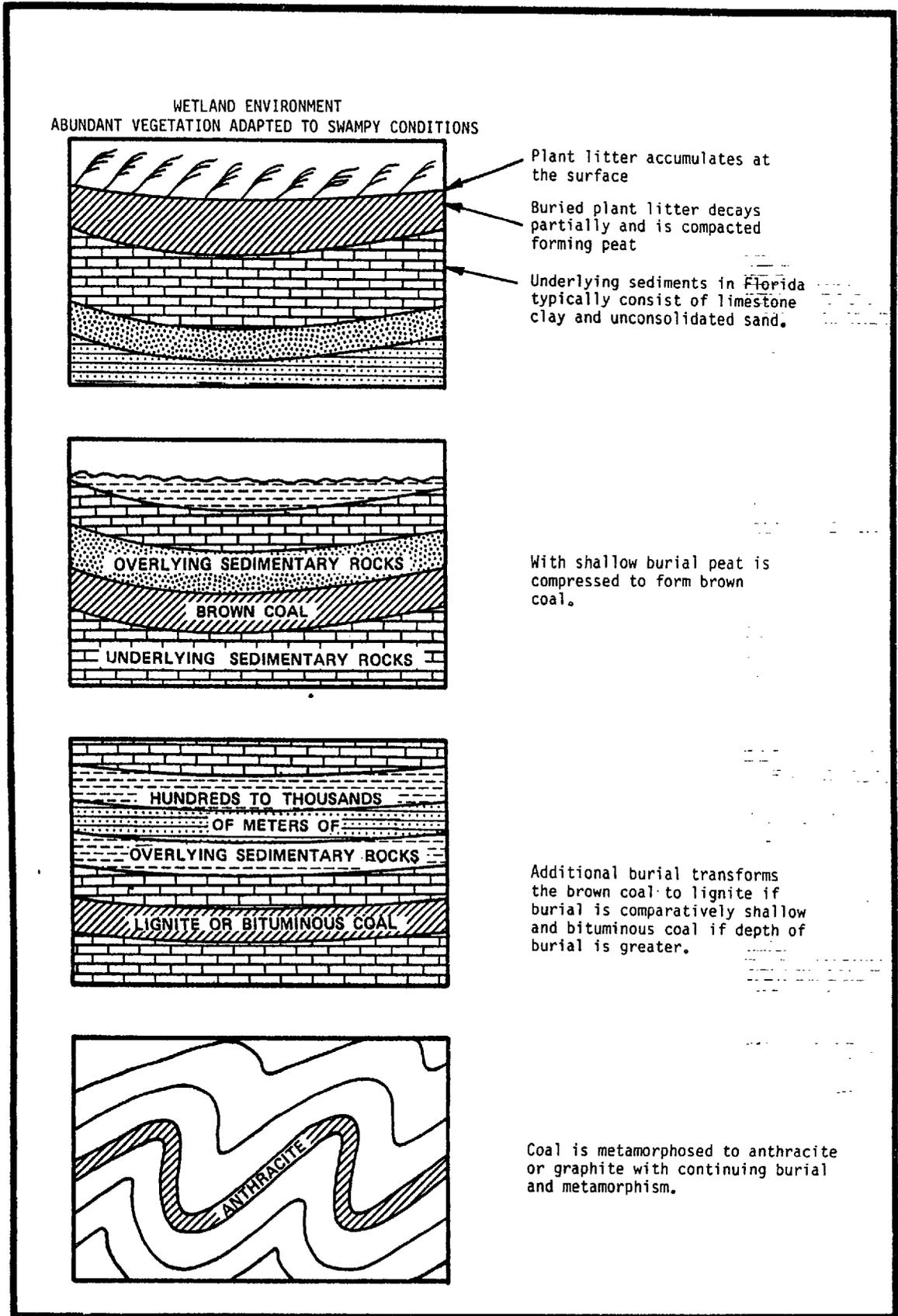


Figure 1. The process of coal formation. (Modified from Press and Siever, 1974, Figure 13-18, p. 468)

1958). The parallels with the case of opal seem apparent. Neither opal nor peat initially attain the internal atomic ordering referred to in Mason and Berry's definition of a mineral. Opal will presumably achieve internal atomic ordering in the course of geologic time (Mason and Barry, 1968). The transformation of peat into the mineral graphite requires, in addition to the passage of time, increases in temperature and pressure (Press and Siever, 1974).

Geologists do not universally include crystalline form as a prerequisite to classification of a material as a mineral. This is demonstrated in the continuation of the AGI Glossary's definition of mineral. "Those who include the requirement of crystalline form in the definition of a mineral would consider an amorphous compound such as opal to be a 'mineraloid'" (Gary, et al., eds., 1974).

The United States Geological Survey in its volume entitled United States Mineral Resources (Brobst and Pratt, eds., 1973), devotes a chapter to peat as well as chapters to petroleum, natural gas and coal. The United States Bureau of Mines also considers peat to be a mineral resource in addition to coals, petroleum and natural gas. These resources including peat are all non-renewable.

#### HARVESTING OR MINING

Harvesting and mining are both terms which are applied to the extraction of peat. As was discussed in the section of this

report "The Definition of Peat and Significance of this Definition" the term "harvesting" properly refers to the practically obsolete procedure of literally harvesting living Sphagnum from the surface of a bog. In this procedure, Sphagnum is allowed to continue its growth subsequent to harvesting (A. Cohen, personal communication, 1984).

Currently, the choice of "harvesting" as opposed to "mining" for terms to describe the excavation process of peat is arbitrary. The nature of the distinction is demonstrated in the following quotation taken from Peat Prospectus: "Thus, the recovery of peat is a surface mining or harvesting process," (Kopstein, 1979, p. 18). It may be significant that surface mining carries with it certain negative environmental connotations. Harvesting is largely free of environmentally negative connotations but this is perceived to be due to a lack of understanding since harvesting is frequently used as synonymous with surface mining.

The equipment utilized in the peat removal process is not associated with harvesting in its commonly accepted sense. Peat operations which are currently active in Florida utilize earth moving and excavating machinery. In drained bogs such machinery commonly includes shovels, bulldozers and front-end loaders while draglines, clamshells and dredges are used in undrained bogs (Searls, 1980).

Harvesting originally referred to removal of living Sphagnum which was allowed to replenish itself after harvesting. Peat is

not considered renewable due to its slow rate of accumulation (Kopstein, 1979; Moore and Bellamy, 1974).

The process of harvesting in its usual sense does not imply the necessity of extensive land reclamation. However, reclamation of peatlands which have been excavated is acknowledged as necessary. (Minnesota Department of Natural Resources, 1981) and is discussed more thoroughly in the section of this report entitled "Reclamation of Peatlands of Florida."

#### CLASSIFICATION SYSTEMS APPLIED TO PEAT

Peat, like many materials, is classified for the convenience of persons using it. Since peat use in the United States has been largely agricultural, most classification schemes are based on properties of peat pertinent to agricultural applications. As one might expect, classification schemes devised for agricultural application do not necessarily indicate peat quality for energy purposes. However, there is a general relationship between peat decomposition and its energy value with respect to direct combustion. This is illustrated in figure 2.

The American Society of Testing and Materials (ASTM) has established maximum and minimum particle sizes for peat (ASTM, 1969). They additionally specify fiber content requirements for various types of peat. The maximum particle size for fibers is 0.5 inch (1.25 cm) and the minimum is 0.006 inches (0.15 mm). Peat is subdivided into five types and each type must contain a

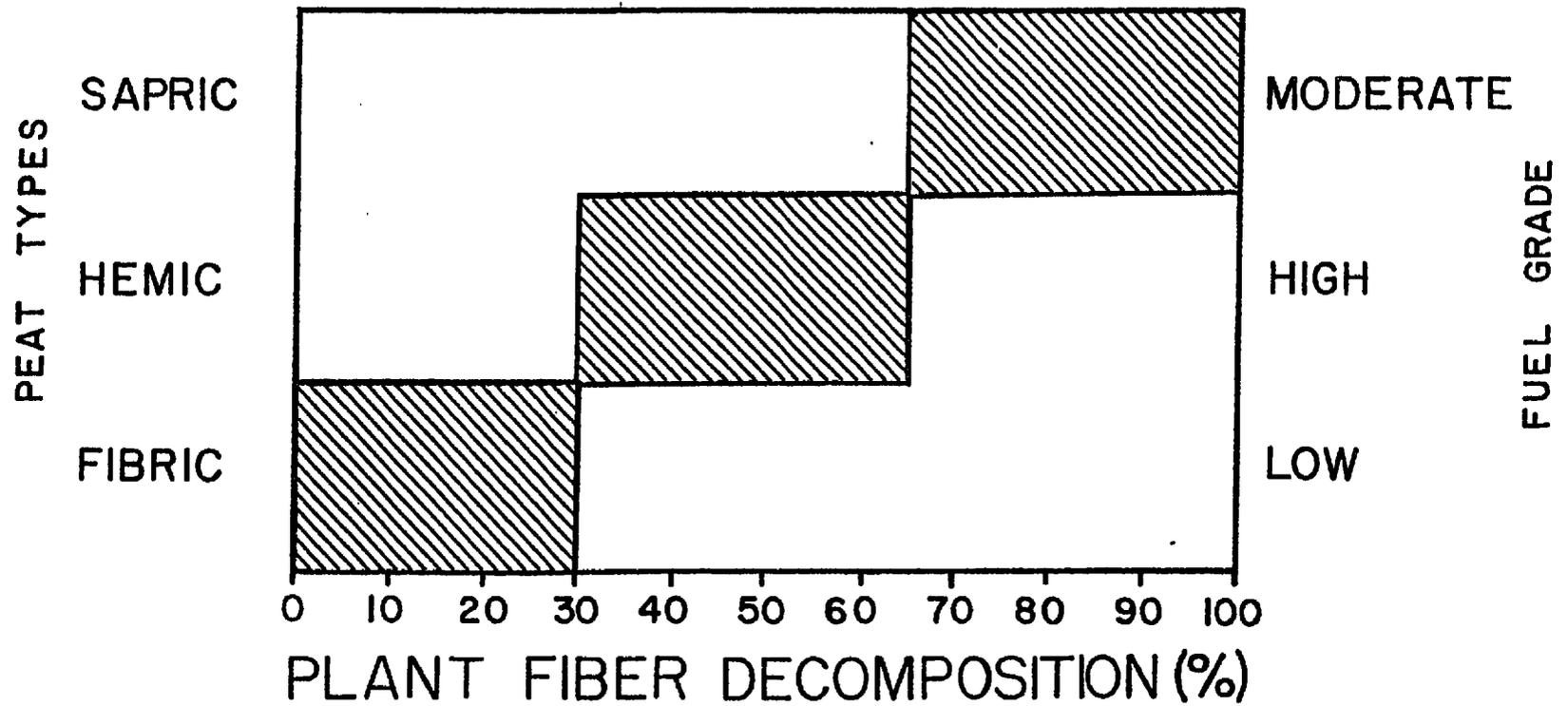


Figure 2. The relationship of peat types to fuel grade. (Modified from Kopstein, 1979)

certain percentage of the characteristic fiber. These percentages are based on an oven-dried weight at 105 °C as opposed to volume. The types of peat recognized by the ASTM include: 1) Sphagnum moss peat which must contain 66.66 percent Sphagnum fibers by weight, 2) Hypnum moss peat which must contain 33.33 percent fibers with one-half of those identifiable as Hypnum moss, 3) reed-sedge peat which must contain 33.33 percent fibers, half of which are reed-sedge and other nonmosses, 4) peat-humus must contain less than 33.33 percent fiber, and 5) other peat, which accounts for all peat not previously classified in ASTM Designation D-2607-69 (ASTM, 1969).

The ASTM classification as discussed in the previous paragraph is currently under revision. Two major factors were considered in this revision. The classification of peat should meet the needs of three major user groups including engineers, energy users and agricultural users. In addition, the classification should be based on parameters which may be measured objectively. These parameters include ash, botanical composition, pH, and water holding capacity. In order to be called peat, a material will have to contain 75 percent or more organic material. Although peats will still be categorized as fibric, hemic or sapric, these general terms will be modified by ash content, botanical composition, pH and water holding capacity (A. Cohen, personal communication, 1983).

One essential parameter that is characteristic of all peat is moisture level, but there are no current regulated standards

for moisture in peat. The United States Bureau of Mines considers a commonly accepted value in the United States to be 55 percent moisture by weight for air dried peat (Searls, 1980).

The U.S. Department of Agriculture divides peat into three categories (Searls, 1980). Fibric peat must contain more than 66.66 percent plant fibers. Hemic peats are more decomposed than fibric peats. They must have a fiber content which ranges between 33.33 percent and 66.66 percent fibers. Sapric peat consists of the most extensively decomposed plant material. Sapric peat contains less than 33.33 percent recognizable plant fragments of any type.

Peat in the United States has often been classified into three general categories (Searls, 1980; Kopstein, 1979). Moss peat comprises Sphagnum, Hypnum and other mosses. Reed-sedge peat is mainly the product of reeds, sedges and other swamp plants. Humus is simply too decomposed for evidence of its origin to be retained.

The parameters which bear most directly on peat's usefulness as a fuel source are measured by proximate analysis. In this procedure, peat is analyzed in the laboratory for its volatile content, fixed carbon, ash content and moisture. The volatile content of peat refers to substances other than moisture which are emitted as gas and vapor when peat is burned. Peat has a very high volatile content compared to coal. This is a positive attribute for peat which is to be gasified since the reactivity of peat in the gasification process increases with increased

volatile content. The fixed carbon content of the peat is responsible for much of its combustion energy.

Ash is the amount of material in a fuel which remains after combustion. The amount of ash varies for different types of peat. Peats which receive their moisture primarily from precipitation are usually lower in ash than those which are nourished by surface waters. In times of flood, surface waters may carry large sediment loads onto the peatlands where it is trapped in the peat.

Peat's high moisture content can be a major problem which must be considered in its utilization. Even a drained and solidified bog may contain 70-95 percent moisture and for some uses peat will require additional drying which will, in turn, require energy.

## THE ACCUMULATION OF PEAT

### THE PROCESS OF PEAT FORMATION

Peat forms when the rate of accumulation of plant matter exceeds the rate at which decomposing organisms metabolize it. The conversion of fresh plant material to peat takes place over a period of time as peat becomes enriched in fixed carbon while evolving water, carbon dioxide and methane (Kopstein, 1979). Peat is comparatively increased in fixed carbon as opposed to cellulose and the process by which this takes place is referred to as carbonization. It is this enrichment of carbon which makes

peat desirable as a fuel source (figure 3). The Peat Prospectus (Kopstein, 1979) compares peat with wood and various grades of coal in terms of fixed carbon and the heating value (in British Thermal Units, BTU). The following values are taken from figure 3 of the Peat Prospectus and are approximate (Kopstein, 1979). One pound of wood with a fixed carbon content of approximately 20 percent, generates 9,300 BTU on a moisture and mineral free basis. An equivalent amount of peat containing 28 percent fixed carbon may generate approximately 10,600 BTU. These values for peat and wood contrast with values for lignite which yields about 12,400 BTU at a fixed carbon content of approximately 47 percent. These figures demonstrate that peat is a material distinguishable from wood in its fuel-producing characteristics.

#### GEOLOGIC CONDITIONS ASSOCIATED WITH PEAT ACCUMULATION

As was previously noted, peat forms when the accumulation of plant material exceeds its destruction by the organisms which decompose it. Since plant matter is usually decomposed before significant accumulations develop, it is instructive to examine the set of circumstances which allow peat to form. Certain geologic, hydrologic and climatic conditions serve to inhibit decomposition by organisms. Ideally, areas should be continually waterlogged, temperatures generally low and pH values of associated waters should be low (Moore & Bellamy, 1974). It should be noted that Moore and Bellamy (1974) primarily treat peats asso-

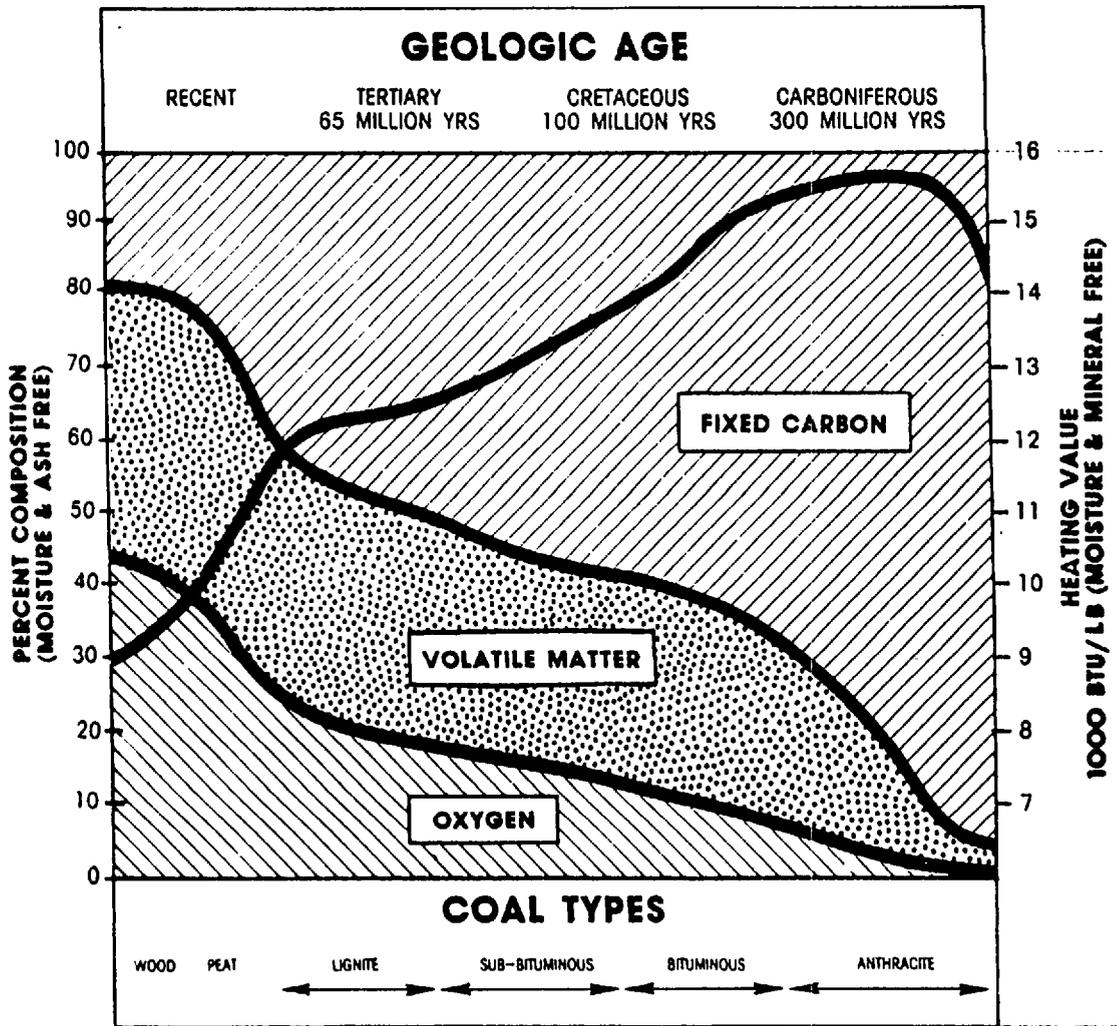


Figure 3. A comparison of moisture content and heating value for peat, wood and various coal types. (Modified from Kopstein, 1979)

ciated with northern cold climates.

Certain geologic characteristics are associated with waterlogged surface conditions. The tendency toward waterlogging is enhanced if topographic relief is generally low and topographic barriers exist which restrict flow and allow water to pond. Additionally, waterlogging is encouraged if highly permeable bedrock is covered with material of low permeability (Olson, et al., 1979).

The chemical nature of the plant litter may also serve to reduce its susceptibility to decomposition. Moore and Bellamy (1974) note the association of cypress and hardwood trees with peats characteristic of the hammocks or tree islands of the Everglades. These hammocks occur on peat deposits which are situated on limestone bedrock. The trees, which are responsible for the peat beneath them, contain enormous amounts of lignin. Lignin is very resistant to decay (Moore and Bellamy, 1974). It is alternatively suggested that hammock peats in Florida may be controlled by the persistence of water (A. Cohen, personal communication, 1984).

## MINING TECHNOLOGY

### MINING METHODOLOGY ASSOCIATED WITH THE USE OF PEAT FOR FUEL

Recently, several potential commercial users have been investigating Florida's peat as a fuel source. This interest is

prompted by the rising cost of traditional fuels. Preliminary proposals for the use of peat as a fuel in Florida suggest that peat will be air dried and burned directly. This usage will require comparatively large amounts of peat which must be dried before it is burned (this drying is in addition to the moisture reduction which accompanies bog drainage) (Kopstein, 1979). The drainage of a peatland is an integral and necessary first step in any large-scale peat mining operation utilizing milled peat or sod peat mining methods. Moisture must be reduced to approximately 90 percent for the bog to be considered workable (i.e., able to bear the weight of machinery).

Drainage is accomplished by construction of a system of ditches and waterways which are designed to capture water and route it away from the portion of the bog to be mined (Kopstein, 1979). If surface streams traverse the bog, they are diverted around it. Eventually, surface vegetation and stumps must be removed.

There are several mining methods in common use in Europe. The manual method is one in which peat is cut into blocks by hand, removed from the bog for air drying and finally burned for home heating and cooking (Kopstein, 1979). Manual peat harvesting is labor intensive and probably will not become important in Florida.

The sod peat mining method is one in which a trench is cut into a previously prepared field. These trenches are cut by excavator/macerators which are specifically designed to cut,

macerate, and extrude sods onto a conveyor which deposits them onto the field for air drying. At a moisture content of about 75 percent the sods are windrowed. Windrows are periodically split and turned to facilitate drying and at about 55 percent moisture sods are considered dry and removed for storage (Aspinall, 1980).

The milled peat mining method is one in which a peat layer 1/4 to 2 inches thick is milled or shredded from the prepared surface of the bog. The peat is periodically harrowed to expedite drying. At a moisture content of 50 to 55 percent, the dried peat is pushed into ridges where it is collected for transportation to storage facilities (Aspinall, 1980).

Several methods of hydraulic peat mining are in development. Examples of these processes are the slurry ditch, hydro peat and slurry pond methods (Aspinall, 1980). In each of these methods, the surface must be cleared; but drainage is not necessary.

The slurry ditch and hydro peat methods utilize high pressure water guns to cut peat from a ditch face. The difference between the methods lies in the post-mining dewatering process. The slurry ditch method utilizes a dewatering apparatus; whereas, the hydro peat method is dewatered by pumping the slurry to a drying field where it spread to dry (Minnesota DNR, 1981). The slurry pond method utilizes mechanical excavators or a dredge to remove peat. Mining equipment is mounted on a barge which floats on a pond excavated within the peat deposits as the mining progresses.

The ultimate success of wet mining methods will depend on the successful development of very large scale dewatering processes and upon the environmental impacts of the mining process (Kopstein, 1979). These may be the preferred methods, however, in areas where drainage of the peat deposit will be difficult.

#### MINING METHODOLOGY ASSOCIATED WITH THE AGRICULTURAL USE OF PEAT

In order to obtain current information on Florida's active peat operations for the present study, the staff of the Bureau of Geology designed and conducted a survey of producers. In the first stage of this survey, a list of peat producers was compiled. In an effort to make this list as comprehensive as possible, a number of sources were consulted including: existing lists of producers (Florida Bureau of Geology, United States Bureau of Mines, United States Mines Safety and Health Administration); agencies contacting peat producers in conjunction with regular professional services (county agricultural agents, Florida Department of Agriculture); and numerous telephone directories. In the second stage of the survey, peat producers were contacted by telephone and field visits were arranged. The information which follows was contributed on a voluntary basis by producers who were contacted during field visits.

Peat extraction methods vary with the size and nature of the

deposit being mined. Most deposits are mined using conventional types of earth-moving and excavating equipment. The machinery used includes draglines, backhoes, grade-alls, front-end loaders and hydraulic excavators. The majority of companies use a dragline for mining. A shredder is used to pulverize the peat.

Most companies drain the immediate area of mining by pumping and ditching, which enables the deposit to be mined by dry processes. Approximately one-third of the companies contacted conduct all or part of their mining below the watertable.

Two companies utilize a variety of the milled peat mining process. After surface clearing and ditching is complete, the surface peat is pulverized with a rotovator. The pulverized material is dried in the sun and is turned by discing to help promote drying. The dried material is mechanically windrowed using a front-end loader or bulldozer and is then stockpiled or loaded for transport. There are no companies currently mining peat by the sod peat method in Florida.

## ACCUMULATIONS OF PEAT IN FLORIDA

### RATES OF PEAT ACCUMULATION

Knowledge of the rate of peat accumulation is important in that it allows various extractive uses for the resource to be weighed in light of the amount of time it takes for the material to accumulate. Rates of peat accumulation are usually deter-

mined using the carbon-14 method of dating organic materials. This method is subject to a number of difficulties when applied to peat. The following problems are enumerated by Moore and Bellamy (1974). 1) Wide errors may be introduced since young roots may penetrate material at depth. This problem could result in apparently rapid rates for the accumulation of peat. 2) Older layers are compacted as new ones are deposited. This could cause rates of deposition to appear anomalously low. 3) Rates of peat formation vary with climate and climate varies with time. Thus, an accumulation rate probably reflects a sort of average rate for some given amount of peat. Several estimates of peat accumulation rates in Florida are presented in Table 1.

TABLE 1. ESTIMATED RATES OF PEAT ACCUMULATION IN FLORIDA

<u>Author</u>	<u>Estimated Rate</u>	<u>Comments</u>
Davis (1946, p. 74)	5.2in/100 years	This rate is computed based on the amount of SiO <sub>2</sub> fixed by a standing crop of sawgrass from the Everglades. It is widely quoted, but a recent analysis of the method (Gleason, et al., 1974) indicates that certain of the assumptions necessary to the calculation must be in error. This difficulty is discussed more completely in the accompanying text.
Kuehn (1980, p. 49)	4.24in/100 years	This rate was computed from a core which penetrated peat formed alternately in marine, brackish and fresh water environments from southwest Florida. The computations were based on radiocarbon ages.
Kuehn (1980, p. 49)	3.64in/100 years	This rate was computed for a single type of peat, red mangrove ( <u>Rhizophora</u> ),

from southwest Florida using measured thickness and radiometric ages.

Stephens (1974, 3 in/100 years p. 356)

Rates were computed from the Everglades using radiocarbon ages which were not specifically referenced in the text.

The variation in rate presented here for peat accumulation may be attributed to a number of factors. Gleason and others (1974) used Davis' (1946) data to compute a value of productivity for the sawgrass environment. Productivity refers to the amount of dry organic matter (measured in pounds) which is formed on an acre of ground in a year. When this productivity is compared to the dry weight of an acre-foot of peat as estimated by Davis (1946), a discrepancy is apparent. According to these computations, more material accumulates as peat than is originally formed in the sawgrass environment (Gleason, et al., 1974). Factors which may account for this difficulty include possible low estimates of productivity and inadequate estimates of silica content or peat density. It is also possible that silica in the peat might not be entirely derived from sawgrass (Gleason, et al., 1974). Rates of peat accumulation computed from radiocarbon age are grouped about an average of 9.1 cm/100 years. The rate of peat accumulation can vary with climate (which also varies with time), the position of the water table and nutrient supply (Moore and Bellamy, 1974). Data are not available which would allow rate variation in different environments to be evaluated. The rates presented here were calculated from peats produced from varying plant communities which thrive in different environments.

In addition, peat has been lost by fire during various prehistoric dry periods (Cohen, 1974). Failure to recognize evidence of fire could alter the rate at which peat is calculated to accumulate.

#### GEOLOGIC SETTINGS OF PEAT ACCUMULATION IN FLORIDA

The conditions under which peat can occur in Florida are highly variable. While geologic and hydrologic relations of peat to its neighboring materials have been thoroughly documented in the Everglades of south Florida, numerous small deposits in the central peninsula remain unmapped. Davis (1946, p. 114), considered the peat deposits of Florida as falling into a number of groups based on their locations. These groups include: 1) coastal associations, including marshes and mangrove swamps, lagoons and estuaries as well as depressions among dunes; 2) large, nearly flat, poorly-drained areas as exemplified by the Everglades illustrated in figures 4, 5, 6, and 7; 3) river-valley marshes such as the marsh adjacent to the St. Johns River; 4) swamps of the flatland region (figure 8); 5) marshes bordering lakes and ponds (figure 9); 6) seasonally flooded shallow depressions; 7) lake bottom deposits (figure 10); 8) peat layers buried beneath other strata (figure 11).

Cohen and Spackman (1977) have devised a more comprehensive classification of south Florida's phytogenic (of plant origin) sediments based on micropetrological studies. They first divide

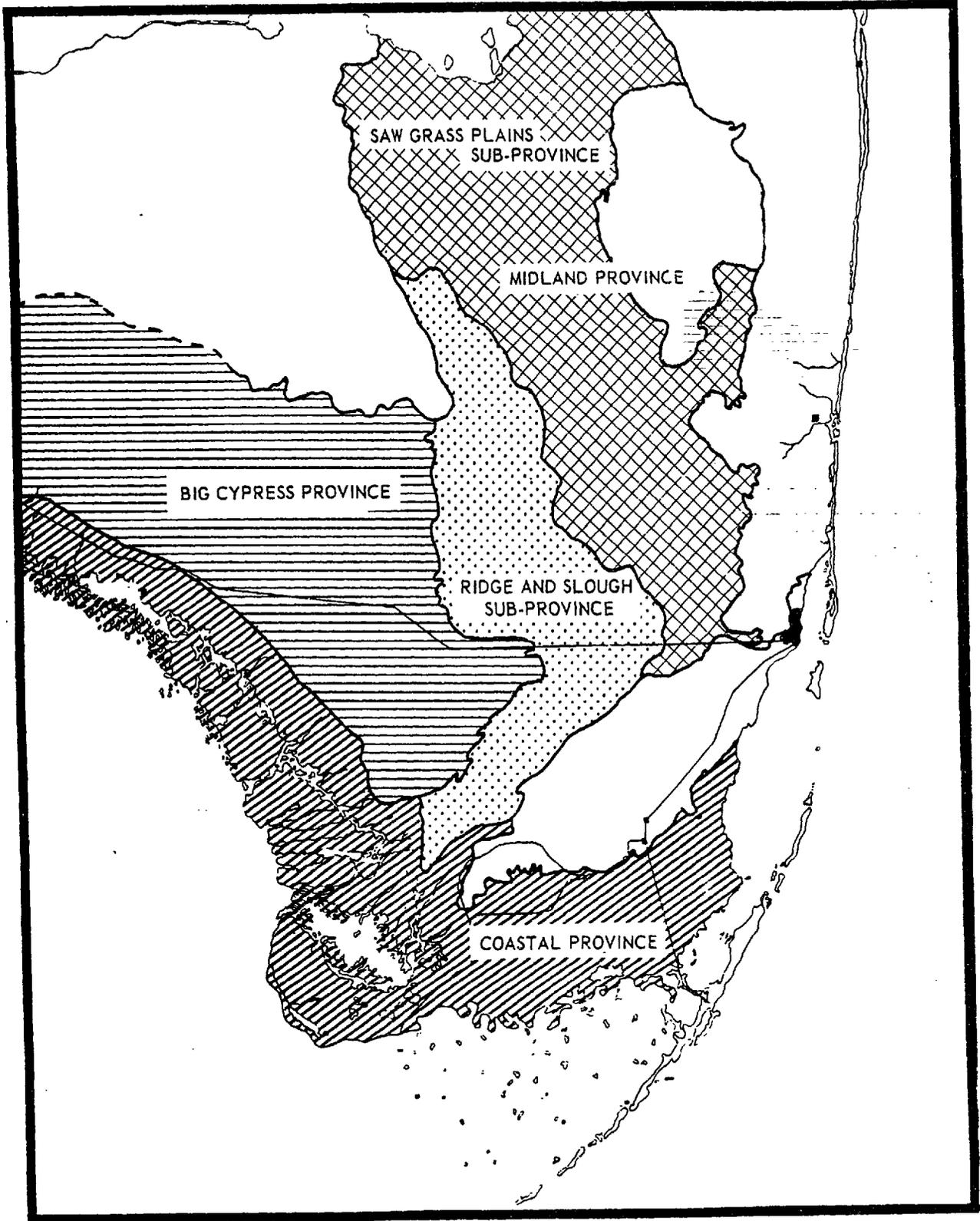


Figure 4. Peat Provinces of Southern Florida. (Modified from Spackman et al., 1976)

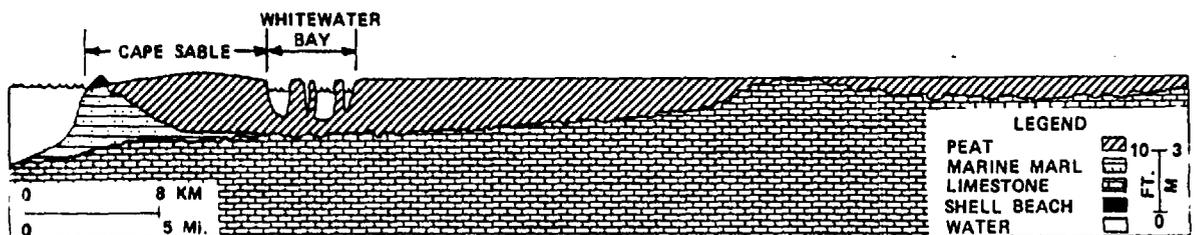
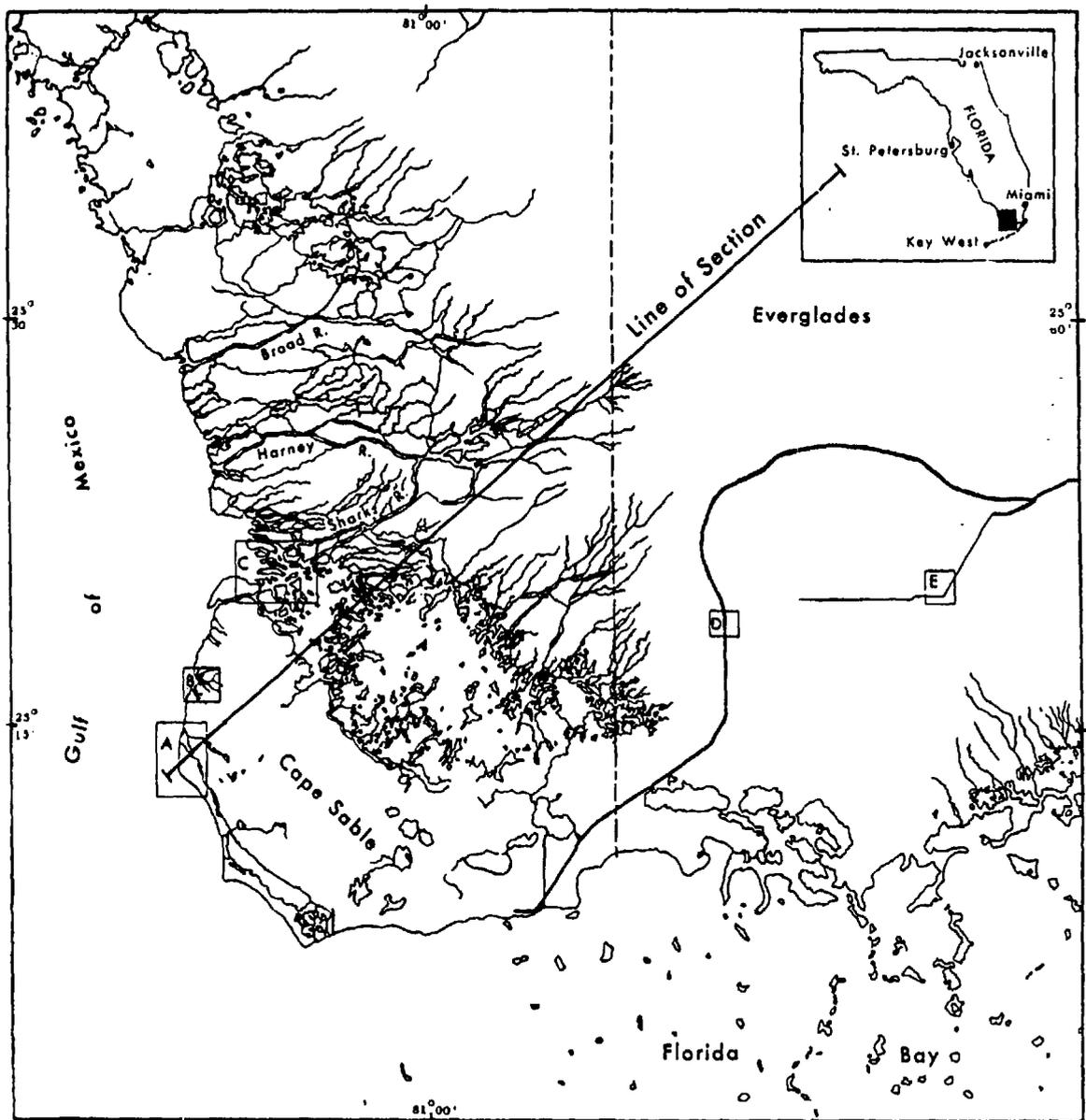


Figure 5. SW-NE cross-section from Cape Sable to vicinity of Tamiami Trail and map showing line of section. (Modified from Spackman, et al., 1964 and Spackman, et al., 1976)

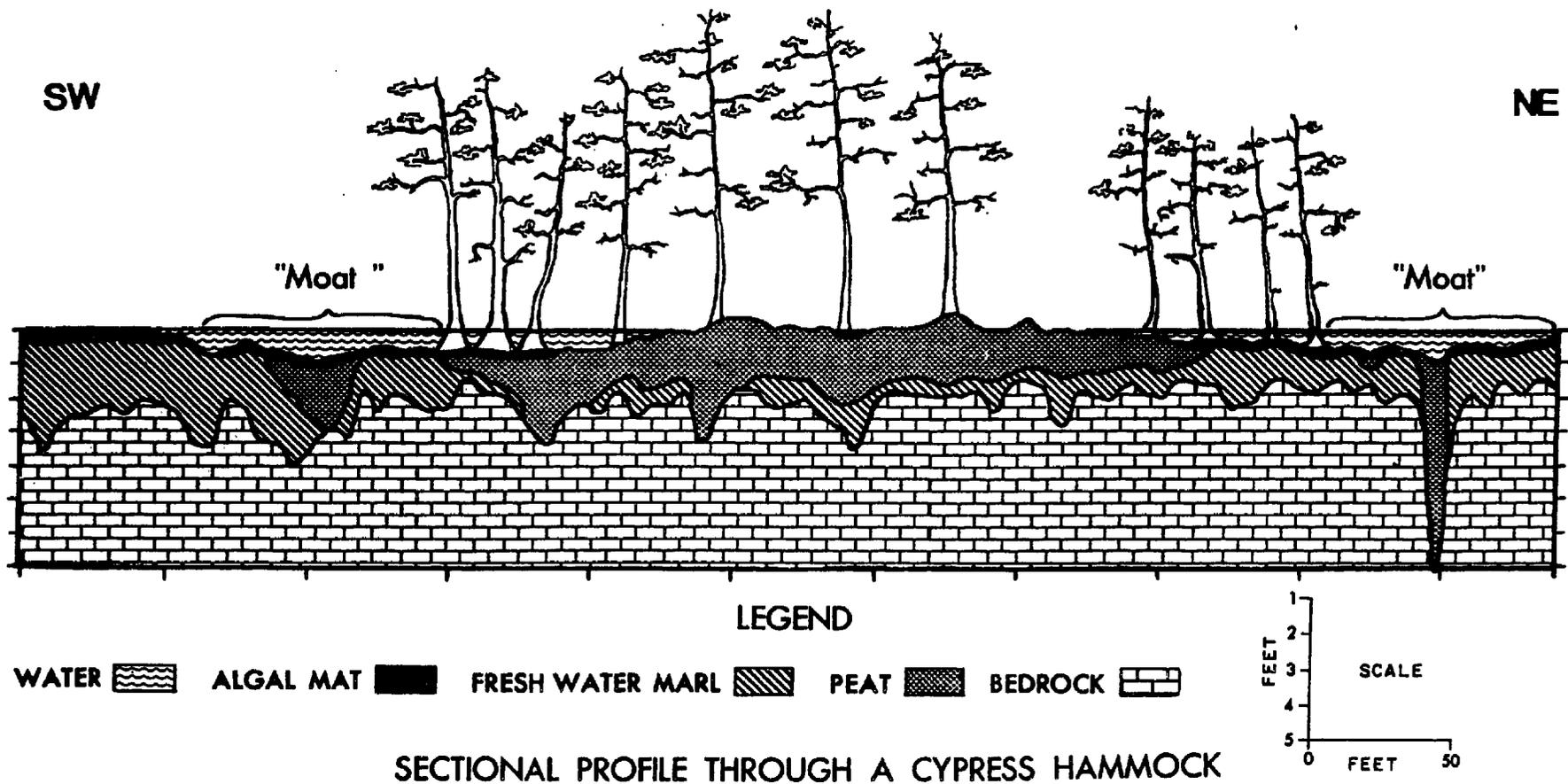
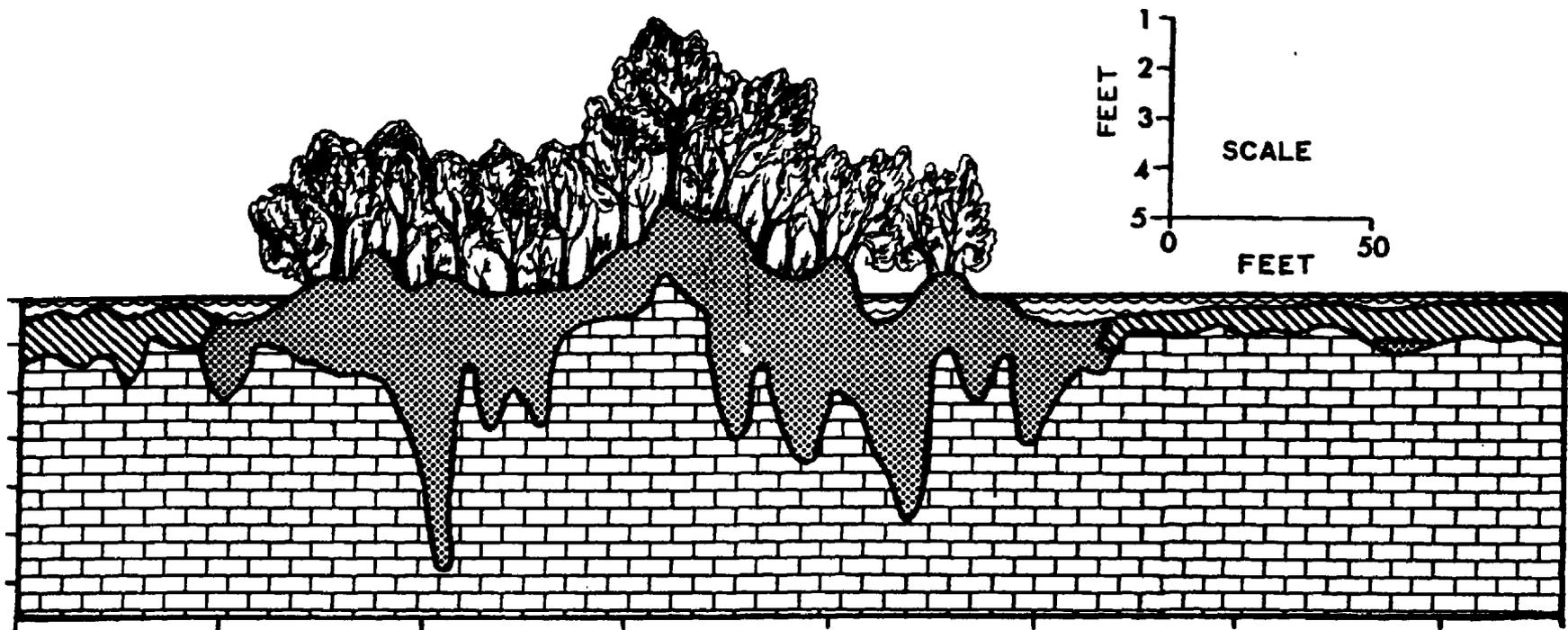


Figure 6. Cross-section through a cypress hammock. (Modified from Spackman et al., 1964)



### LEGEND

WATER 
 FRESH WATER MARL 
 PEAT 
 BEDROCK 

Figure 7. Cross-section through a "Bay Head". (Modified from Spackman et al., 1964)

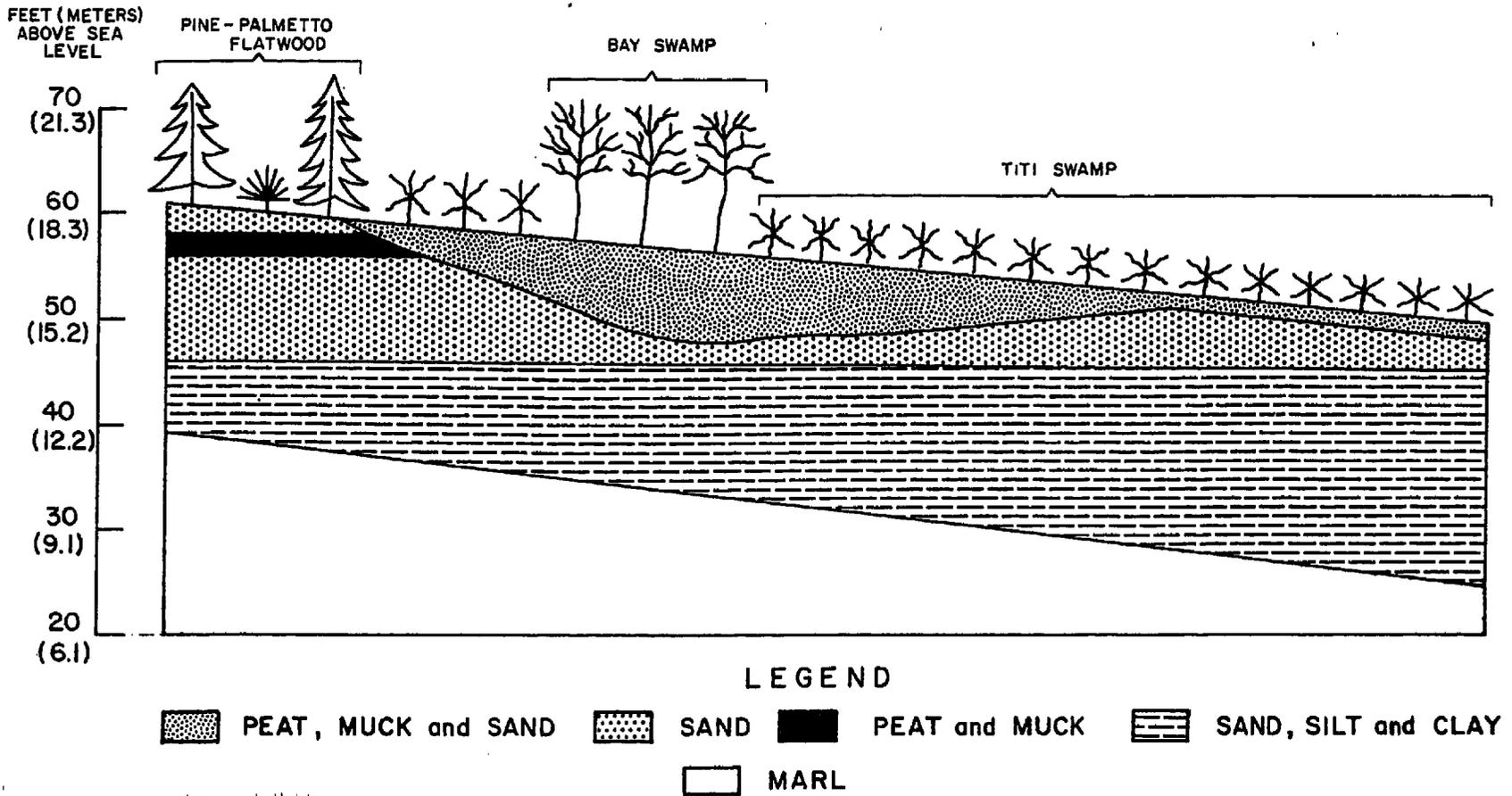


Figure 8. Cross-section through bay swamp and titi swamp. (Modified from Cameron et al., 1977).

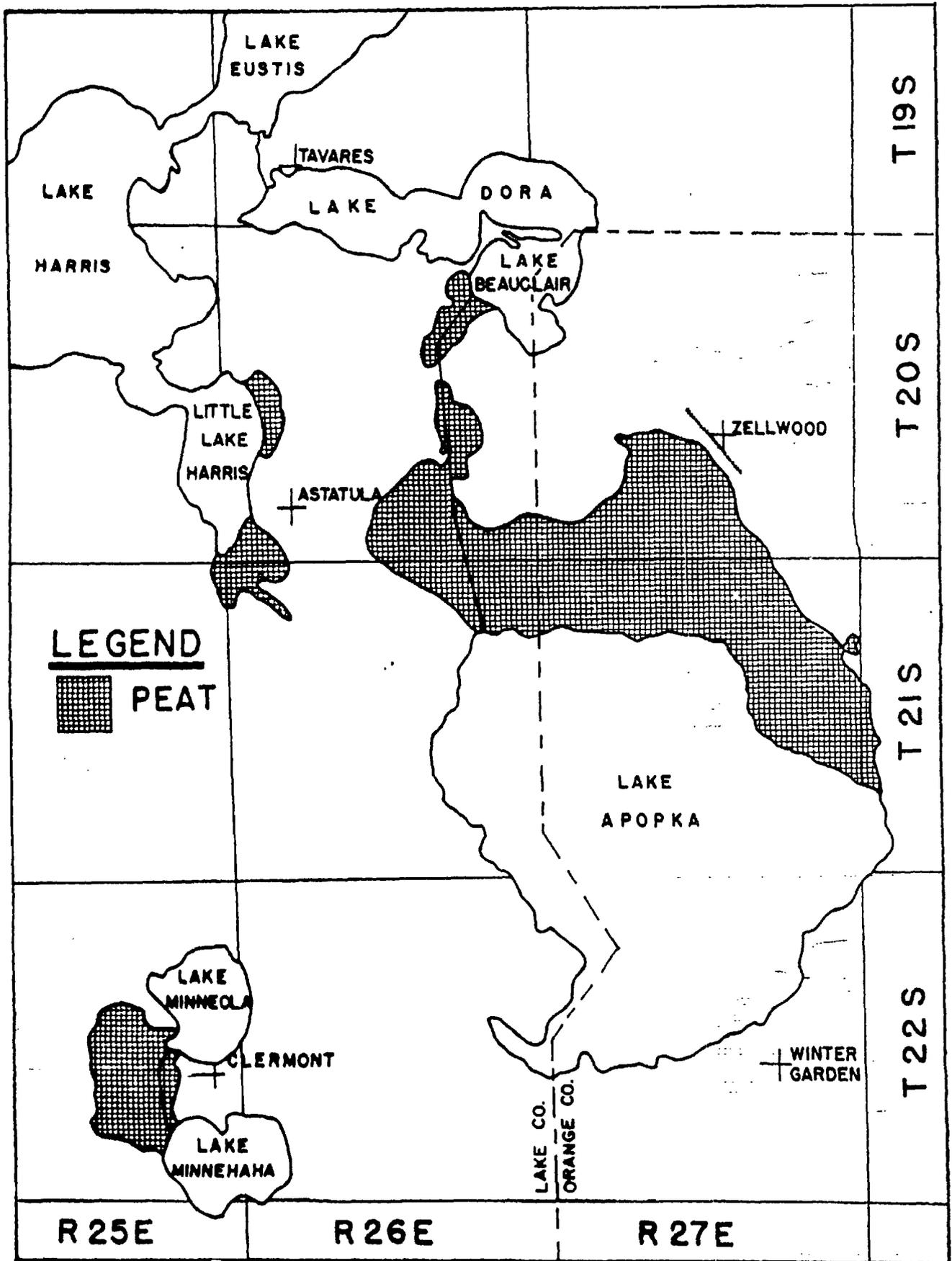
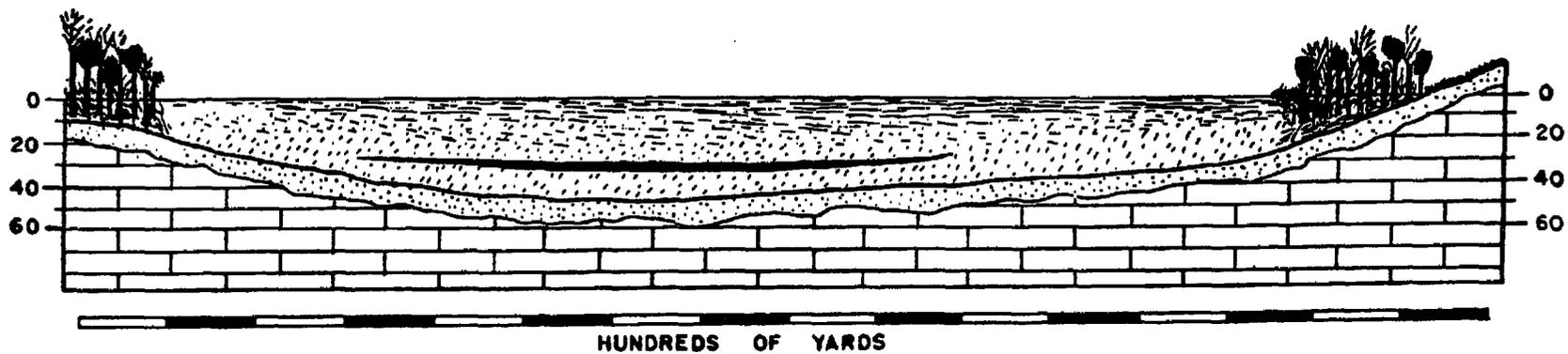


Figure 9. Peat deposits bordering lakes. (Taken from Davis, 1946)



**LEGEND**



SAPROPEL



FIBROUS SAWGRASS PEAT



CLAY

Figure 10. Cross-section showing peat filling lake. (Taken from Davis, 1946)

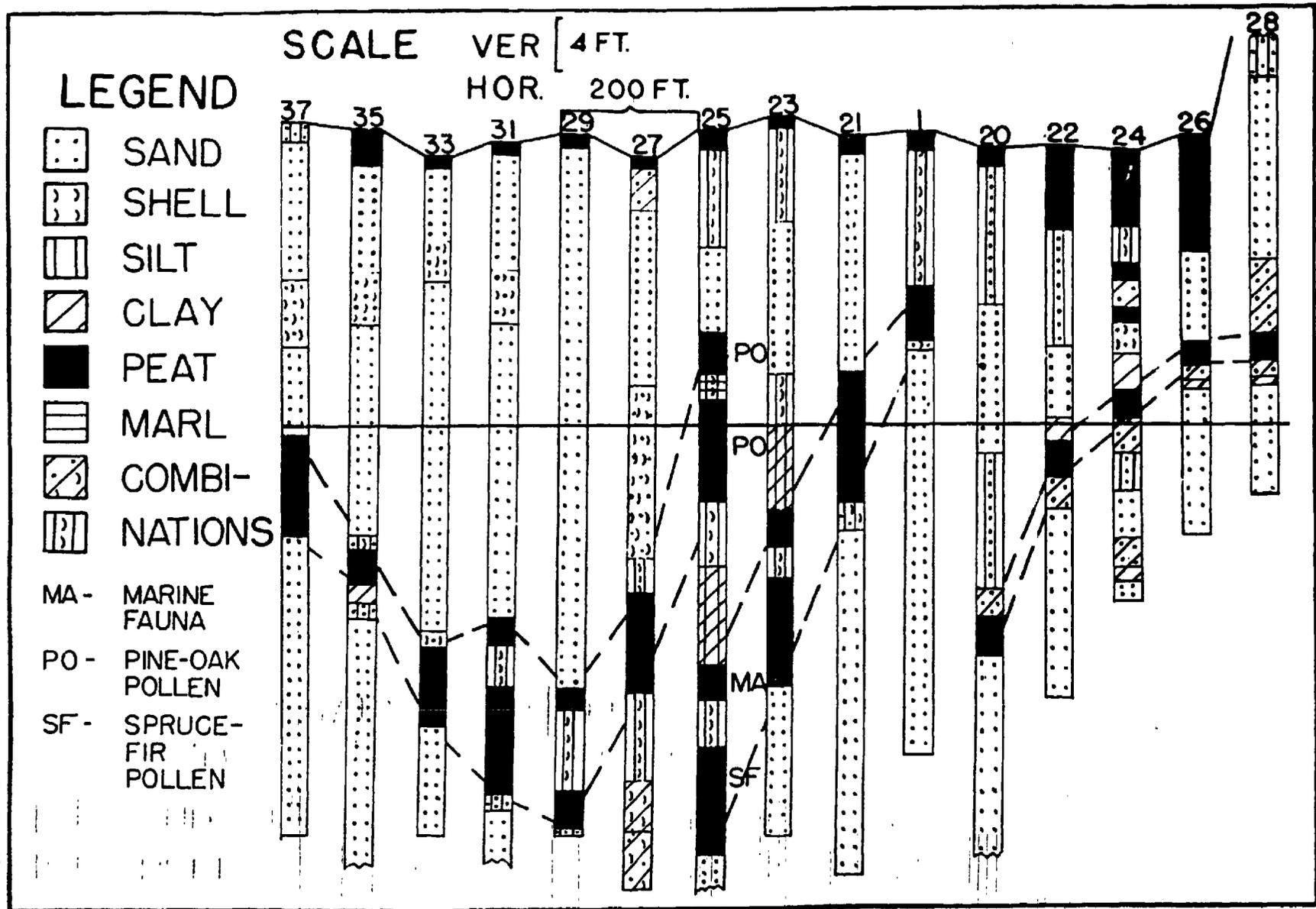


Figure 11. Cross-section using cores to show buried peat layers at Eureka Dam Site, Oklawaha River, Marion County, Florida. (Taken from Davis, 1946)

phytogenic sediments into two groups based on whether the plant material is transported from the site of growth or deposited at or near the growth sites of their source plants. Transported and nontransported phytogenic sediments are subdivided as occurring in marine to brackish water or fresh water. Specific environments are enumerated for both marine to brackish water deposits and also fresh water deposits. Peats of these deposits are differentiated based mainly on their botanical composition.

In Florida, peat deposits occur above or below the watertable (Davis, 1946; Gurr, 1972). Wet peat deposits occur if the watertable remains relatively high. Peat may be actively accumulating in these deposits. Certain areas within the Everglades, the coastal mangrove peats, and some lake-fringing peat deposits, such as the one associated with Lake Istokpoga, are examples of deposits which occur below the watertable. In other instances, peat deposits are located above the watertable. This drainage may have been instigated to enhance the land for agricultural use. The Everglades agricultural region contains numerous tracts drained for this purpose. Other deposits have apparently been drained as a result of regional lowering of the watertable. Most peatlands in Florida occur at or below the watertable and, thus, are very frequently also wetlands.

## INVENTORY OF PEAT IN FLORIDA

### MAPPING AND EVALUATING THE PEAT RESOURCE

There is no comprehensive inventory of Florida's peat deposits currently in print. Until recently, peat was not even remotely considered as a fuel source in Florida; and several scattered deposits were adequate to satisfy the state's agricultural and horticultural needs. Thus, neither interest nor funding were available for a complete peat inventory in the recent past.

It is important to point out that a comprehensive inventory of Florida's peat resource is, of necessity, a massive undertaking. The reasons for this difficulty are manifold. Florida is currently estimated to have 6.8 billion tons of peat contained in 4,700 square miles (U.S. Soil Conservation Service). This peat occurs in a variety of geologic settings which are both discontinuous and widely distributed across the breadth and length of the state. The various geologic settings of peat in Florida are discussed in a previous section, "Geologic Settings of Peat Accumulation in Florida."

These difficulties are compounded by the inaccessibility of many peat-producing areas. Peat actively accumulates in wetland situations typified by marshes, swamps, and mangrove islands. Much of Florida's peat occurs in the Everglades region (figure 12). Due to extensive drainage in the Everglades the exact

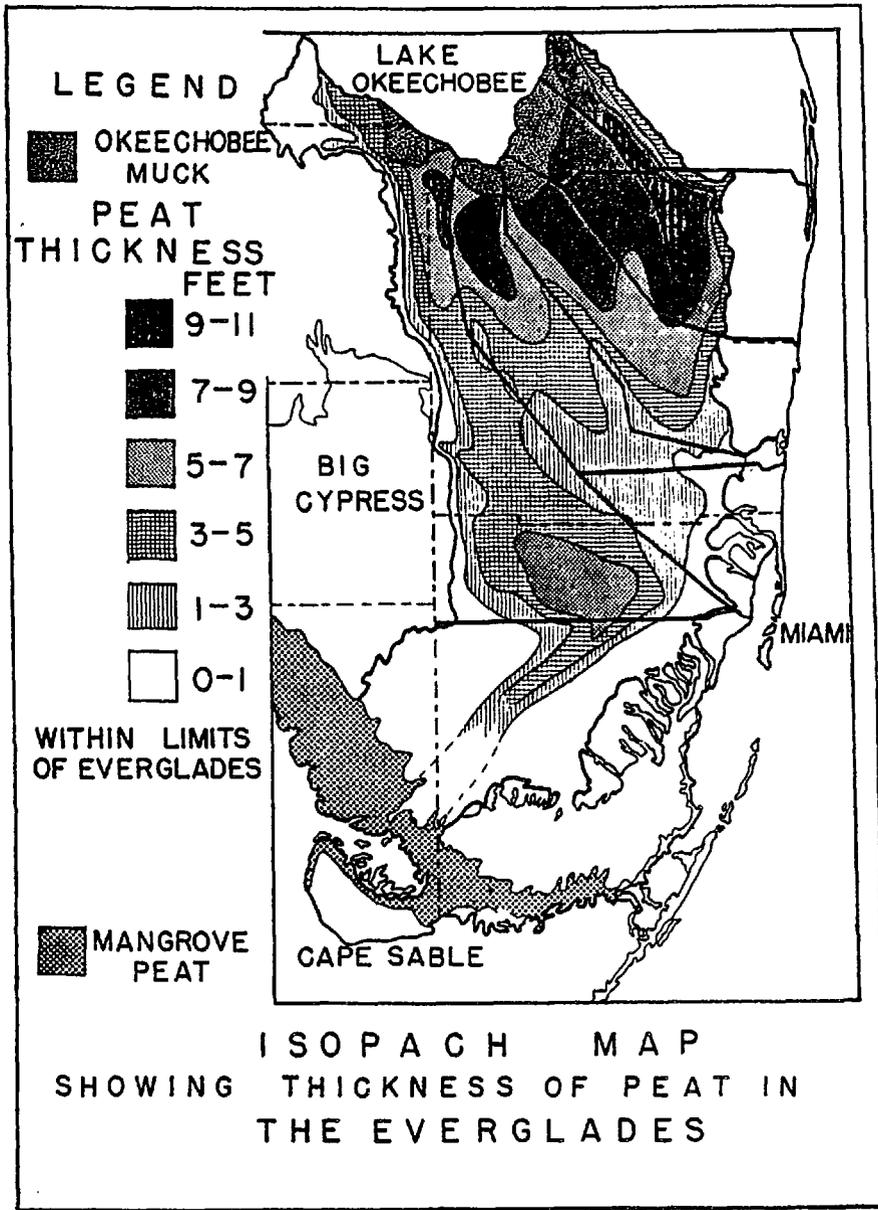


Figure 12. Isopach maps of the Everglades region showing thickness of peat and some muck areas. (Taken from Davis, 1946)

thickness and extent of the peat has decreased since figure 12 was prepared. Many of these areas are not accessible to conventional vehicles. Their size and character may render foot travel unfeasible. Some, but not all, sites may be accessible to boats. Coring apparatus for taking samples and measuring thickness must, in addition, accompany any field party charged with assessing peat reserves.

A realistic appraisal of Florida's peat resource is further complicated by the variability of the material. Peat may be classified as fibric, hemic or sapric depending on the extent to which it has decomposed (see section entitled "classification systems applied to peat"). It also varies with respect to chemical properties that affect its viability as a fuel source. Complete assessment of the peat resource requires laboratory analysis in addition to time-consuming field studies.

Attempts to assess the amount and locations of peat in Florida are hampered by an additional factor. Peat deteriorates by oxidizing when the wetlands where it accumulates are drained. This drainage may be due to the activities of man or by natural lowering of the water table in times of drought. Any data base for peat will require periodic updating if it is to remain useful.

#### CURRENT ESTIMATES OF PEAT IN FLORIDA

The total peat resources available in Florida are difficult to estimate and published values vary widely. The paucity of

actual peat resource investigations is an important hindrance to the development of accurate figures. A few published studies are concerned with the entire state (Davis, 1946; Griffin, et al., 1982). Several others concentrate on limited areas (Stephens and Johnson, 1951; Gurr, 1972).

Individual county soil surveys vary in their usefulness due to apparent inconsistencies in the terminology relating to organic and organic-rich soils. The more recent studies were used by Griffin, et al. (1982) to estimate fuel grade peat resources. Unfortunately, these studies are not complete for every county in the state. As a result, Griffin, et al. (1982) were unable to provide a comprehensive inventory of the peat resources for the entire state.

Another possible reason for the variation between resource estimates may be the result of the specific material studied. Griffin, et al. (1982) investigated "fuel-grade peats" while Davis (1946) inventoried a variety of organic materials classified as peats. The United States Soil Conservation Service (1981) studies soils in general and describes their organic content in addition to other characteristics.

Griffin, et al. (1982) report the discrepancies among the figures from various studies but were unable to determine the reason for the differences. Griffin, et al. (1982) also state that verbal reports from other Department of Energy peat researchers indicate that they have found similar discrepancies between the resource figures from the Soil Conservation Service

and their own figures in other states.

Published estimates of Florida's peat resources vary nearly by an order of magnitude. Griffin, et al. (1982) provide the lowest figure of 677,688 acres (1,059 square miles) consisting of 606 million tons of peat. Davis (1946) estimated 2,240,000 acres (3,500 square miles), comprising 1,750,000,000 tons of peat. The highest figure is provided by the Soil Conservation Service and is 3,000,000 acres (4,700 square miles), or 6,900,000,000 tons of peat.

The published resource estimates vary significantly and thus should be used with reservation. The U.S. Bureau of Mines currently uses the Soil Conservation Service figure (C. Davis, personal communication, 1983).

The determination of a more accurate resource figure for Florida peats would require a significant investment of time and money to complete. The scattered nature of the deposits in north and central Florida (figure 13) is such that there are literally thousands of sites to be investigated. In south Florida, peat deposits cover broad areas which would have to be examined in order for accurate estimates to be prepared.

The greatest potential peat resources in Florida lie predominantly in south Florida (figures 13, 14, and 15). The vast majority of this peat lies in the Everglades and associated swampy areas. It is interesting to note that while Davis (1946) (figure 13) and the Department of the Interior (Christ et al., 1981) (Figure 15) show similar areas of peat in south Florida,



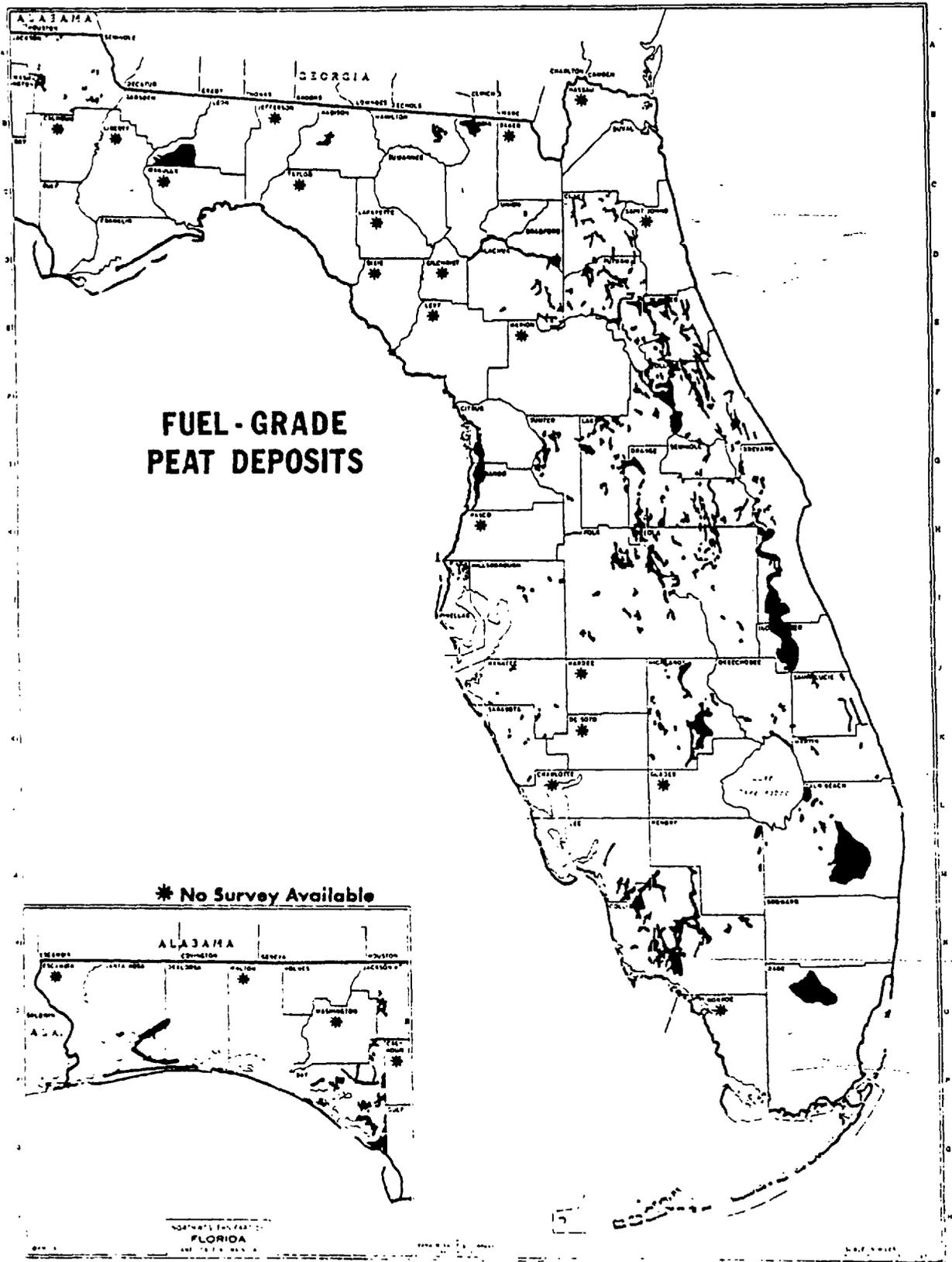


Figure 14. Fuel Grade Peat in Florida. (Taken from Griffin, et al., 1982)

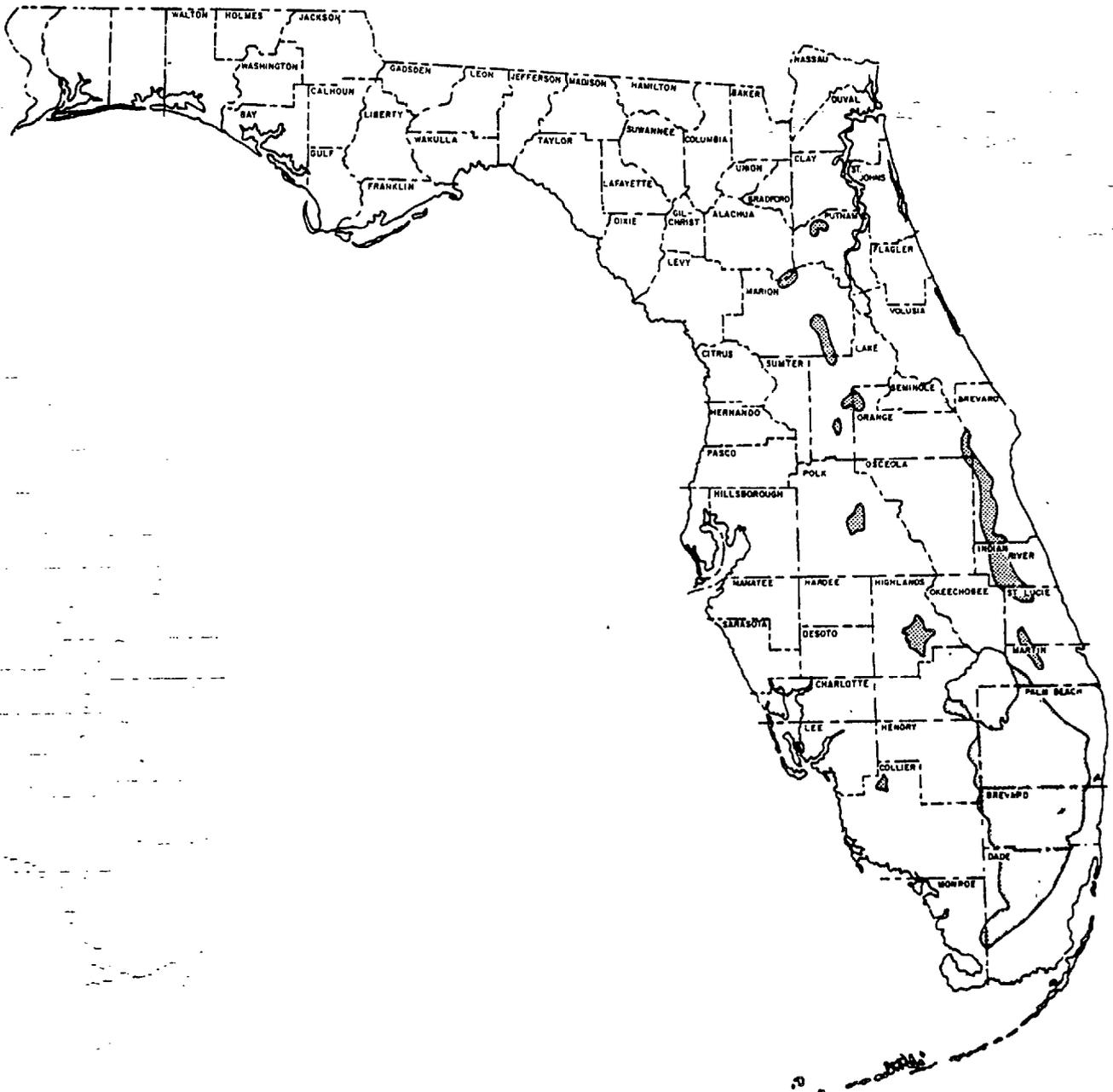


Figure 15. Peat deposits in Florida. (Taken from Christ, et al., 1981)

Griffin et al. (1982) (figure 14) show a significantly smaller area. This discrepancy may be due to subsidence and high ash content which would render peat unsuitable for fuel use.

Griffin, et al. (1982) show peat deposits in Collier and Lee counties that are not included on the other maps.

Figures 13, 14, and 15 indicate the presence of large deposits in the St. Johns River Valley (Indian River, Brevard and Orange counties), and the Oklawaha River Valley (Marion and Lake counties). Other relatively large deposits include: Lake Apopka (Orange and Lake counties), near Lake Arbuckle (Highlands County), Orange Lake area (Marion and Alachua counties) and the Florahome deposit (Putnam County). Smaller deposits are also indicated on Davis' (1946) map (figure 13) and Griffin, et al. (1982) map (figure 14).

It is interesting to note that while Davis (1946) (figure 13) shows scattered samples taken from small peat areas in the panhandle, Griffin, et al. (1982) (figure 14) show a number of deposits including a large deposit in Leon County and smaller deposits in Bay, Jackson, and Santa Rosa counties. The Department of the Interior map (Christ et al., 1981) (figure 15) does not indicate any deposits in the panhandle.

Peat associated with mangrove and coastal swamps generally occur in a narrow band paralleling Florida's coastline. The zone occupied by these environments is widest in southwest Florida. These peats are not generally shown on the maps of peat resources due to the scale of the maps.

Until a more detailed investigation of our peat resources is undertaken the published resource estimates must suffice. It must, however, be kept in mind that the figures are estimates of the available resources and vary from one investigator to another.

## THE EVERGLADES AGRICULTURAL AREA

### HISTORY OF THE EVERGLADES AGRICULTURAL AREA

The Everglades Agricultural Area is a part of an immense natural drainage system that begins in the northernmost reaches of the Kissimmee River drainage basin near Orlando. The Kissimmee River flows to the southeast into Lake Okeechobee. In its natural state, the level of Lake Okeechobee fluctuated within a range of approximately 8 feet, that is, between 12 to 20 feet above mean sea level (M.S.L.) (Parker, 1974). The water level in the upper Everglades rose and fell in response to the fluctuations of Lake Okeechobee.

In the wet season, most of the Everglades was inundated much of the time. When the water level of Lake Okeechobee reached about 14.6 feet (M.S.L.), two separate segments of the lake shore would begin overflowing into the Everglades. At about 18 feet (M.S.L.), the entire southern shore (30 miles) overflowed pouring a flood into the upper Everglades (Parker, 1974). It is important to note, however, that losses to evapotranspiration are

estimated to have been as high as 82 percent. Thus, flood water from Lake Okeechobee most probably did not travel the entire length of the Everglades, but rather local precipitation caused the inundation (Parker, 1974). This mass of water flowed sluggishly to the Gulf and has come to be described as sheet flow (Parker, 1974). The chronic inundation allowed the accumulation and preservation of the organic soils which characterize the highly productive Everglades Agricultural Area.

In about 1880, Hamilton Disston entered into a contract by which he would drain land on the upper Kissimmee River and receive as compensation half of the land he drained. His success was debatable (Tebeau, 1974). The history of early drainage efforts is a history of inadequate technical expertise and insecure funding. The scope of the drainage issue was continually underestimated. Disasterous floods associated with hurricanes in 1926 and 1928 moved the Federal Government to take action. The extensive floods of 1947 and 1948 made it obvious that water control had not yet been established and set the stage for the intervention of the Army Corps of Engineers (Tebeau, 1974).

In 1947, most of south Florida was flooded for several months. The U.S. Congress, in response to the continuing water-control problems, passed the Flood Control Act of June 30, 1948. This action directed the Army Corps of Engineers to plan, design and construct a massive project which would ultimately solve water problems in all or parts of 18 counties in central and south Florida (Snyder, et al., 1978). In the plan proposed by

the Army Corps of Engineers, major concern was devoted to the protection of life and property along the lower east coast of Florida. The first phase of the project involved building an artificial levee from Lake Okeechobee to about Homestead in order to confine flood waters to the Everglades. The project was also designed to provide water control for soil, water conservation and farming (Snyder, et al., 1978).

After studies by both the United States Department of Agriculture and the University of Florida, the lands of the present "Everglades Agricultural Area" were set aside for agricultural development. The organic soils of the Agricultural Area were the only soils of sufficient depth and of the proper type to support cultivation for a period of time sufficient to justify development (Snyder, et al., 1978). It is important to note that when the Everglades Agricultural Area was being planned it was recognized that subsidence of organic soil would occur and that the area could not support cultivation indefinitely (Snyder, 1978).

#### CROPS AND SOILS OF THE EVERGLADES AGRICULTURAL AREA

The Florida Everglades comprises the single largest body of organic soils in the world, 1,976,800 acres (Shih, 1980). The Everglades Agricultural Area consists of 1,892,811 acres of fertile organic soil. Winter vegetables from the Agricultural Area include sweet-corn, celery, radishes, leaf crops, carrots and

beans. In addition, lands of the agricultural tract are used for sugar cane, pasture and turf (Shih, 1980). Sugar cane is the dominant crop with cash receipts of \$215 million in 1977-1978 (Snyder, et al., 1978).

The proximity of the Florida Agricultural Area to the south shore of Lake Okeechobee is not coincidence (figure 16). Before the activities of man altered the tendency of Lake Okeechobee to overflow along its southern edge silt, clay, and organic colloids were mixed with dead plants to form muck. In this way, the mucks became enriched in the microelements that peat lacks (Stephens, 1974), enhancing the mucks as an agricultural growth medium.

The soils of the Everglades Agricultural Area are classified by soil scientists on the basis of the percentage of inorganic matter they contain and their thickness. The Torry Series soils occur within two to five miles of Lake Okeechobee. They contain black organic layers more than 51 inches thick and are characterized by a range of 35 percent to 70 percent mineral matter (mostly the clay minerals sepiolite and montmorillonite) (Snyder, 1978) and are not considered peats according to ASTM standards. The Terra Ceia, Pahokee, Lauderhill and Dania soils are dark organic soils which are differentiated from one another based on their thickness above bedrock. The Terra Ceia soils are the thickest with the Pahokee, Lauderhill and Dania becoming successively thinner. As the process of subsidence occurs, Terra Ceia soils will become Pahokee soils since Pahokee soils differ from Terra Ceia soils only in their thickness (Snyder, 1978).

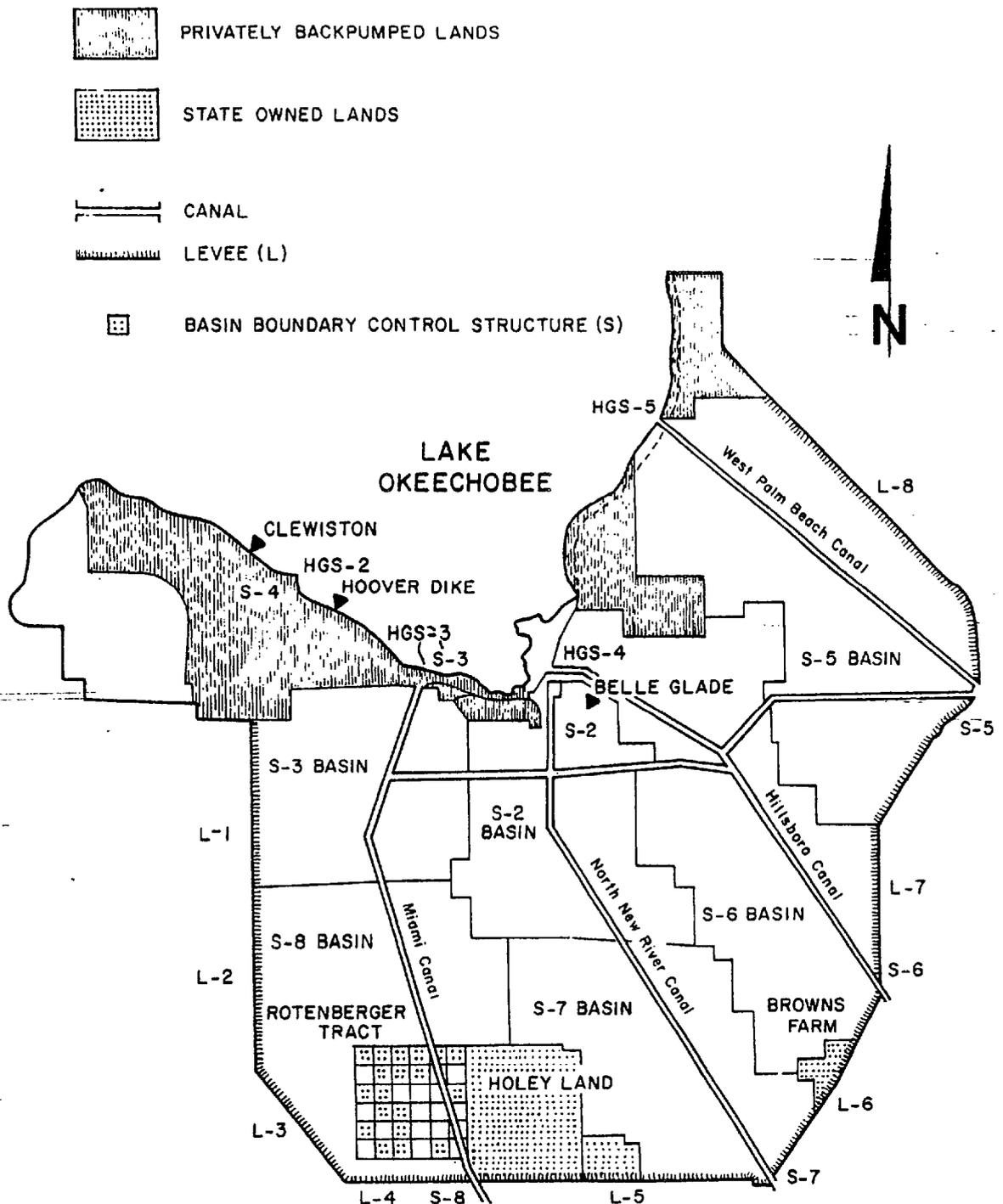


Figure 16. Location map of the Everglades Agricultural Area. (Modified from Snyder et al., 1978)

## SUBSIDENCE

Subsidence refers to the loss of thickness which is incurred by organic soils when they are drained. A group of physical processes are responsible for subsidence, including 1) shrinkage due to dessication, 2) consolidation by loss of the buoyant force of groundwater and loading, or both, 3) compaction by tillage, 4) wind erosion, 5) burning and 6) biochemical oxidation (Stephens, 1974). The processes of drying, consolidation and compaction do not result in actual loss of soil (Shih, 1980). Stephens and Johnson (1951) documented an increase of oven dried weight for Everglades peat from about 9 pounds to about 16 pounds per cubic foot after cultivation. This increase in density corresponds to a decrease in soil volume. In this manner, the volume of the soil decreases although there is little actual loss of soil.

The processes of wind erosion, burning and oxidation do, however, result in the actual loss of organic soils (Shih, 1980). Wind erosion is thought to have minor effects in the Everglades Agricultural Area. Numerous charcoal rich lenses which represent ancient fires have been found at depth in cores through the organic soils of the Everglades and coastal swamps (Cohen, 1974). Attempts to correlate charcoal layers from core to core were futile suggesting that fires were not widespread geographically. The fires were confined mainly to sawgrass-dominated peats. Modern observation indicated that fires are very common in sawgrass communities and it is suggested that sawgrass may be

especially well-adapted to survival of fires (Cohen, 1974).

The most serious cause of long term subsidence in the Everglades is biochemical oxidation. Biochemical oxidation has been responsible for 55 to 75 percent of the total soil loss in the upper Everglades Agricultural Area (Stephens, 1974). Although original plans for drainage in the Everglades recognized that subsidence would occur, the causes were apparently misunderstood (Stephens and Johnson, 1951). Shrinkage of original peat due to drainage was taken into account, but the slow continual loss of peat due to biochemical oxidation was not considered.

The organic soils of the Everglades are a collection of organic particles and mineral particles which are interspersed with void spaces or pores. When these pores are filled with water the micro-organisms which actively decompose the organic soil are unable to function or function at a greatly reduced rate (Snyder, et al., 1978). This is the condition that allowed organic soils to accumulate before modification of natural drainage patterns. Biochemical oxidation of organic soils is facilitated by warm temperatures, low water tables, high pH and high organic content (Stephens, 1974).

Drained organic soils of the Florida Everglades Agricultural Area subside at an average rate of approximately 1 inch/year (Stephens, 1974). This rate varies with variation of depth to the water table. Rates of subsidence for experimental plots with water table depths of 12 inches, 24 inches and 36 inches were

measured to be 0.6 inches per year, 1.4 inches per year and 2.3 inches per year, respectively.

Subsidence has been documented in the Everglades using repeated surveys of ground elevation along certain lines. In figures 17, 18 and 19 (Stephens and Johnson, 1951), the solid lines represent the original elevation of the surface of the ground and the elevation as measured in 1940. The dashed lines indicate the topographic elevations predicted from subsidence rates. Stephens (1974) notes that subsidence was measured to be 33.5 inches between 1941 and 1966 in the upper Everglades which may be compared to a predicted subsidence loss of 33.0 inches in 25 years (Stephens and Johnson, 1951).

Rates of subsidence in the Everglades Agricultural Area vary with the depth to which the water table is maintained. The depth at which the water table is maintained depends on optimum conditions for each land use. Snyder and others (1978) note that most vegetable crops produce high yield when the water table is maintained at 24 inches below the surface. Sugar cane normally requires a water table depth which is greater than 24 inches; and in certain organic soils, a water table depth of 30 to 36 inches greatly improves sugar cane quality. Water tables for cattle and sod production may be maintained at levels which would be considered too high for most crops. It is important to note that extremely high water tables may cause problems specifically related to crop land use even though high water tables allow maximum soil preservation (Snyder, et al., 1983).

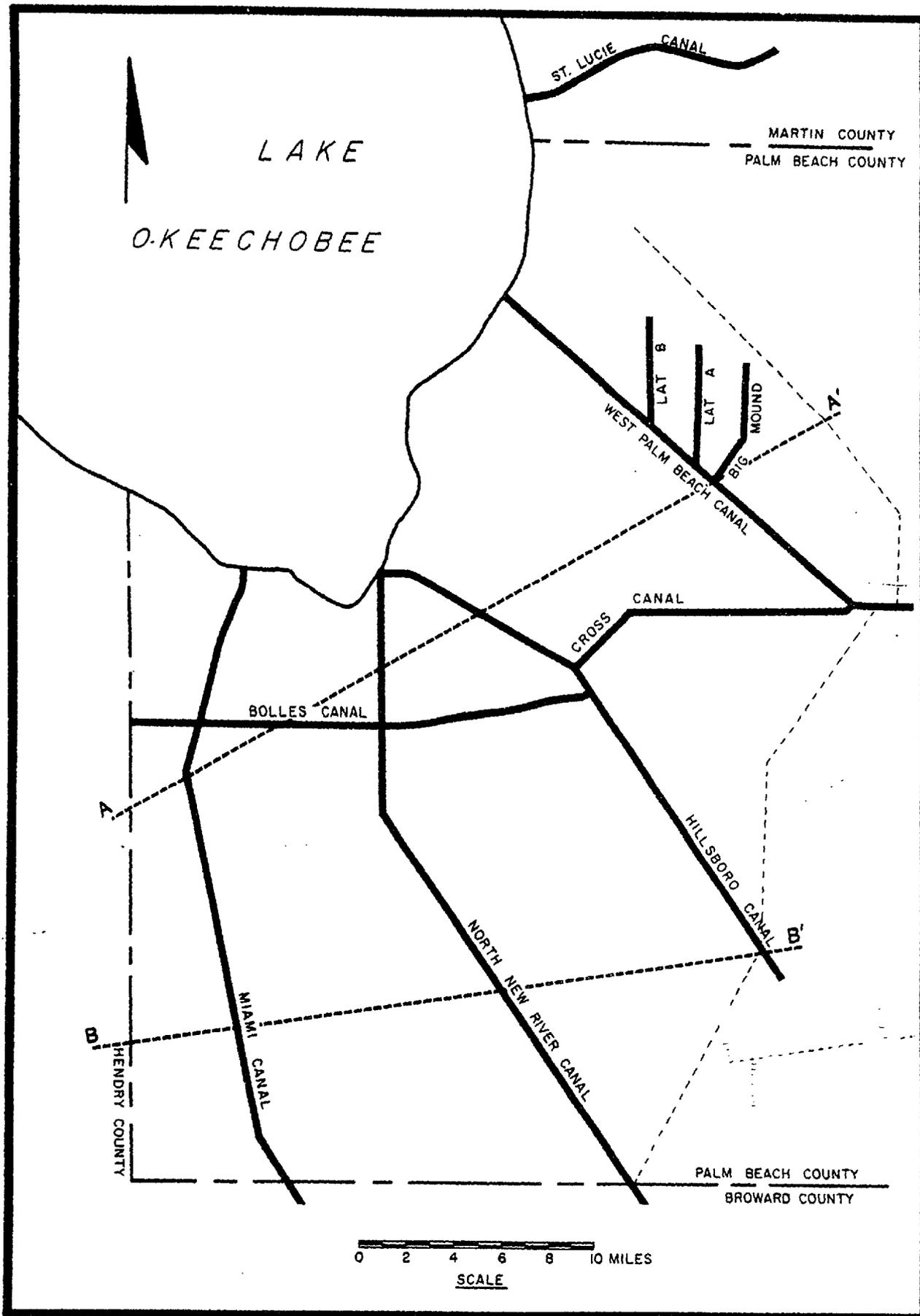


Figure 17. Map of the Everglades Agricultural Area showing the locations of profiles A-A' and B-B'. (Modified from Stephens and Johnson, 1951)

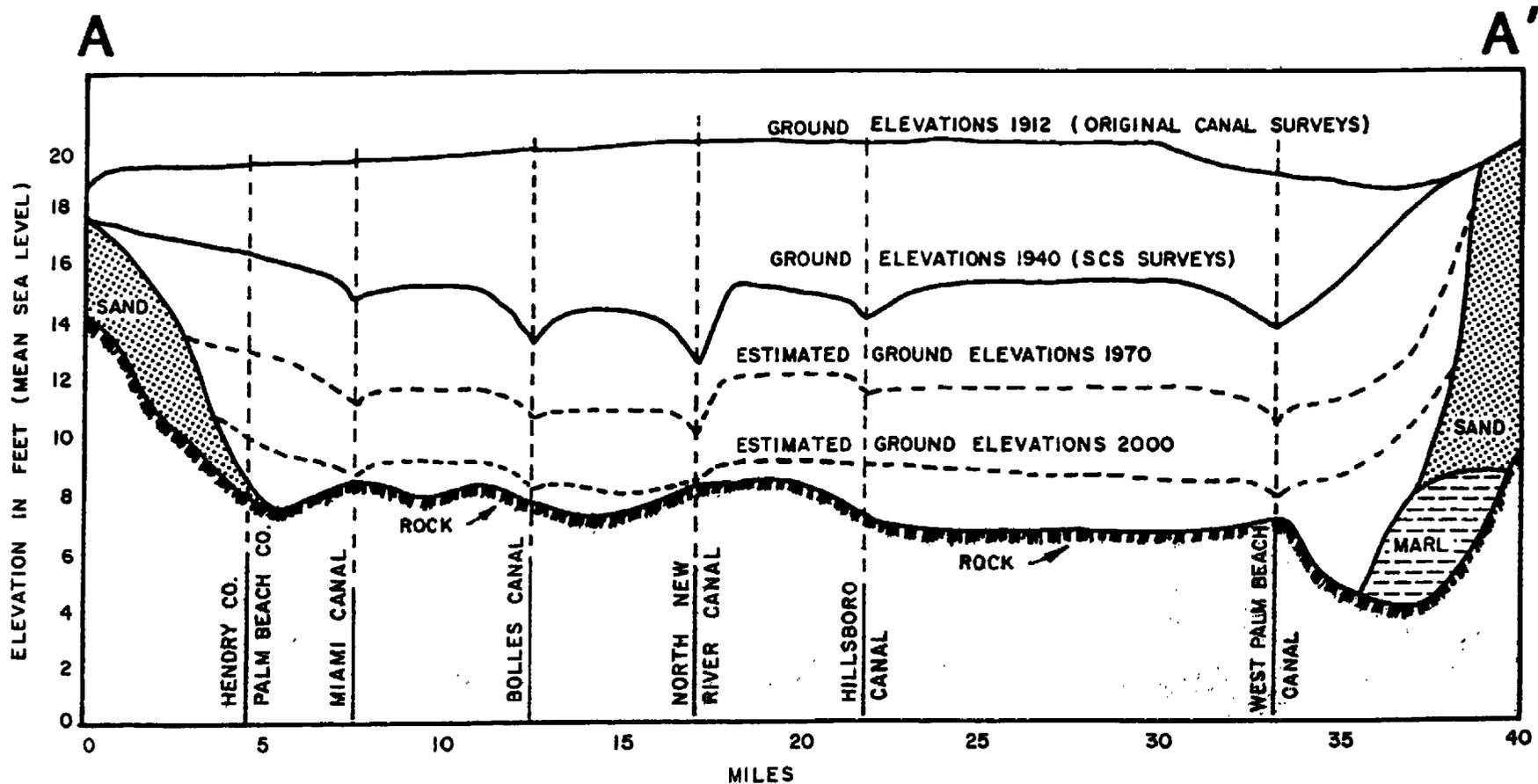


Figure 18. Profile A-A' across the upper Everglades showing the original surface elevations and the ground elevation in 1940 as shown by topographical survey. Profiles for the years 1970 and 2000 are estimated. (Modified from Stephens and Johnson, 1951).

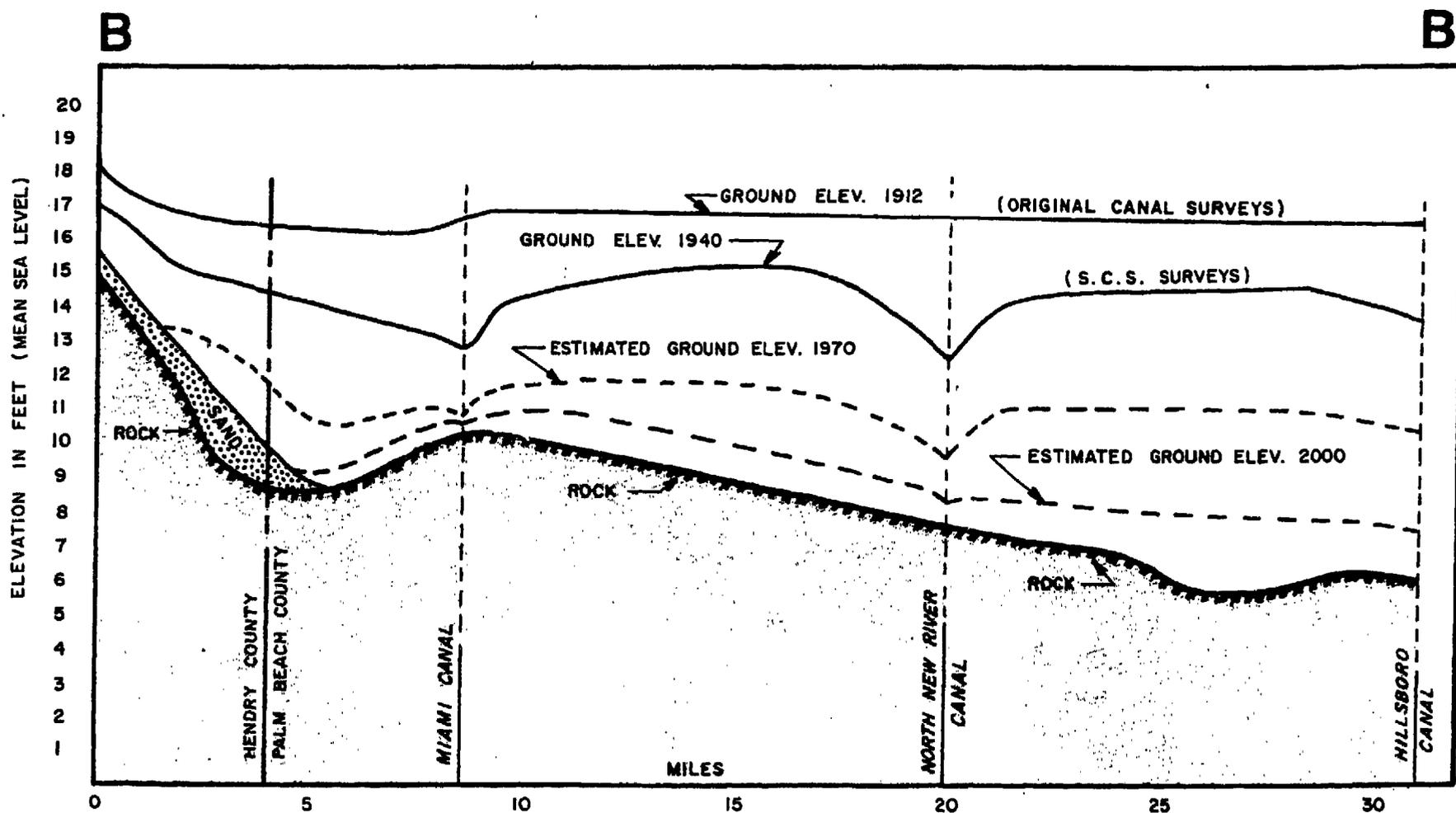


Figure 19. Profile B-B' through the lower part of the Everglades Agricultural Area show the original surface elevation and the surface elevation as determined in 1940 by topographic surveys. Profiles for the years 1970 and 2000 are estimated. (Modified from Stephens and Johnson, 1951)

## CONSERVATION MEASURES

Researchers who have worked in the Everglades Agricultural Area suggest that maintenance of high water tables is the most effective measure available for conservation of organic soils. Tate (1980) notes that the only feasible means of controlling subsidence is knowledgeable manipulation of the water table. Snyder and others (1978) recommend: "For best conservation organic soils should be kept flooded whenever not in use. When soils are used, the water table should be maintained as high as is possible for that use." Stephens (1974) lists a number of suggestions geared toward conservation of organic soil: "(1) provide adequate water control facilities for keeping water tables as high as crop and field requirements will tolerate; (2) make productive use of drained lands as soon as possible; and (3) intensify research studies to develop practices to prolong the life of the soils."

It has been suggested that extending the life of organic soils by plowing under cover crops or litter (Snyder, et al., 1978; Stephens, 1974) is probably not an effective conservation measure. The rate at which peat forms is extremely slow and the volume of plant litter produced is very small. Snyder and others (1978) discuss an example which clarifies this relationship. Sugar cane produces an amount of top growth exceeded by few, if any, plants. An average cane crop (30 tons/acre) is estimated to contain approximately 8 tons of dry matter. If all of the dry

matter from an entire crop were added to the soil, it could be assumed that about half of it would be decomposed rapidly. One acre-inch of top soil is about the amount lost to subsidence each year in the Everglades Agricultural Area. That amount of soil weighs approximately 50 tons. Thus, 4 tons are replaced each year, which is still only approximately 1/12 the amount which is lost.

#### THE NEAR FUTURE OF THE EVERGLADES AGRICULTURAL AREA

Snyder and others (1978) have included a discussion of land use in the Everglades Agricultural Area through the year 2000. It is noted that the predictions of Stephens (1951) have proved reliable (compare figures 20 and 21). These predictions are presented in Table 2 (Snyder, et al., 1978). Although land elevations are shown through the year 2000, subsidence will continue. By the year 2000, only approximately 80,000 acres of soil three feet in depth or deeper will remain. It is predicted that sugar cane acreage will decrease, pasture acreage will increase significantly and vegetable acreage will remain essentially unchanged assuming the economic viability of such operations. By the year 2000, over 500,000 acres will be less than 3 feet in thickness. Approximately half of this will be less than a foot in depth (Snyder, et al., 1978). The depth of 3 feet is significant because, at depths of less than 3 feet, the use of mole drains becomes impractical. The soils which have subsided to depth of

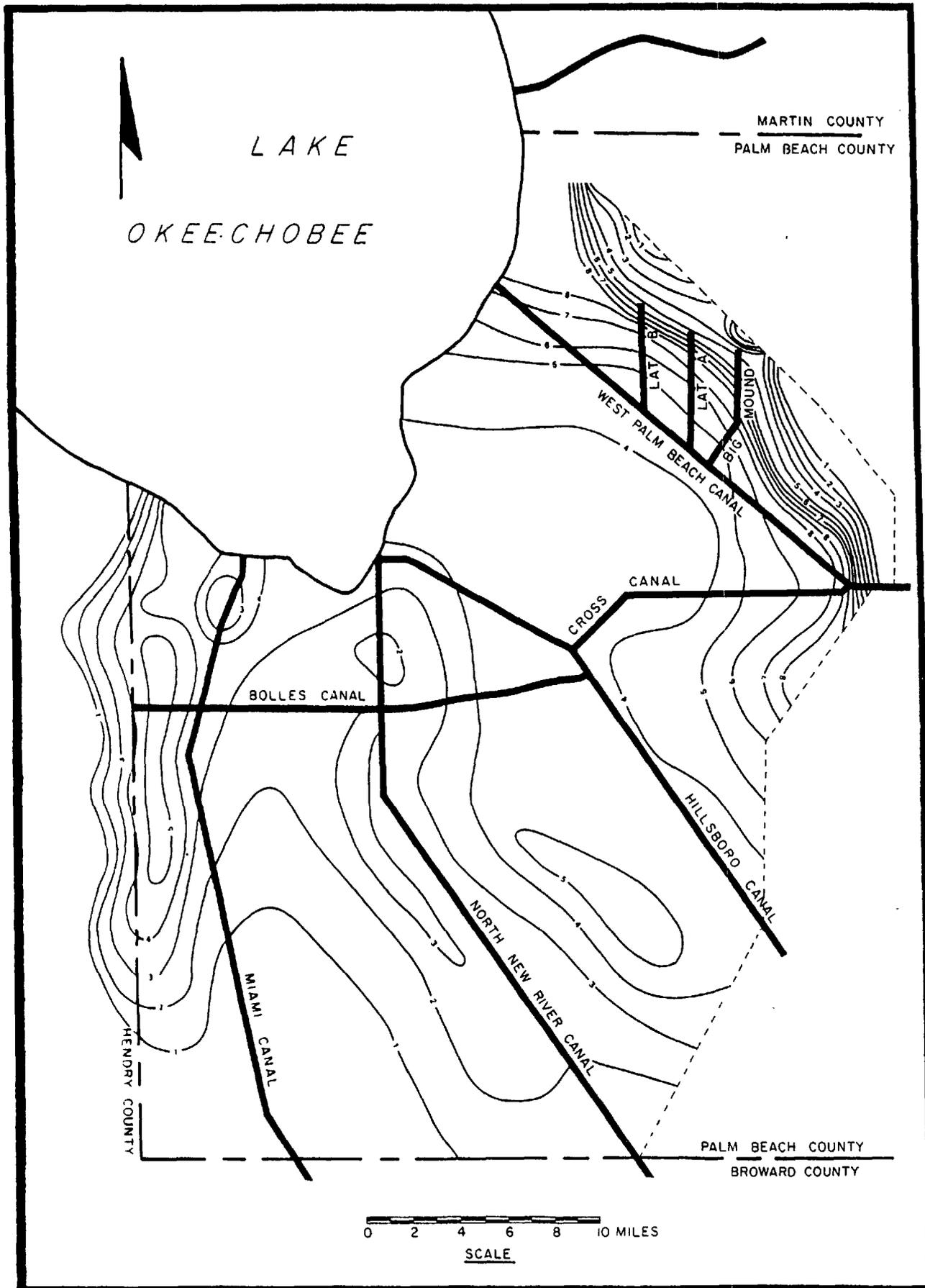


Figure 20. Soil depths predicted for the year 1980. (Modified from Stephens and Johnson, 1951) Compare with Figure 17. (Taken from Griffin, et al., 1982)

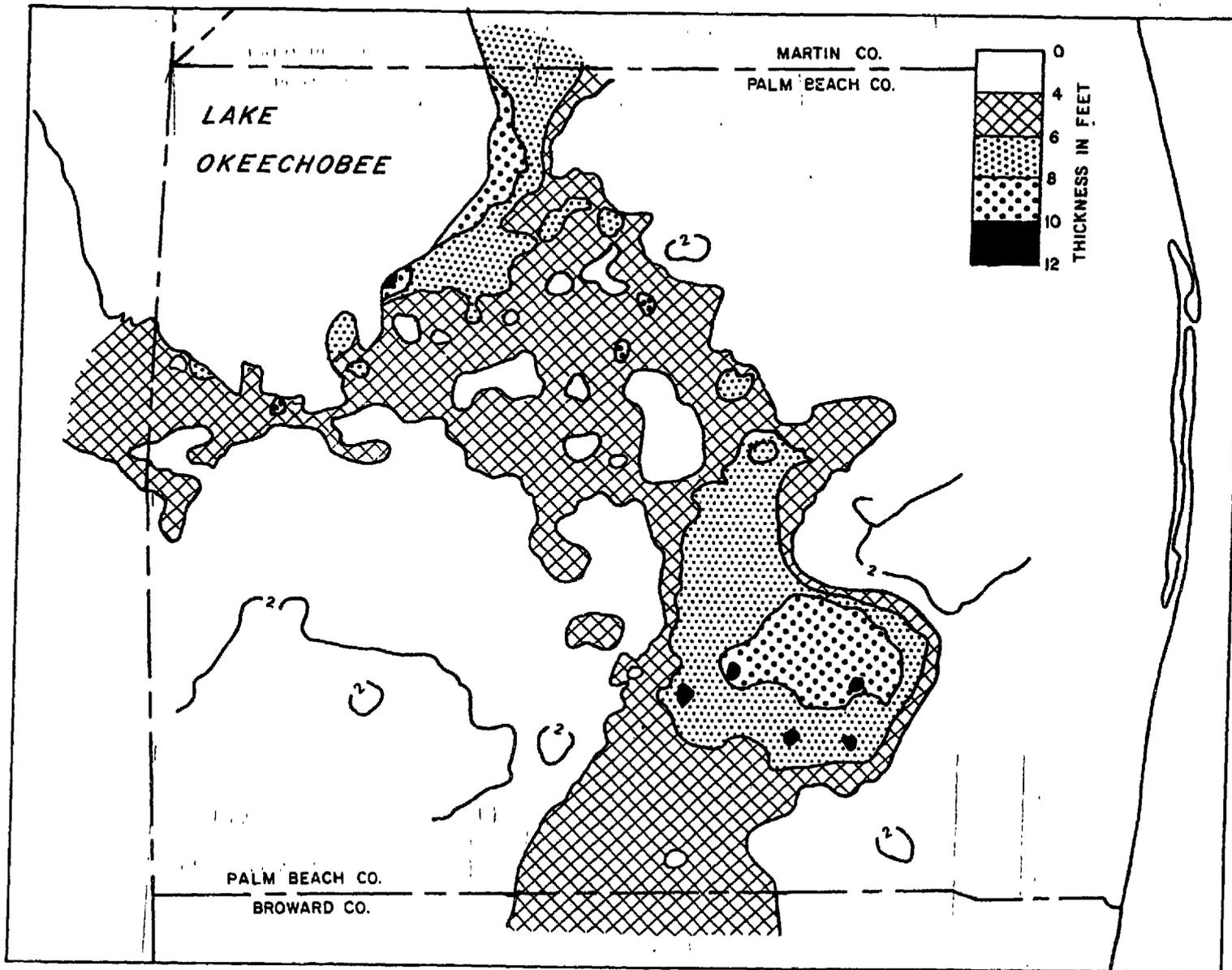


Figure 21. Thicknesses of soils from the Everglades Agricultural Area as determined in a recent study. (Modified from Griffin et al., 1982).

TABLE 2

Proportions of the Organic soils of the Everglades Agricultural Area falling into categories based on thickness (after Snyder, 1978).

YEAR	0 to 1 ft.	1 to 3 ft.	3 to 5 ft.	over 5 ft.
1912	0	1	3	95
1925	1	3	7	89
1940	1	7	14	85
1950	2	7	28	78
1960	4	12	28	55
1970	11	16	41	45
1980	17	28	41	14
1990	27	28	39	7
2000	45	42	9	4

less than one foot face an uncertain fate. Snyder and others (1978) suggest that while some of those soils may be suitable for pasture, the soils may be abandoned for agricultural uses. It is also suggested that the remaining soils and the existing water-control structures be used to produce aquatic crops. The authors suggest that such a usage could greatly extend the useful agricultural life of the soils.

#### INDUSTRIAL USES OF PEAT

Industrial use of peat can be divided into two major categories: extractive and non-extractive (Minnesota DNR, 1981). The extractive uses include direct combustion, gasification, industrial chemicals, horticultural products and sewage treatment. The non-extractive uses include agriculture, energy crops and again sewage treatment (Minnesota DNR, 1981).

#### PREPARATION OF PEAT FOR INDUSTRIAL UTILIZATION

For most applications, peat must be dewatered before processing. Biogasification and some energy crops and sewage treatment processes do not require dewatering.

Solar drying in the field is energy efficient but is not suitable to wet mining processes or to all mining plans. Alternative dewatering processes include mechanical presses and thermal dryers, in addition to pretreatment processes such as wet

carbonization, wet oxidation and solvent extraction.

Mechanical methods are limited in the amount of water they can remove. Most of the water contained in peat is held in chemical bonds, colloidal suspensions and small pores in the organic matter. Mechanical methods may reduce water content to 70 percent at best (Minnesota DNR, 1981). Thermal dryers can be utilized to reduce the moisture content further. The efficiency of mechanical dewatering is greatly enhanced by pretreatment processes such as wet carbonization, wet oxidation and solvent extraction. Peat can be mechanically dewatered to approximately 30 percent water content after wet oxidation (Mensingher, et al., 1980 in Minnesota DNR, 1981, p. 30).

Wet carbonization consists of heating a slurry of peat and water (approximately 3 percent solids) to 300-400°F at 50-100 atmospheres of pressure for 30 minutes. A "peat coal" with a heat value of 12,000-14,000 BTU/lb dry weight is obtained after the liquid is removed (Kopstein, 1979).

Wet oxidation is an established process for the oxidation of many wet organic materials. Air or oxygen is pressure fed to wet peat in a closed, heated vessel. Combustion is rapid and is controlled by the rate of supply of the oxygen or air. The process can be stopped after enough heat has been generated to carbonize the remaining peat or can be carried to completion to produce energy (Kopstein, 1979).

Solvent extraction reacts a heated peat-water slurry under pressure with an organic solvent. The water is extracted from

the peat by the solvent. Subsequent to cooling, the absorbed water is stripped from the solvent and after treatment is disposed of as waste.

## FUEL USES

### Direct Combustion

Direct combustion of peat is a method of producing energy which has been utilized on a commercial scale in Ireland, Finland and the Soviet Union for several decades. The Soviet Union had installed an electric power station fueled entirely by peat as early as 1914 (Kopstein, 1979).

The U. S. Department of Energy has developed several criteria for fuel-grade peat. The criteria are: 1) heat value greater than 8000 BTU/lb (dry weight), 2) greater than 80 acres of peat per square mile, 3) peat depth greater than 4 feet, and 4) ash content less than 25 percent (Minnesota DNR, 1981). Hemic and sapric peats are the most suitable for direct combustion useage. The more decomposed peats (sapric) have been carbonized to a greater extent but often have larger ash contents which reduces their fuel value. Hemic peats generally are the most suitable for fuel use (Minnesota DNR, 1981).

Direct combustion of peat is accomplished in boilers designed or retrofitted for either peat fuel entirely or mixed fuel feed. Boiler design must accomodate the characteristics of

peat fuel: low energy density, high moisture content. Both of these characteristics result in increased cost (approximately 50 percent greater) of the boiler and feed system compared with a coal or oil fired boiler of the same capacity (Kopstein, 1979). Grate fired and fluidized-bed boilers require pelletized or briquetted feed. Pulverized-fired boilers require peat ground to the particle size compatible with the combustor design.

Direct combustion techniques can result in partial oxidation of the peat and generation of synthetic fuel gases. Reduced oxygen input and/or water vapor injection are required to generate the fuel gases.

### Gasification

Peat is very reactive during gasification. Gasification can yield low to medium BTU fuel gases, synthesis gases (those which can be further upgraded by hydrocracking) fuel liquids, ammonia, sulfur and oil byproducts (naphthalene, benzene and phenol) (Kopstein, 1979; Minnesota DNR, 1981).

Several basic designs of gasifiers are feasible for peat gasification, however, data for peat gasification is primarily limited to laboratory scale operations (Kopstein, 1979). Entrained flow and fluid bed gasifiers appear attractive. An example is the PEAT GAS process developed by the Institute of Gas Technology. Dry peat is fed to the gasifier, and heated under pressure with a hydrogen rich gas. The carbon in the peat reacts

with the hydrogen to form hydrocarbon gases (primarily methane and ethene). The gases produced can be upgraded to pipeline quality (Minnesota DNR, 1981). Byproduct oils (benzene, naphthalene and phenols), ammonia and sulfur are extracted in turn from the liquids which are condensed during various gas upgrading processes (Minnesota DNR, 1981).

The ratio of gaseous to liquid products is controlled by changes in temperature, pressure and length of reaction time. Increased temperature and reaction time lead to gaseous product increases. With higher temperature and longer reaction times, the large hydrocarbon molecules comprising the liquid products are hydrocracked into lighter gaseous molecules (Kopstein, 1979).

### Biogasification

Biogasification is an anerobic fermentation process. An important advantage of biogasification is that dewatering is not required. Biogasification is a two-stage process. In the first step, the peat-water slurry is partially oxidized to break it down to simple compounds. Aldehydes, ketones, organic acids and esters are the main products at this stage. The pH is adjusted and the mixture is transferred to the fermenter (anerobic biological reactor) where bacteria catalyze methane production. Methane and carbon dioxide are produced in stoichometric proportions (Kopstein, 1979) with up 95 percent of the material being

converted to methane or carbon dioxide (Minnesota DNR, 1981). The resulting gas can be upgraded to substitute natural gas (SNG) by scrubbing the carbon dioxide and hydrogen sulfide from the methane gas (Kopstein, 1979).

The waste material from the fermentation process contains undigested peat components, inorganic residues and residual bacteria. These materials can be utilized for soil conditioners, animal feeds, or can be concentrated for disposal. Excess water is recycled to the fermenter (Kopstein, 1979).

## INDUSTRIAL CHEMICALS

Peat has been utilized as a raw material for the production of industrial chemicals for many years in Europe and the Soviet Union. U. S. interest has developed only recently. Peat bitumens, carbohydrates and humic acids are extracted by processes at low to moderate temperatures. Peat coke, peat tar and activated charcoal are produced by pyrolysis. The use of peat for industrial chemicals does not pose major technical problems. The technology has been developed in Europe and the Soviet Union. The chemicals produced are similar to petroleum derived products. As petroleum becomes more expensive, the incentives to utilize peat will increase (Minnesota DNR, 1981).

### Bitumens

Peat bitumens are those peat components which are soluble in nonpolar organic solvents. The yield of bitumens depends on the extracting solvent chosen. Yield increases from low to high in the following list of solvents: petroleum ether, gasoline, dichloroethane, benzene, ethanol:benzene (1:1) (Fuchsman, 1978). Although various solvents are utilized for analytical purposes, gasoline is the solvent used in commercial processes. Benzene is not used because of health hazards (Bel'Kevich, 1977). The peat bitumens of commercial interest are peat waxes and resins. The waxes are the most important commercially (Fuchsman, 1978).

Peat, suitable for commercial wax production, contains at least 5 percent gasoline extractable material and has an ash content less than 10 percent (Lishtvan and Korol', 1975). The wax content of peat is higher in more highly decomposed peats (Naucke, 1966) particularly those with remains of shrubs and trees (Fuchsman, 1978).

Dried peat particles in the size range of 0.02 inches - 0.2 inches are required for efficient solvent extraction. Wax extraction utilizes gasoline as the solvent and extracts most of the wax but relatively few of the resins (Bel'Kevich, 1977). Gasoline and peat are mixed at 20:1. Approximately 5 percent of the gasoline is lost in the process, with the rest being recycled after wax removal by solvent evaporation.

The crude wax contains some resins. Resins are partially removed by treatment with an appropriate solvent (cold acetone, alcohol and ethyl acetate) (Fuchsman, 1978). Further purifica-

tion is accomplished by treatment with potassium dichromate and sulfuric acid at 167°F-230°F. The result is a fairly hard, light tan wax (Bel'Kevich, 1977).

Peat waxes are produced commercially only in the Soviet Union where they are used as release agents in foundry castings and on polyethylene surfaces. Peat waxes are similar to montan wax which is derived from lignite. Montan wax is a substitute for beeswax and carnuba wax and is used as an industrial lubricant and as an ingredient in shoe and furniture polish, electrical insulating materials and in candles (Minnesota DNR, 1981).

Peat resins are the primary byproducts of peat wax production. The resins are of importance as a source of steroids for use by the pharmaceutical industry (Minnesota DNR, 1981).

### Carbohydrates

Peat carbohydrates consist primarily of cellulose and related materials such as hemicellulose and starches (Fuchsman, 1978). Sugars are produced by acid hydrolysis for use in yeast culture. Yeast culture can be optimized for the production of single cell protein or for the fermentation of alcohol (Fuchsman, 1978).

Peat suitable for carbohydrate hydrolysis, according to Soviet criteria are: Spagnum peat with degree of decomposition less than 20 percent, ash content less than 5 percent and at least 24 percent of the dry weight of the peat recoverable as

fermentable sugars from the easily hydrolyzable carbohydrates (or 45 percent if difficultly hydrolyzable carbohydrates are included) (Fuchsman, 1978). Cellulose is classified as being difficult to hydrolyze. The preferred Soviet process (Ishino, 1976) is as follows: peat with a maximum grain size of 0.4 inches is slurried with water to 7-20 percent solids and mixed. The suspension is then pumped at 5-7 atmospheres of pressure and concentrated sulfuric acid is added to give an overall acid concentration of 0.25-1 percent. The slurry is heated to 284°F-338°F by steam injection and discharged to atmospheric pressure and reacted for 10-30 minutes. Volatile matter is flashed off, the fluid is diluted and reacts for an additional 10 minutes at 284°F to allow hydrolysis completion. Solids are then removed by sedimentation centrifuge or filtration. Yield by this process is 34-40 percent of the peat dry weight.

#### Humic Acids

Fuchsman (1978) describes humic acid as "alkali-soluble, acid-insoluble organic compounds, excluding bitumens and carbohydrates." There are several lines of chemical modification of humic acid: pyrolysis, oxidation and reduction (Fuchsman, 1978).

To date, there are no large scale commercial uses for humic acid. Present industrial uses for humic acids include sizing for paper, tanning agents, in fertilizers and as viscosity modi-

fiers for oil well drilling mud (Fuchsman, 1978). Potential uses include the production of plastics and synthetic fibers, components for paints and adhesive formulations and flocculants or thickeners in water purification systems. These uses are based primarily on the adsorption and ion exchange properties of humic acids (Fuchsman, 1978).

#### Peat Coke, Peat Tar and Activated Carbon

Peat coke, tar and activated carbon are produced by the process of pyrolysis. Pyrolysis consists of decomposition of organic substances by heat in the absence of air. When carried to a high enough temperature and for long enough time, the process yields a carbon residue (peat coke), a water immiscible condensate (peat tar) and non-condensable gases which can be utilized as fuel gases.

Peat suitable for coking requires a relatively high carbon content (high level of decomposition), low ash content and low phosphorous content (Fuschman, 1978). High carbon content is necessary for acceptable yields. Phosphorous and ash degrade the product quality.

Several factors influence the yield of pyrolysis products. Coke yields are increased with more highly decomposed peats and slower rates of heating. Peat tar and gases generated by the pyrolysis process are often recycled as fuel for the coking process.

Activated carbon is produced from peat coke by treating coke with steam at 1632°F-2012°F. The reaction forms hydrogen gas and carbon monoxide which has the physical effect of expanding the pores in the peat coke, greatly increasing the surface area available for adsorption (Norit, N.V.).

Peat coke is utilized to form high purity silicon for the electronics industry and as a reducing agent in electric smelting furnaces especially in the production of ferrochrome and ferrosilicon alloys (Eckman, 1975). Peat tars are refined for pesticide and wood preservative use. The primary use, however, is as fuel recycled to the peat coke production process (Minnesota DNR).

Activated carbon is utilized for a variety of purposes, all of which take advantage of the large surface area available for adsorption. Uses include removal of pollutants from industrial waste gases, as a gas absorber, deodorizer, and for purification of water and sugar (Fuchsman, 1978).

## USE OF PEAT AS A GROWTH MEDIUM

### Horticulture

Essentially all of the peat mined in Florida, at the present time, is used for horticultural purposes. Peat is used by home owners for soil enhancement, by nurseries and landscapers for potting soils and growing media for plants, and also as a medium for mushroom and earthworm culture.

## Agriculture

Agricultural uses of peat are similar to horticultural uses. The peat is utilized as a growing medium (soil) for agricultural crops. The material is not mined, however, drainage is generally necessary to provide the proper moisture conditions.

Hemic and sapric peats, as well as mucks, are utilized for agricultural purposes. Fibric peats, typically are not suitable due to the low pH (acidic) which makes nutrients unavailable to many plants (Farnam and Levor, 1980). Large areas of Florida peats and mucks are utilized for agricultural purposes.

## Energy Crops

Growing energy crops for plant biomass production allows peatlands to be utilized to produce renewable energy sources. Plant biomass can be harvested and burned directly or can be gasified to produce liquid and gaseous fuels. Energy crops can be an alternative to conventional mining (using the peat as a growing medium) or can be utilized as a reclamation technique on mined out peatlands (Minnesota DNR, 1981).

Plants which may be suitable for energy crop use in wetlands include: cattails, reeds and sedges, willow and alder (Minnesota DNR). These wetland species have two distinct advantages over conventional crops for use in biomass energy production: 1) the biomass productivity of wetland species is often higher than

conventional crops (corn, soybeans, etc.) and 2) they can be grown in wetlands unsuitable for conventional crop plants and thus do not compete with conventional crop production (Minnesota DNR, 1981).

## SEWAGE TREATMENT

Peat has been utilized in the tertiary treatment of waste water both in the U. S. and in Europe. The primary objective is to reduce nutrient levels, primarily phosphorous and nitrogen (Minnesota DNR, 1981).

Phosphorous is removed from solution by bacteria present in that portion of the peat exposed to air. Bacterial metabolism converts the phosphorous to insoluble forms. Chemical reactions with calcium, aluminum and iron present in the peat also remove phosphorous from solution (Nichols, 1980).

Nitrogen is metabolized by anerobic bacteria, converting nitrate in the waste water to gaseous nitrogen which is released to the atmosphere (Nichols, 1980). Additional nutrients are removed through uptake by plants growing on the peat surface.

Three methods are commonly used for the tertiary treatments of waste water. Two utilize the peat in place, the third utilizes excavated peat (Minnesota DNR 1981). The waste water can be introduced directly to the bog surface and allowed to filter through the peat or may be introduced to a ditched and drained peat deposit. This would increase the volume of peat exposed to

the waste water, increasing residence time and allowing more efficient nutrient uptake (Nichols, 1980). The third method involves a built up filter bed of peat, sand and gravel. The effluent is applied to the filter surface by sprinklers. Generally, the surface of the filter would be seeded with a suitable sedge or grass to remove additional nutrients (Minnesota DNR, 1981).

Peat water treatment systems and experimentation has not been conducted for enough time to determine the period of time over which it can effectively remove nutrients before it becomes saturated. Environmental effects, therefore, must be strictly monitored (Minnesota DNR, 1981).

#### ECONOMIC IMPACT

Peat is currently mined in twelve Florida counties (figure 22). In each of these counties, the mining companies provide jobs, pay state and local taxes, require the services of various support industries and provide a valuable product to nurseries and individuals.

#### PRICE, PRODUCTION, AND VALUE OF PEAT

The U. S. Bureau of Mines reports an average 1982 price for Florida peat of \$13.12 per short ton. 1983 prices quoted by mining companies range from \$8.50 to \$18.00 per cubic yard of

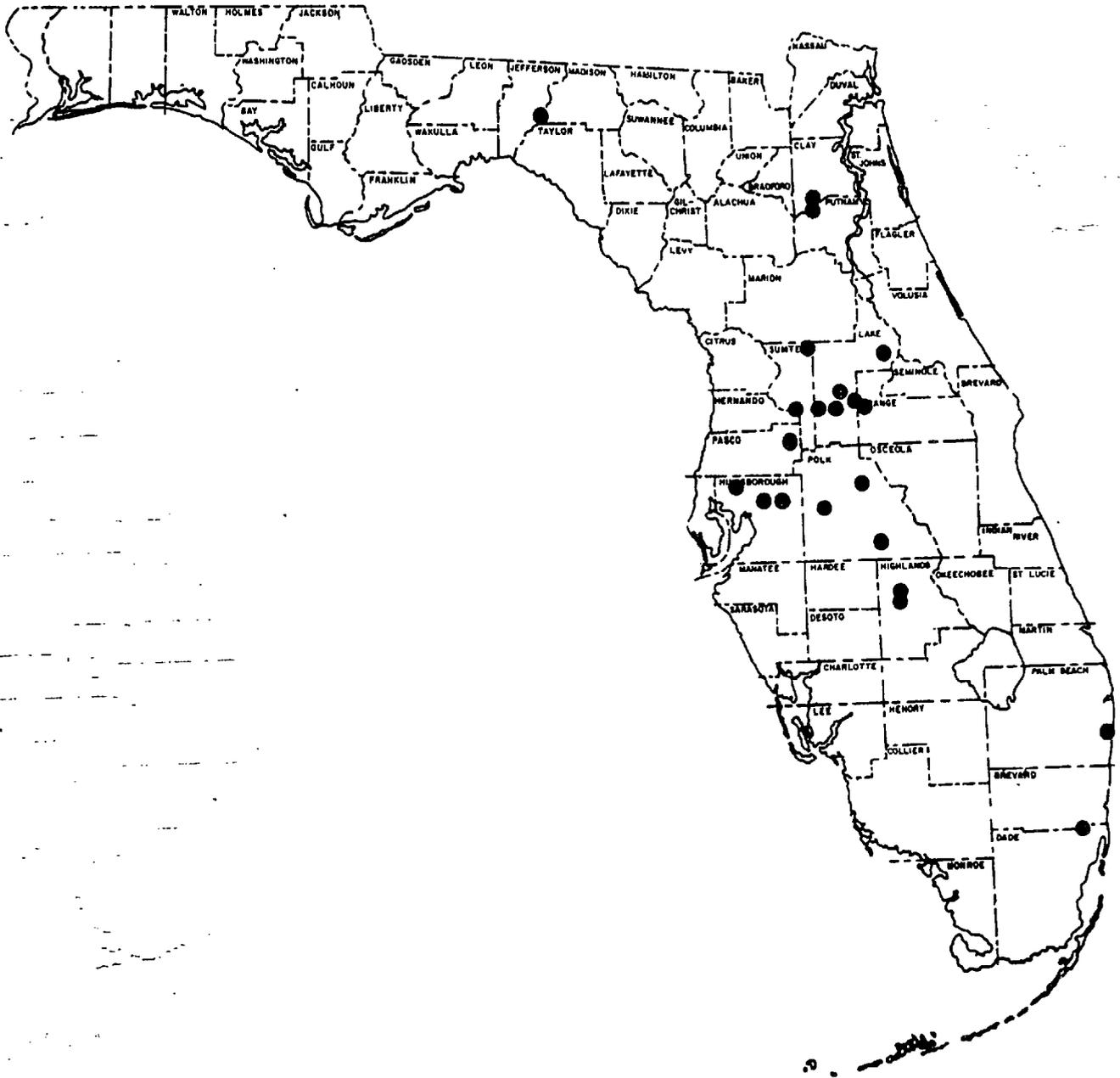


Figure 22. Location of Current Peat Producers. (Bureau of Geology survey for this study)

peat with the most common price being \$10.00 to \$10.50 per cubic yard. Blended topsoils range from \$11.00 to \$20.00 per cubic yard. If one ton of peat is assumed to occupy 2.3 cubic yards, the \$10.50 per cubic yard price is equivalent to \$24.15 per short ton. Bagged peat prices are higher and are in the range of \$45.00 per ton.

Florida ranked second in peat production nationally in 1982 (Boyle and Hendry, in press, 1984). The U. S. Bureau of Mines (B.O.M.) reported peat production in 1982 as 120,000 short tons, with a value of \$1,575,000 dollars (figure 23). The average price in 1982 was \$13.12 per short ton. The above figures represent a 25 percent drop in production and a 47 percent drop in value from 1981.

The B.O.M. production and value figures do not represent the complete picture. The B.O.M. reported peat production from four counties in 1982. Of the ten companies on the B.O.M. peat producer list, only six are still active. The authors have compiled a list of 21 peat producers, located in 12 counties. The actual peat production in the state must be significantly higher than reported by the B.O.M.

#### LOCATION OF PEAT PRODUCERS

Peat production is concentrated in central peninsular Florida, in Sumter, Lake, Orange, Pasco, Hillsborough, Polk and Highlands counties. Additional producers are located in Madison

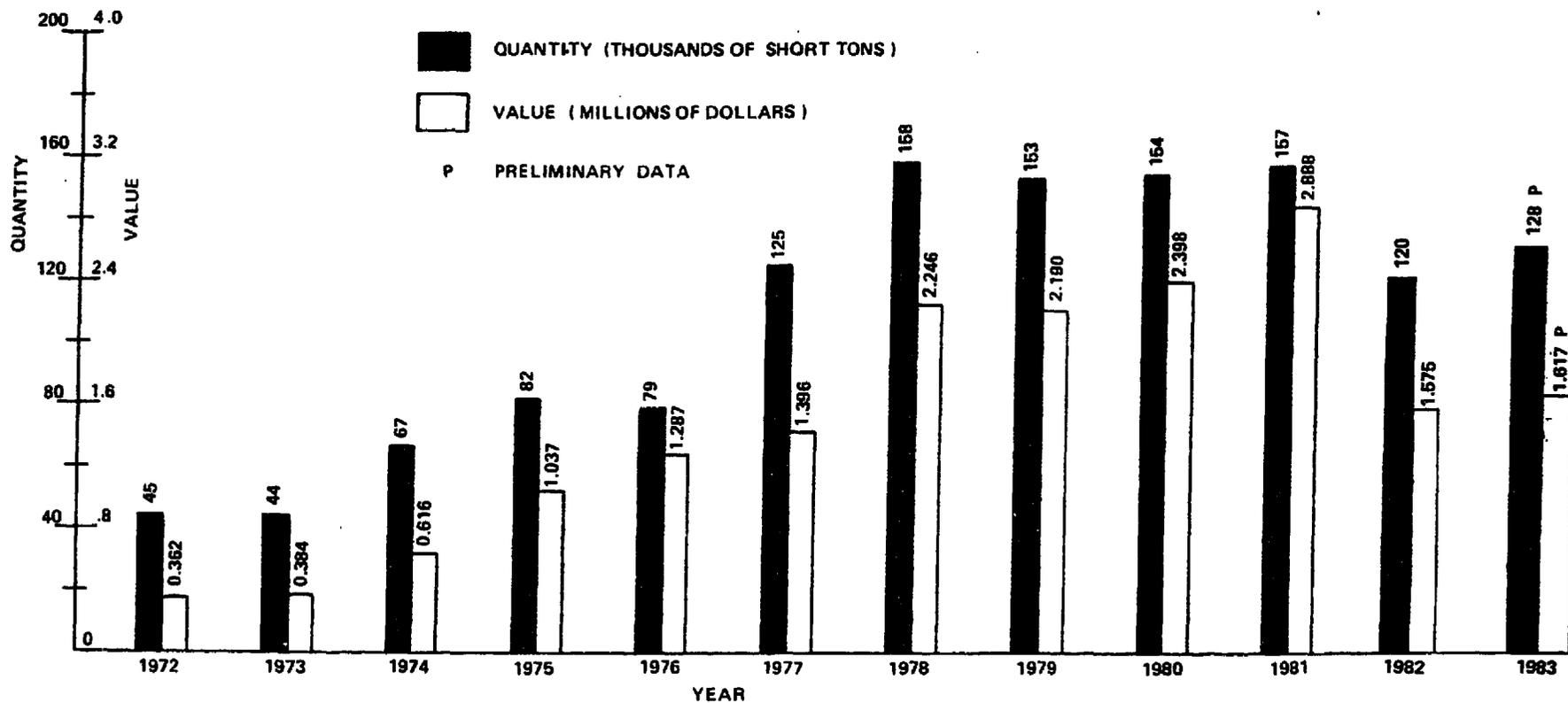


Figure 23. Production and value of peat in Florida. (Compiled from Minerals Yearbooks 1972-1981, U.S. Bureau of Mines; The Mineral Industry of Florida, 1982, U.S. Bureau of Mines; U.S. Bureau of Mines, Mineral Industry Surveys, Annual Preliminary Mineral Industry of Florida, 1983)

County (N-W peninsula), Clay and Putnam counties (N-E peninsula) and in Palm Beach and Dade counties (south Florida). The authors did not locate any active peat producers in the panhandle of Florida.

#### LOCATION OF MARKETS

The majority of Florida peat producers market bulk peat and blend potting soils for regional or statewide distribution. Two companies have only local markets, 11 have regional markets and 6 have statewide markets. Two companies market their product outside of Florida, primarily in the southeast United States. One of the companies, however, ships bulk peat to Texas where it is bagged for retail sale.

#### USE OF PEAT

The principal use of peat mined in Florida is as a soil conditioner, with large amounts being used for lawns, golf courses and in nurseries and greenhouses.

The majority of Florida peat production is marketed as a bulk product (typically 30-50 cubic yard truck loads) for nursery and landscaping purposes, with the remainder bagged for the retail market. The peat may be marketed as is (peat only) or blended with other materials to form topsoil and potting soil products. Blended products are generally custom mixed to the

customers specifications. Quartz sand, sawdust and wood chips are typical ingredients added in order to improve the drainage characteristics of the peat. The nurseries may blend their own potting soil mixes using bulk peat purchased from mining companies. The bulk materials may be utilized as a growing medium for nursery plants, or it may be bagged for retail sale.

Peat from several Florida deposits has been tested for suitability as an alternative boiler fuel. Although tests have indicated that peat can be an effective and price competitive fuel, there is no current peat usage for fuel in Florida.

#### PERMITTING

County, state and federal permits may be required in order to open a new peat mine. The process is very site specific and varies from county to county. Under some conditions, permits may not be required by any agency.

#### COUNTY LEVEL PERMITS

Operational peat mines are located in 12 Florida counties. In most of the counties, zoning regulations are the only county regulations which apply to opening a peat mine. A summary of county permitting processes is shown in Table 3.

TABLE 3: SUMMARY OF COUNTY LEVEL PERMITTING REQUIREMENTS (Prepared by Bureau of Geology Staff)

COUNTY	TITLE OF ORDINANCE	PERMIT REQUIRED	ADMINISTRATIVE AGENCY	PUBLIC HEARING REQUIRED	HEARING BODY	COMMENTS
Clay	Clay Co. Zoning Ordinance 82-45	Borrow Pit	Planning, Building and Zoning Comm.	Yes	Zoning Board of Adjustment	Mining is allowed only as a special exception to zoning regulations. A certified survey and site plan are required. County regulations specify setback and sloping requirements.
Dade	County Zoning Ordinance	Excavation Permit	Building & Zoning Department	Yes	Zoning Appeals Board	Public hearing approval by Z.A.B. is required to obtain excavation permit. No specific zoning required.
Highlands	County Zoning Ordinance	Special Exception	Planning and Zoning Department	Yes	Board of Zoning Adjustment	Permitted in industrial zoned areas; and in agricultural zoned areas after a special exception is granted.
Hillsborough	County Zoning Code and Borrow Pit Ordinance	Borrow Pit	Development Coordination	Yes	County Commission	Requires proper zoning, the issuance Borrow Pit Permit & the approval of the Hillsborough County Environmental Protection Commission.
Lake	Lake Co. Zoning Regulations 1971-6	Conditional Use, Operational	Planning Department	Yes	Planning & Zoning Commission	Allowable only agricultural zoned areas after issuance of Conditional Use Permit. Site plan is required. Before final operational permit will be granted all other permits required (Ex. DER) must have been approved.
Madison	None as of 10-83 Development code if passed:					Development code is expected to pass approximately 1-84. No current regulations cover peat mining.
Orange	Excavation & Fill Ordinance 71-11	Excavation Permit	County Engineering Department	Yes	County Commission	Not zoning dependent, not allowed in planning conservation areas.
Palm Beach	Planning & Zoning Ordinance	Occupational Building, Electrical	Planning and Zoning Department	Yes	County Commission	Land must be zoned agricultural. Site plan must be approved.

TABLE 3 CONTINUED

COUNTY	TITLE OF ORDINANCE	PERMIT REQUIRED	ADMINISTRATIVE AGENCY	PUBLIC HEARING REQUIRED	HEARING BODY	COMMENTS
Pasco	Pasco County Mining Ordinance	Mining Permit	County Planning Department	Yes	County Commission	Mining ordinance refers specifically to inorganic materials, peat may not be covered county source did not know. If covered, mining & reclamation plan, evidence of fiscal responsibility and prior approval of all necessary state and federal permits would be required.
Polk	Polk County Zoning Ordinance & Flood Protection & Surface Water Management Code (81-82)	Conditional Use	Planning Department	Yes	County Commission	Allowed in Rural Conservation Districts only after public hearing approval for conditional use. Polk County is not actively permitting present peat operation & no new permits have been submitted, but the County has the option to do so.
Putnam	Zoning Ordinance of Putnam County 75-5 Amend	None	Building, Zoning & Building Department	Yes	Zoning Board	Allowable as a special exception in agricultural zoned area only.
Sumpter	County Development Code	Excavation Permit	Planning, Zoning & Building Department	No		Allowable in A-5 zones: Require site plan & prior approval of any necessary state & federal permits.

## STATE LEVEL PERMITTING

The primary state agencies with permitting responsibility with respect to peat mining are the Department of Environmental Regulation (DER) and the five individual Water Management Districts. The Department of Community Affairs has jurisdiction over Developments of Regional Impact (DRI).

### Department of Environmental Regulation

A peat mining operation falls under DER jurisdiction only if either of two conditions are met. These criteria are: 1) the operation is located in or would affect surface "Waters of the State;" or 2) there is water discharged off the property or to groundwater. If neither of these conditions apply, then DER does not require a permit (Mark Latch, DER, personal communication, 1984).

The procedure involved is as follows: A site plan is submitted to DER. DER makes a determination as to whether there is jurisdiction and permits are required. If DER does have jurisdiction, the next step is to apply for the applicable permits. Any or all of the following permits may be required by DER depending on the specific site conditions and the site plan proposed: Dredge and Fill; Stormwater; Groundwater; Industrial Waste Water Discharge, NPDES certification; Power Plant Siting and Air Quality.

## Water Management Districts

Four of the five Water Management Districts in Florida have peat mines located within their boundaries. They are the Suwannee River, St. Johns River, Southwest Florida and South Florida Water Management Districts. The permitting required by each management district is discussed below.

### Suwannee River Water Management District

Any wells drilled for water withdrawal or monitoring purposes require well construction permits. Water use permits are required for all uses of water whether the withdrawal is through wells or from surface water bodies. A water use permit is not required for monitor wells (Ron Ceryak, SRWMD, personal communication, 1984).

### St. Johns River Water Management District

There are four permits which may be required by the SJRWMD. They are the Consumptive Use Permit (40C-2), Water Well Construction Permit (40C-3), Management and Storage of Surface Waters Permit (40C-4) and Works of the District Permit (40C-6). The permits and pertinent thresholds are summarized below by Frank Meeker (SJRWMD, Division of Permitting, personal communication, 1984).

A Consumptive Use Permit (CUP) is required to put down a well if it meets certain thresholds. These thresholds are:

1. If the average annual daily withdrawal exceeds 1,000,000 gallons per day on an annual basis,
2. If there is a withdrawal from a combination of wells with a combined capacity of 1,000,000 gallons per day,
3. If the withdrawal equipment has a capacity of 1,000,000 gallons per day,
4. If the outside diameter of the well is 6 inches or greater.

A Water Well Construction Permit (WWCP) is required prior to construction, repair or abandonment of any public supply well having a nominal casing diameter exceeding 4 inches. In the Oklawaha River Basin (all or parts of Marion, Lake, Polk and Orange counties) a permit is required for the same parameters, however, the nominal casing size is reduced to 2 inches. Volusia and Duval counties do not require permits except for public drinking water supply wells.

A Management and Storage of Surface Waters Permit (MSSW) is required when a mining operation exceeds one of several

thresholds. To construct, alter, operate, repair or abandon a project, a permit is required if:

1. It is capable of impounding 40 acre-feet,
2. The project is greater than 40 acres in size,
3. It has 12 or more acres of impervious surface which constitutes 40 percent or more of the total land area.
4. The project has a traversing work which traverses:
  - a. an impoundment of 10 acres or more,
  - b. a stream or watercourse with a drainage area of 5 square miles,
  - c. or a H.S.A. not wholly owned by the applicant.

A Work of the District Permit (WOD) is required to make use of, alter, remove works from or place works within, on or across a WOD. Examples of WODs are the St. Johns River, St. Johns Marsh and the Oklawaha River.

In addition to these rules, the District requires a reclamation plan to mitigate adverse water quality, quantity, com-

pensating storage and environmental impacts. These impacts are directly related to the mining operation. Specific guidelines are listed below and are utilized with site specific information (including soil types, slopes, water levels and vegetation types) to help mitigate the impacts to the water resources and related parameters.

1. On a given site, the littoral zone (that vegetated area around the perimeter of a wetland extending from the mean high water mark to the mean low water mark) will be given prime consideration as an area left in its natural state. Applicant will provide an area equal to a 50 ft. wide belt of the perimeter of the wetland or 20 percent of the total area of the project, whichever is greater.
2. Applicant will leave a 1 foot or greater layer of peat material at the bottom of the excavation, except in those areas where necessary for heavy equipment to operate. In these places, it is acceptable to go down to bare sand to provide a solid roadway; however, this area must be sealed with a 1 foot or greater layer of peat at abandonment and meet any other reclamation requirements.
3. Overburden removal of a new site should coincide with viable seed bank for reclamation. Strips of overburden

from donor marshes can be used in reclamation techniques, providing the total mined strips do not exceed 20 percent of the wetlands existing area and the strips are greater than 150 feet apart.

4. While water levels are still low, heavy equipment will provide any final adjustments to slopes bringing them into compliance with the General Mining Procedures previously discussed or as agreed upon by the applicant and the District. Any breaches of the bottom peat layer which were necessary to facilitate heavy equipment operations will be covered with a 1 foot or greater layer of peat material. Slopes will be adjusted at this time to be shallower than 6 horizontal to 1 vertical from the mean high water mark or an elevation as agreed to by the applicant and the District to a depth of 6 feet below the mean low water mark except for small isolated pockets as identified by District staff in consultation with the applicant on site.
  
5. Mulching of the site with existing overburden, stockpiled overburden or in consultation with District staff donor marsh overburden will be provided to those areas which do not already exhibit a viable seed bank starting at the high water mark or an elevation as agreed to by the applicant and the District, and proceeding to a

depth of 3 feet below the mean low water mark, following the gentle slopes as described above. This mulch material will be disced into the soil to aid stabilization procedures.

6. The area above the mean high water mark or that elevation agreed to by the applicant and the District will be revegetated with native grasses to aid in the prevention of soil erosion. Bahia grass with a hay mulch would be satisfactory for this purpose.
7. It is suggested that no disturbance to the site by livestock during reclamation or initial vegetative establishment will be permitted.
8. Applicant will use best effort and be responsible to see that a viable wetland will be established within two growing seasons.
9. District employees, upon notification to the applicant, will have access to the project to inspect and observe permitted activities in order to determine compliance with reclamation proceedings."

## Southwest Florida Water Management District

The district permitting requirements which could pertain to peat mining are summarized below by Kenneth Weber (SWFWMD, Resource Regulation Department, personal communication, 1984).

"Permits may be required for activities related to peat mining under four chapters of District rules. Under Chapter 40D-2, Consumptive Use of Water, permits are required when surface or ground water withdrawals: (1) exceed 1 million gallons on any single day, or 100,000 gallons average per day on an annual basis, (2) if the withdrawal is from a well larger than 6 inches inside diameter, (3) if withdrawal equipment has the capacity of greater than 1 million gallons per day, or (4) if the withdrawal is from a combination of wells, or other facilities, or both, having a combined capacity of more than 1 million gallons per day. Under Chapter 40D-3, Regulation Wells, permits may be required for construction of any wells 2-inches in diameter or greater, and for test or foundation holes. Under Chapter 40D-4, Management and Storage of Surface Waters, permits are required for various activities involving construction of impoundments, diversions of water involving dikes, levees, etc., operable structures, and rerouting or altering of the rate of flow of streams or other water courses. Under Chapter 40D-6, Works of the District, permits are required 'to connect to, withdraw water from, discharge water into,

place construction within or across, or otherwise make use of a work of the District or to remove any facility or otherwise terminate such activity.' Note that there are specific exemptions to each of these rules."

#### South Florida Water Management District

The South Florida Water Management District has several permits which would be required in the operation of a peat mine.

The permits which would be required are determined on a site specific basis. The possible permits include Surface Water Management, Dewatering, Public Water Supply or General Water Use (dependent on volume) and the Industrial Water Use Permit. District personnel recommend a pre-application meeting with district staff to expedite the permitting process, (Ms. Rebecca Serra, SFWMD, personal communication, 1983).

#### Department of Community Affairs

A mining operation (including peat mining) is considered to be a development of regional impact (DRI) when either of two criteria are met. The criteria are (1) when more than 100 acres per year are mined or disturbed and (2) when water consumption exceeds 3 million gallons per day. (Sarah Nall, Department of Community affairs, personal communication, 1984).

## FEDERAL LEVEL PERMITTING

Two federal agencies, the Army Corps of Engineers (ACE) and the Environmental Protection Agency (EPA) have permitting jurisdiction which may apply to peat mining. Each agency will be discussed below.

### Army Corps of Engineers

The Army Corps of Engineers (ACE) operates under two federal acts: The Rivers & Harbors Act and the Clean Water Act (Vic Anderson, ACE, personal communication, 1984). Both acts apply in navigable waters, however, only the Clean Water Act applies in non-navigable water. The legislative mandate of the Clean Water Act is to "restore and maintain the physical, chemical and biological integrity of the nation's water." Authority under the Clean Water Act extends up tributaries and headwater streams to the point where average annual flow is 5 cubic feet per second (CFS). ACE has discretionary authority upstream of this point if 1) toxic materials are released, 2) wild or scenic rivers will be affected, 3) endangered species are involved, 4) the operation will result in downstream turbidity or erosion, or 5) the EPA requests ACE involvement. Individual permits are required under the River & Harbors Act (navigable waters) and under the Clean Water Act up tributaries to the 5 CFS mean annual flow point, or beyond if conditions warrant the involvement. When conditions do

not warrant involvement above the 5 CFS point, the regulations state that the activity is covered by a nationwide permit.

### The Environmental Protection Agency

In the past, the EPA has administered air quality and water quality permitting programs. Air quality regulation and permitting has been delegated to the Florida Department of Environmental Regulation. The state of Florida requires permits for all sources of air pollution. The EPA still controls the National Pollutant Discharge Elimination System (NPDES) permitting. A NPDES permit is required for any operation which would result in discharge to the surface water of the U.S. (this includes "waters of the state"). The NPDES permit is required even for intermittent discharges (Mark Latch, DER, personal communication, 1984).

### PEAT REVENUE AND TAXATION

The volume of peat sales in the state of Florida generally increased from 1972 to 1978 (figure 23). During the same period the value of peat also increased. The value and tonnage fluctuated from 1978 through 1981 prior to a rather drastic decrease in 1982. In 1982, the quantity dropped 25 percent from the estimated tonnage (Boyle and Hendry, 1984) and 24 percent from the previous year. The 1982 value was 47 percent below the predicted

level (Boyle and Hendry, 1984) and 45 percent less than 1981. Figure 23 reflects these trends as compiled by the U. S. Bureau of Mines.

The differences between the predicted and actual numbers for peat mining in Florida is significant in two important ways. First, the differences reflect the recent recession which had a tremendous effect on the mineral industries as a whole with greatly declined production and value. Secondly, future revenue estimates for peat from the Florida Department of Revenue are based on the trends of the recent past. The recently released 1982 figures may indicate a drastic change in the trend and may require a significant alteration of the previously predicted peat values for 1983-1984 which were \$3.9 million (figure 23). The peat industry may rebound to its previous levels. However, in light of a 1982 value of \$1.575 million, it seems highly unlikely that a value of \$3.9 million would be achieved in 1983-1984.

Currently, the vast majority of peat sales in Florida are wholesale and for agricultural purposes and, as such, are exempt from state sales taxes. Some peat products are used in potted plants and sales taxes are collected on retail sales of the potted plants. However, the value of the peat and the tax upon that value are not separated from the value and tax on the total sale. Thus, the amount of tax arising from retail sale of peat cannot be determined. Also, there are no records for sales tax applied to peat based potting soils (L. Voorhies, Department of Revenue, personal communication, 1983). As a result, there is no

way of estimating the current tax income derived from the exploitation of peat resources in the state of Florida.

Estimated tax revenues derived from the imposition of a severance tax on peat could be determined from the revised predicted values for the near future. The Florida Department of Revenue does not currently have such an estimate available.

## POTENTIAL ENVIRONMENTAL IMPACTS OF PEAT MINING

### THE EFFECT OF PEAT MINING ON WETLANDS

Cowardin and others (1979) define wetlands as "...lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water." This definition encompasses a number of environments which are commonly associated with the accumulation of peat including bottoms of lakes, vegetated and forested wetlands (such as swamps, heads and sloughs), scrub or shrub wetland (such as shrub swamp, mangrove swamp, pocosin and bog) and emergent wetland (such as marsh, fen and bog). This general definition of wetland may not apply to all of Florida's myriad wetland environments. The complexity of Florida's wetlands is reflected in the various classification systems designed especially for them. Appendix B describes several classifications developed specifically for use in the state which list and describe various wetland environments of Florida. King and

others (1980) note that state and federal land management and environmental agencies will classify most peatlands as wetland habitats. It was also noted by those authors that peatlands falling into a wetlands land use category would be closely scrutinized so that it would be necessary to demonstrate substantial benefits to the state, in order for land use permits to be secured.

It is generally accepted that peat mining in a wetland environment will modify the existing system. It is, thus, instructive to examine the various functions attributed to wetlands. The hydrologic functions of wetlands are summarized by Carter, et al. (1978). Hydrologic functions include: flood storage and storm flow modification, base flow and estuarine water balance, recharge, indicators of water supply, erosion control and water quality. Flood storage and storm flow modification, base flow and water quality are treated in sections of this report dealing with water resources and water quality. Estuaries are characterized by a balance between fresh water (from landward sources) and salt water (from seaward sources). Rivers which flow into estuaries may be flanked by wetlands which are flooded on occasion due to increased river discharge combined with tidal action. Waters which temporarily reside in wetlands lose some of their nutrient load as well as sediment load. They likewise gain organic detritus and decomposition products which are passed on to the estuary for entry into certain food chains. Temporary residence in wetlands causes a decrease in velocity

which aids in controlling both timing and volume of fresh water influx (Carter, et al., 1978).

Recharge occurs when water moves into an aquifer. Carter and others (1978) note that there is considerable disagreement concerning the role of wetlands in recharge. It is noted that while some recharge may occur in wetlands, all wetlands are not recharge areas. Little information in the literature supports the idea that significant recharge occurs in wetlands. Some studies indicate that most wetlands are discharge areas while a few provide limited recharge (Carter, et al., 1978).

Recharge in wetlands is not completely understood but is apparently limited in its extent. Confusion in the literature suggests that generalizations concerning recharge in wetland areas should be made with caution and that site specific studies may be needed in order to understand individual systems.

In certain geologic settings, development of a wetland may indicate favorable areas in exploration for groundwater. Carter and others (1978) note that a wetland developed on a floodplain of water-saturated sand might serve as an indicator of potential water supply while simultaneously reducing groundwater levels by evapotranspiration and the inhibition of downward percolation of water.

Wetlands have been cited as having a role in the control of both inland and coastal erosion (Carter, et al., 1978). This role is dominantly related to wetland vegetation which is described as serving three primary functions including: 1)

binding and stabilization of substrate, 2) dissipation of wave and current energy and 3) the trapping of sediment. Substantial evidence exists suggesting that native plants are an effective part of natural erosion control along river and lake shorelines. Limitations to that effectiveness arise since vegetation can be undermined by wave and water, severely damaged by floating debris or covered by debris and silt during floods (Carter, et al., 1980). Vegetation performs a function in coastal wetlands similar to that documented for inland lakes and rivers. It is noted, however, that the ability of wetlands to mitigate the catastrophic flooding from storm surge in combination with wind and high tide may be relatively small (Carter, et al., 1978).

Brown and others (1983) list the following biological functions of wetlands: 1) wildlife utilization, 2) life form richness and 3) gross primary productivity. Wildlife use measures the diversity of species inhabiting a given community. It is the summation of amphibians, reptiles, mammals and birds which commonly inhabit any wetland community. Life form richness refers to diversity in the physical structure or growth habits of plants. Various life forms comprise trees, shrubs, emergents, surface plants and submergent plants (Brown, et al., 1983). Gross primary production measures plant matter during the growing season that may eventually become food for various consumers. Gross production is important since it is the first step in the food chain (Brown, et al., 1983).

Peat is very frequently found in wetland environments, since

waterlogging is necessary in order for peat to accumulate and be preserved. The mining of peat in wetlands will of necessity modify the wetland system from which peat is taken. The hydrologic functions of a wetland are site specific (a wetland may or may not perform any given function) and, thus, impacts of mining will also be site specific. Biologic functions of wetlands include the support of a diverse flora and fauna and also the gross primary productivity of the environment itself. The modification of wetland systems associated with mining will result in displacement and possibly in some cases death of flora and fauna specially adapted to an individual wetland environment. Florida Statutes pertaining to wetland regulation are included in Appendix C of this document.

#### THE EFFECTS OF PEAT MINING ON WATER QUALITY

This discussion is primarily from a study of environmental issues associated with peat mining prepared for the United States Department of Energy by King and others, 1980.

The water quality of surface waters flowing from a peatland is characteristic of the peatland and controls to some extent aquatic habitats both onsite and downstream. Peat mining will be accompanied by discharge of water from drainage as well as waste water derived from the processing of peat for energy purposes. The release of organic and inorganic compounds is thought to be

capable of generating a number of water quality impacts (King, et al., 1980). The following water quality characteristics are listed in decreasing order of importance. It is also noted that this list may not include all possible water quality problems. Table 4 ranks water quality issues with respect to scales of peatland development:

1. Low pH
2. High BOD/COD
3. Nutrients
4. Organic Compounds
5. Colloidal and Settleable Solids
6. Heavy Metals
7. Carcinogenic and Toxic Materials

Water discharged from a peatland may be acidic in character because waters entering the peatland lack natural buffering capacity. Additionally, hydrogen ion production and organic acids produced by plant photosynthesis and decomposition contribute to the acidic nature of waters from peatlands. The pH values from ombrothrophic peatlands range from 3 to 4 and from minerotrophic peatlands range from 4 to 8 (King, et al., 1980). Although these low pH values are of completely natural origin, they can result in significant changes to the aquatic ecosystem. These changes may include species specific fertility problems, morbidity, mortality and mobility problems as well as other physical and physiological problems (King, et al., 1980).

The discharge of waters resulting from peatland drainage as

**TABLE 4**  
**WATER QUALITY ISSUES ASSOCIATED WITH PEAT MINING (Taken from King, et al., 1980)**

PRIMARY ENVIRONMENTAL RESOURCE ISSUE	SCALES OF DEVELOPMENT								
	SMALL			MODERATE			LARGE		
	MAJOR	MODERATE	MINOR	MAJOR	MODERATE	MINOR	MAJOR	MODERATE	MINOR
DISCHARGE LOW pH WATER	X			X			X		
DISCHARGE HIGH BOD/COD	X			X			X		
DISCHARGE NUTRIENTS	X			X			X		
DISCHARGE COMPOUNDS		X			X		X		
DISCHARGE COLLOIDAL & SETTLEABLE SOLIDS		X			X		X		

well as discharge of water released by the dewatering process may create Bio-chemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The dissolved oxygen levels in surface streams are crucial for protection of fishery resources. These oxygen levels may be depressed as a result of increased turbidity within the stream and the decomposition of soluble and insoluble material by aerobic microbiota.

Peatlands are known to store nitrogen and phosphorus. Thus, concern exists that, during drainage and processing, significant amounts of these nutrients could be released to receiving waters. If nutrient supplies are increased, eutrophication rates would increase and changes in the aquatic ecosystem would occur (King, et al., 1980).

Peat contains a number of organic acids. These compounds (fatty acids, humic acids, amino acids, tannic acids and other organic acids) are partially responsible for the low pH values associated with waters from peatlands. The release of waters containing such compounds as a part of the drainage and dewatering process could have a direct toxicological effect on aquatic organisms.

Peat, since it is derived from an accumulation of plant material, may also contain microlevels of heavy metal ions which were used by original plants for life processes. Heavy metal ions are also derived from fallout of pollutants directly onto the surface of the peat and from the filtering of surface waters by peats. If peats are exploited as a fuel resource, they must

be drained and dewatered and, eventually, processed for energy production. This processing may lead to the release of metals to the air and water.

It is suggested (King, et al., 1980) that all effluent streams be monitored qualitatively and quantitatively to determine the characteristics of organic chemicals being released. Harvesting of peat and its processing for energy may possibly lead to an inadvertent release of toxic inorganic compounds and phenols. It is important to note that release of these materials may not necessarily occur. Peat mining and subsequent processing for energy, however, have not been extensively practiced in the United States and monitoring is suggested as means of offsetting this lack of experience.

The mining and dewatering of peat may result in the release of colloidal and settleable solids into receiving streams. Peat itself comprises water-soluble colloidal material and small particles of cellulose and fibrous material. The nature of these materials and of the constituents which may become adsorbed onto them is such that oxygen levels are expected to be depressed. Additionally, the transport of nutrients which might lead to eutrophication and heavy metals might be increased.

Three states which have begun to cope with water quality aspects which might accompany the mining of peat for energy include Minnesota, North Carolina and Florida. Appendix D of this document includes lists of water quality parameters chosen for measurement by each state. The lists are different,

since they were prepared for somewhat different purposes. The state of Minnesota, after an extensive literature review, concluded that baseline data was needed. A study was devised in which 33 water quality parameters were monitored in 45 undisturbed peatlands in northern Minnesota. The list of parameters being monitored in North Carolina has been developed for the assessment of wastewater discharge in conjunction with a proposed peat to methanol plant at Creswell, North Carolina. The Florida Department of Environmental Regulation has required monitoring of 26 water quality characters in a permit for construction of a storm water disposal system associated with mining of peat in central Florida (Putnam County).

#### THE EFFECT OF PEAT MINING ON WATER RESOURCES

##### Water Resources in an Undisturbed System

The mining of peat will cause changes in the hydrologic budget associated with a peatland. The changes could be helpful or possibly be detrimental, but the system will change. In order to better understand the changes which are discussed in the next portion of the text, it is instructive to examine the system as it operates naturally.

The hydrologic cycle is used by geologists to describe what happens to water which falls to the earth as precipitation. The

water which falls as precipitation has a number of possible fates. It may evaporate from falling rain and never reach the earth's surface. It may be taken up by the roots of plants, carried to the leaves and returned to the atmosphere by transpiration (the process by which the foliage of plants releases water vapor). Evaporation, which returns water to the atmosphere, occurs from soil, from the surfaces of lakes, rivers and oceans, even from the dew which collected on plants. Some portion of the rain which falls does reach the earth's surface and flows across it to reach lakes, streams or possibly the ocean. This portion is referred to as runoff. Some part of rainfall soaks into the ground (infiltration). A portion of the water which soaks into the ground will make its way slowly to streams or lakes, and in certain areas, some of this water may enter a porous and permeable rock unit referred to as an aquifer.

For a given geographic area, geologists may estimate the proportion of water which is lost to the processes of evaporation and transpiration. Measurements are made so that geologists are familiar with average values of stream discharge, and lake levels. The depth to the water table may be measured. (The water table is the level below which pores in the rock or sediments are filled with water and above which they are partly or totally filled with air.) The measurements may be used to make up a hydrologic (water) budget for a given area. Thus, water resources are a system. If one aspect of the system is modified, other aspects change in response to the modification.

## Water Resource Parameters Affected by Peat Mining

This discussion is primarily from a study of environmental issues associated with peat mining, completed for the United States Department of Energy by King and others, 1980.

In a study which deals solely with environmental issues arising from mining of peat, King and others (1980) report that the development required for mining will modify natural groundwater and surface water characteristics of the mined area. Net changes both on and off site will be a function of the size (or scale) of the operation, the mining procedures which are employed and technology used for energy processing following mining. Water resources issues listed in decreasing order of their importance include:

1. Floodwater Runoff Response
2. Groundwater Elevations
3. Salt Water Intrusion
4. Surface Flow Patterns
5. Minimum Stream Discharges
6. Mean Surface Water Discharges
7. Hydrological Budget
8. Groundwater Aquifers
9. Evapotranspiration Rate

Table 5 lists various water resource parameters which might be affected by development of peat mining operations. The opera-

**TABLE 5**  
**WATER RESOURCE ISSUES ASSOCIATED WITH PEAT MINING (Taken from King, et al., 1980)**

DEGREE OF CONCERN	SCALES OF DEVELOPMENT								
	SMALL			MODERATE			LARGE		
	MAJOR	MODERATE	MINOR	MAJOR	MODERATE	MINOR	MAJOR	MODERATE	MINOR
INCREASED FLOODWATER FLOW POTENTIAL			X		X		X		
GROUNDWATER ELEVATIONS MODIFICATION			X			X		X	
POTENTIAL SALT WATER INTRUSION			X		X			X	
MODIFICATION OF SURFACE WATER FLOW PATTERNS			X			X		X	
INCREASE MINIMUM STREAM DISCHARGES			X			X			X
INCREASE MEAN SURFACE WATER DISCHARGE			X			X			X
ALTER THE HYDROLOGICAL BUDGET			X			X		X	
ALTER GROUNDWATER AQUIFER			X			X		X	
REDUCE EVAPO-TRANSPIRATION			X			X			X

tions are classified into three size groups and each water resource parameter is evaluated in terms of the effects of small, moderate and large scale development. Obviously, the hydrologic characteristics of each individual site must also be considered in determining the extent to which a given peat mining development will modify a specific water resource parameter. Mining operations are classified as small, moderate or large based on the peat they require and the amount of energy they produce.

A small peat operation (1 megawatt - MW) would require approximately 6.5 acres of peat, 6 feet in depth per year. The total amount of peat consumed in an operation projected to last four years would be approximately 26 acres mined to a depth of 6 feet. A peat operation of moderate scale (60 MW) is projected to consume approximately 3,500 acres of peat averaging 6 feet in depth over a 20 year period. An operation categorized as large (800 MW) would require approximately 125,000 acres of peat to operate for 20 years (King, et al., 1980).

Development which accompanies peat mining and subsequent reclamation may change an area's floodwater response. The extent of this change will vary with the size of the development itself. Some factors accompanying development will tend to increase flood flows and other factors will tend to decrease them (King, et al., 1980). The net effect of these potential opposing factors will have to be evaluated for each site specifically. King and others (1980) suggest that appropriate state agencies define downstream flood prone areas so that they may be protected from large or

moderate peatland developments at upstream sites.

Drainage of mined areas and potential ponding will cause changes in groundwater levels. Groundwater levels are of prime concern in choosing an appropriate mining method. The groundwater levels in peatlands may also influence groundwater levels in aquifers which are connected hydrologically (King, et al., 1980). It is important to define the relationship, or lack of relationship, between peatlands which are to be mined and aquifers which might possibly be affected by removal of peat.

If coastal peatlands are to be mined, the drainage necessary to reduce water levels could possibly lead to saltwater intrusion. In addition, groundwater recharge may be reduced and groundwater levels could be lowered (King, et al., 1980). The combination of these three effects could lead to saltwater intrusion and King and others (1980) suggest the effects of this change should be researched carefully before development.

Peat mining will require construction of drainage ditches, water control devices and roads among others. Thus, the patterns of surface water flow in the mined area and in downstream channels will be modified (King, et al., 1980).

It is believed (King, et al., 1980) that peatland development will increase minimum stream discharge. Net evapotranspiration from the peatland will be reduced since vegetation must be cleared in order for mining to occur. Thus, a greater portion of net precipitation will drain. As ditches are constructed, more of the peatlands will be able to contribute flow directly to

artificial surface streams (King, et al., 1980).

A number of factors associated with peat mining will serve to increase mean surface water discharge. If the mining method chosen involves drainage, then water being drained will be added to surface water discharge. Additionally, mined peat will have to be dewatered, so another addition to surface water discharge occurs. It is projected (King, et al., 1980) that the effects of a small scale development on mean surface discharge would be minor. Proposed moderate and large scale mining operations should be evaluated on a site specific basis to protect downstream water users and aquatic resources (King, et al., 1980).

The development and reclamation of a peatland will permanently change the hydrologic budget of the area (King, et al., 1980). These changes may be helpful or detrimental offsite.

If peatlands contribute to aquifers in a given area, then the effect of positive or negative changes affecting that aquifer should be researched. The groundwater flow from peatlands to connected regional aquifers will change with mining (King, et al., 1980).

Lastly, the evapotranspiration rate from the mined area will change (King, et al., 1980). Since mining involves removal of surface vegetation, net evapotranspiration will be reduced. Ditching will lower the groundwater level and cause a moisture deficiency in the upper portion of the drained area which will contribute to a lower net evapotranspiration rate. Although the

effects of these changes are expected to be minor for all scales of development, the modifications in adjacent plant and animal communities and in local climate are poorly understood (King et al., 1980).

#### THE EFFECTS OF PEAT MINING ON AIR QUALITY

This discussion is taken primarily from a study of environmental issues associated with peat mining prepared for the United States Department of Energy by King and others (1980).

The mining and storage of peat, as well as its processing for energy purposes, will produce certain air quality impacts. Expected major air quality concerns are related to fugitive emission factors from large-scale mining and storage operations. Overall particulate emission problems are generated during dry mining, transportation and storage of peat. Small and moderate scale peat-fired power plants are expected to produce less air quality impacts than equivalent coal burning plants. Airborne emissions associated with a large synthetic natural gas plant can only be discussed on a generalized basis. Table 6 lists a number of air quality issues in order of their projected importance (King, et al., 1980).

Milled and sod peat mining methods both require that peat be drained previous to mining and also dried on the ground. Drying peat may be suspended by wind or mechanical action. After peat is dried, it must be collected, stored, transported and restored.

TABLE 6  
 AIR QUALITY ISSUES ASSOCIATED WITH PEAT MINING (Taken from King, et al., 1980)

DEGREE OF CONCERN	SCALES OF DEVELOPMENT								
	SMALL			MODERATE			LARGE		
	MAJOR	MODERATE	MINOR	MAJOR	MODERATE	MINOR	MAJOR	MODERATE	MINOR
HARVESTING EMISSION FUGITIVE DUST			X		X		X		
CARBON MONOXIDE EMISSIONS			X			X		X	
NITROGEN OXIDE EMISSIONS			X		X			X	
SULFUR OXIDE EMISSIONS			X			X			X
PARTICULATE EMISSIONS			X			X		X	
NONMETHANE HYDRO-CARBON EMISSIONS			X			X		X	
PHOTO CHEMICAL OXIDANTS			X			X		X	
HEAVY METAL EMISSIONS			X			X			X
REDUCED SULFUR COMPOUND EMISSIONS			X			X			X
NITROGEN COMPOUND EMISSIONS			X			X			X
HALOGEN COMPOUND EMISSIONS			X			X			X
VISIBILITY REDUCTION		X			X		X		
WATER VAPOR EMISSIONS			X			X			X
CARBON DIOXIDE EMISSIONS			X			X			X

All of these steps may result in loss of peat to the atmosphere (King, et al., 1980).

Carbon monoxide will be emitted from the direct combustion of peat. Carbon monoxide is not easily collected in air scrubbers and emissions may be improved only by improving the combustion process (King et. al, 1980).

Nitrogen oxides are formed when fuels are burned in air. Emission of nitrogen oxides from direct combustion of peat fuel may exceed allowable levels.

Various sulfur oxides ( $SO_x$ ) may be emitted when peat is burned. Peat is relatively low in sulfur and, thus, may not result in severe emission problems (King, et al., 1980). A. Cohen (personal communication, 1984) notes that sulfur must be determined on a site specific basis and further comments that it may especially be a problem in coastal areas.

The strong affinity of emitted  $SO_2$  and  $SO_3$  for water causes formation of droplets in the emissions plume. The long distance transport of these emission products can result in acid rains in areas remote to the plant site (King, et al., 1980).

King and others (1980) report that direct combustion of various forms of peat fuel may generate particulate matter including sulfate, heavy metals, polynuclear aromatic hydrocarbons and some particles in the submicron range.

Non-methane hydrocarbons resulting from incomplete combustion of peat may react in the atmosphere to form photochemical oxidants (ozone). Non-methane hydrocarbons include polynuclear aro-

matic hydrocarbons which are carcinogenic at very low levels and stable in the environment. Most control strategies for ambient ozone involve emission controls on non-methane hydrocarbons (King, et al., 1980).

Photochemical oxidants (ozone) may be derived from direct burning of various forms of peat fuel. They are formed in the atmosphere from non-methane hydrocarbons and nitrogen dioxide and are controlled by emission controls on non-methane hydrocarbons.

Metals may be concentrated in the organic or inorganic fraction of peat as a consequence of water flow through peat or by deposition from the atmosphere. These metals may be volatilized at high combustion temperatures or emitted as gaseous molecules. The behavior and effects of these metals are complex (King, et al., 1980).

Emissions of reduced sulfur, nitrogen compounds and halogen compounds may all exceed allowable levels from synthetic fuel plants (King, et al., 1980). The effects of reduced sulfur emissions and nitrogen compounds (other than  $\text{NO}_x$ ) are dependent on meteorological conditions and ambient air chemistry and quality. The emissions of particulate matter and plume condensation may cause visibility reduction in the immediate vicinity of the combustion source when various forms of peat fuel are burned directly. The extent of this effect will depend on the rate of wind dispersion of emitted materials (King, et al., 1980).

Combustion sources will generate water vapor which may con-

dense and precipitate downwind of the processing plant. If water vapor combines with  $SO_x$ , acid mists may be formed (King, et al., 1980).

Production of peat energy will necessitate emission of carbon dioxide. The production of  $CO_2$  will contribute to the global carbon dioxide build-up, the significance of which is still subject to debate (King, et al., 1980).

#### THE EFFECTS OF MINING ON TOPOGRAPHY

Peat is currently mined from deposits formed in a number of specific geologic settings. These include bayhead swamps, closed depressions or karst basins, river valley marshes and large, flat, poorly drained areas such as the Everglades.

Closed depressions or karst basins occur predominantly in north and central Florida. The depressions or basins are the result of sinkhole formation and do not have surface outlets for water. Topography of this type of deposit is shown in figure 24.

River valley and bayhead swamp deposits occur throughout much of the state. Notable examples of these are the upper St. Johns River Valley and Oklawaha River Valley peat deposits (figure 13) and the Santa Fe Swamp peat deposit (figure 14). These areas have surface drainage by streams and rivers. The general topography of the deposits is shown in figures 25, 26 and 27.

In general, the large, flat, poorly drained areas of peat

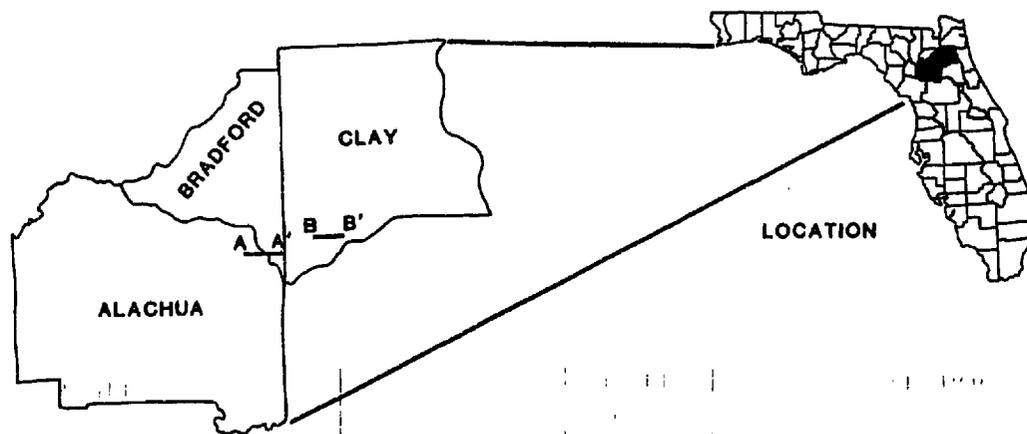
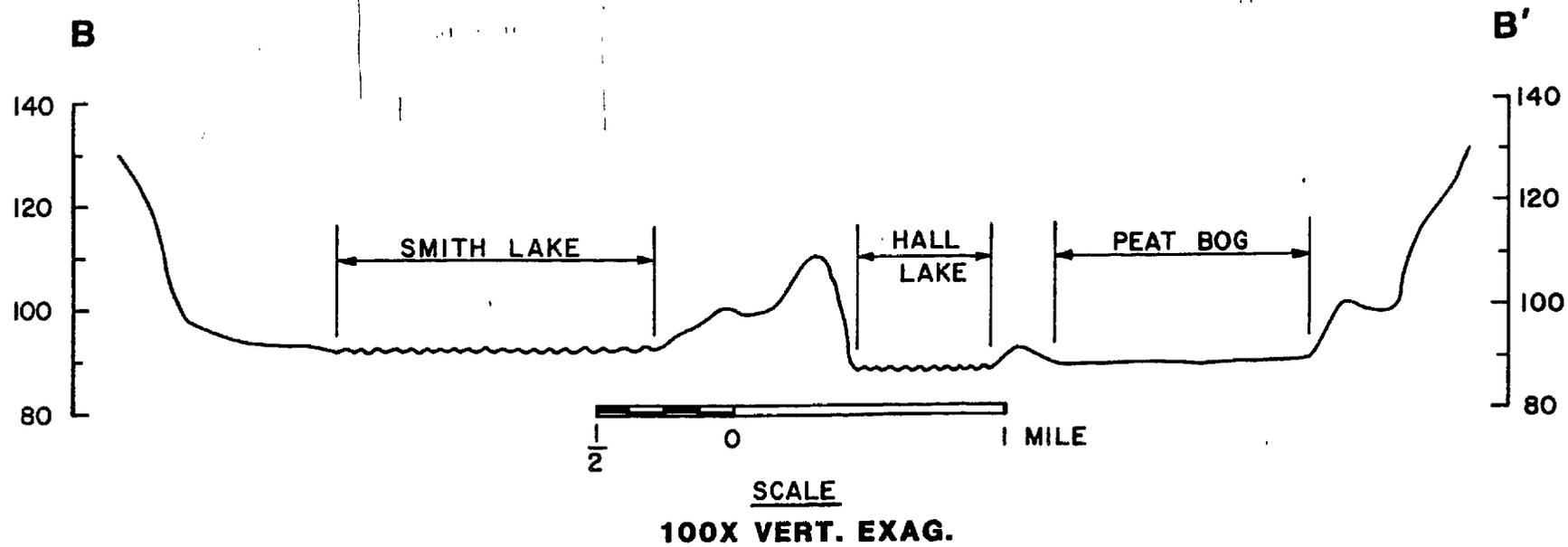


Figure 24. Topographic profile of a karst basin peat deposit in North Florida. (Prepared by Bureau of Geology staff for this study)

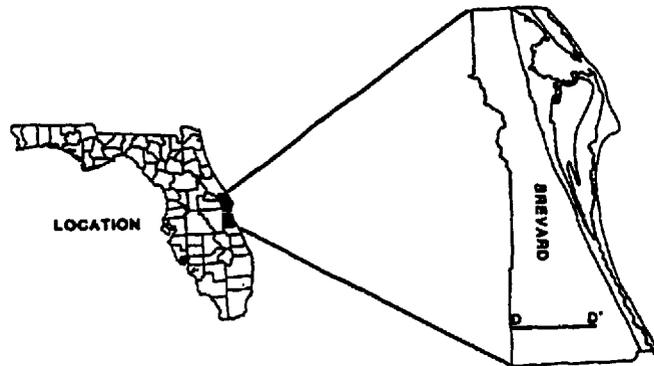
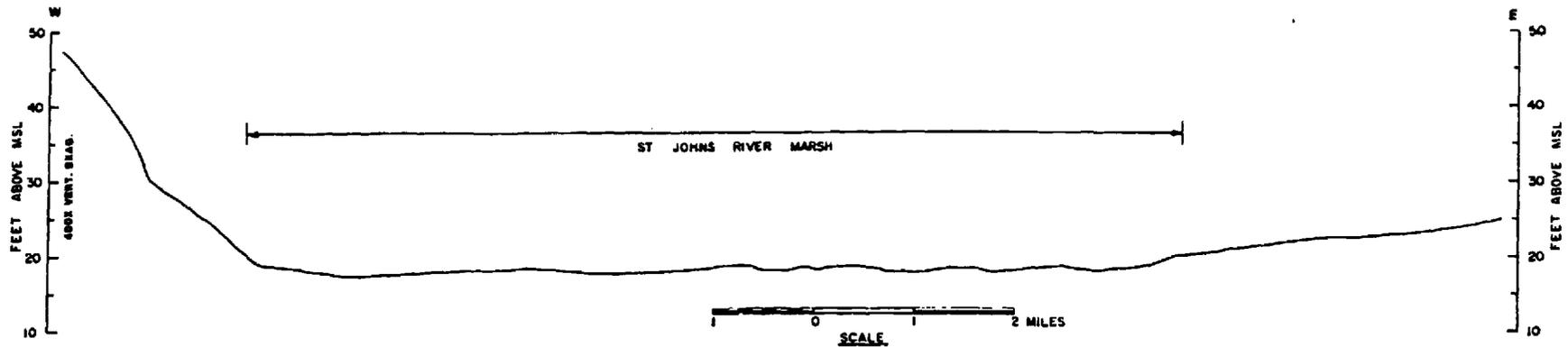


Figure 25. Topographic profile of St. Johns River Marsh peat deposit in southern Brevard County. (Prepared by Bureau of Geology staff for this study)

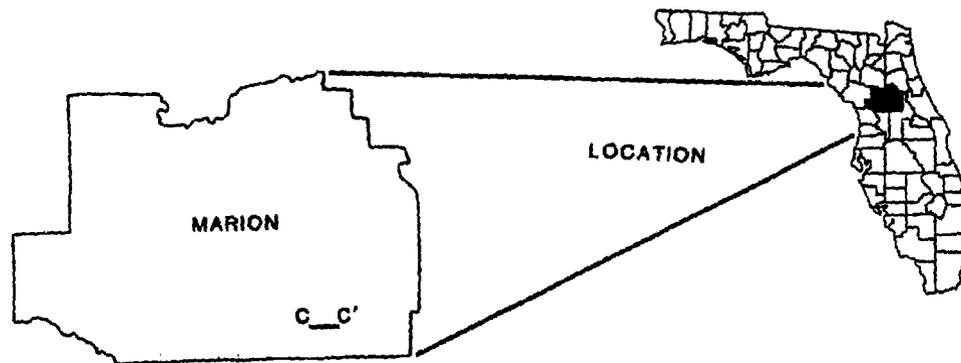
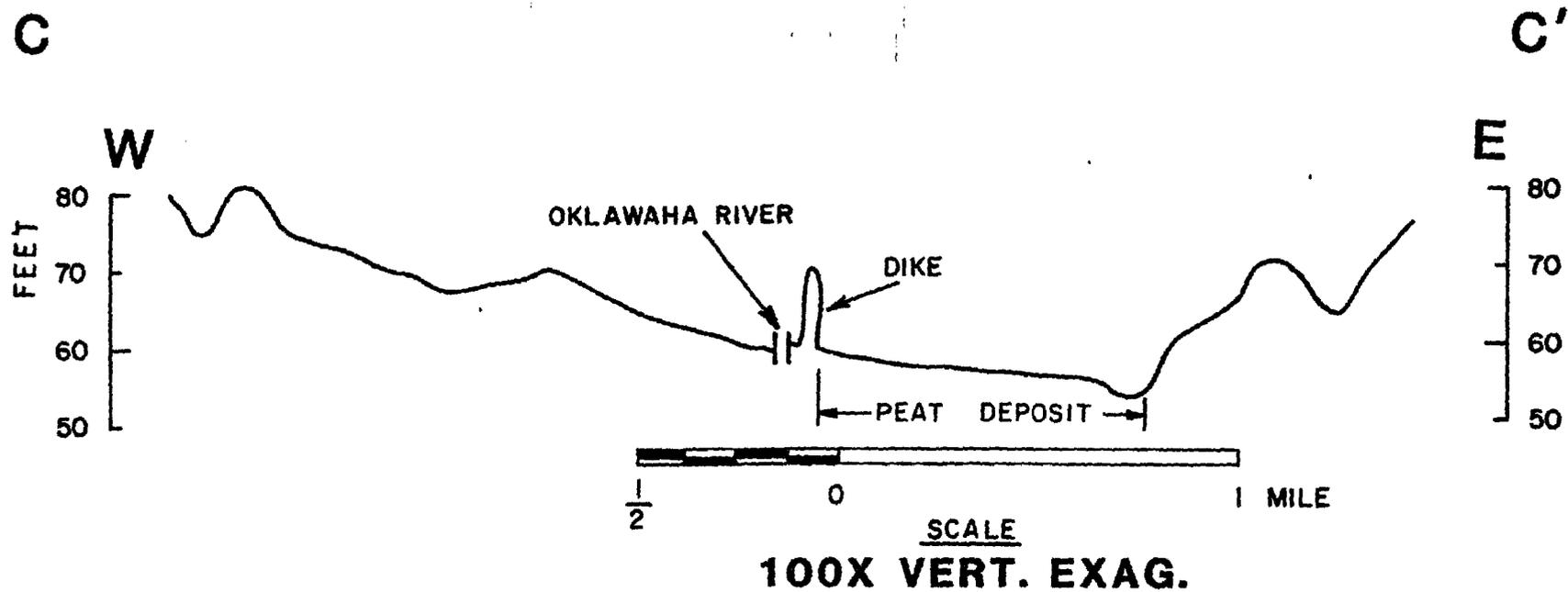


Figure 26. Topographic profile of the Oklawaha River peat deposit in Northern Lake-Southern Marion counties. (Prepared by Bureau of Geology staff for this study)

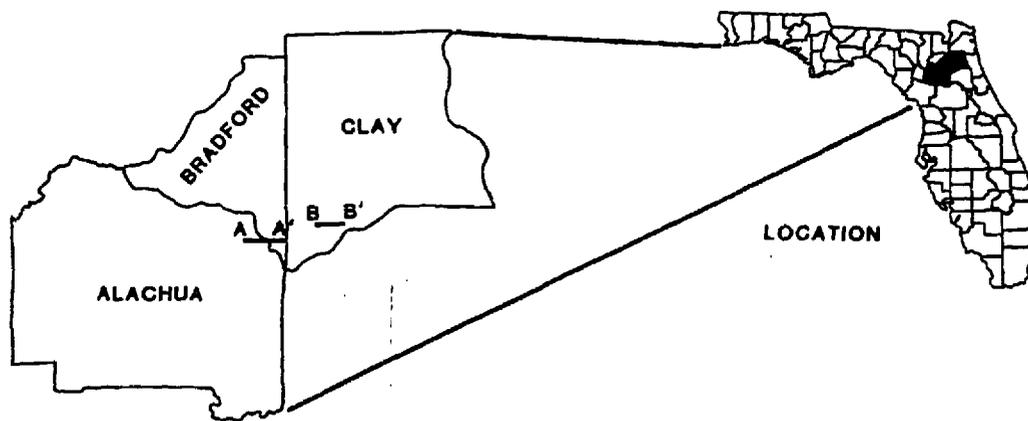
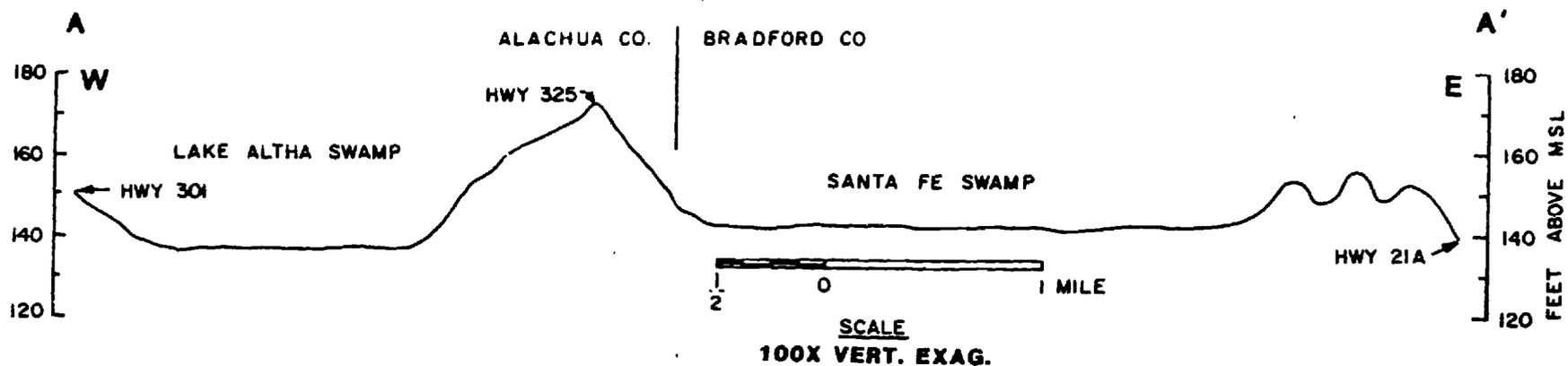


Figure 27. Topographic profile of the Santa Fe Swamp peat deposit in Alachua and Bradford counties. (Prepared by Bureau of Geology staff for this study)

development are in south Florida, south of latitude 29°N (Davis, 1946). The Everglades and its associated peats are a typical example of this type of peat deposit. The topography of this type of deposit is shown in figure 28.

The topography of other peat forming environments can be seen in the cross sections showing the cypress dome type of peats (figure 6). These, however, are not typically mined.

The peat mining process is an excavation process which removes the original surface vegetation and significantly alters the topography of the terrain. Various types of equipment are used to remove the peat and waste material, leaving a water filled (dry, if pumped) pit. During the course of mining, the size of the existing pit may vary from less than one acre to tens of acres. This depends on areal extent of the deposit, thickness of the peat and rate of production.

Stock piles and waste piles are the result of the mining process. The stock piles are created to allow the peat to dry prior to shipping. These piles vary in size and shape during the life of the mine and are not present after mining is completed, having been depleted as peat is sold. The waste piles, on the other hand, are not sold and remain after the completion of mining. The waste material generally consists of peat that is too contaminated with weed seeds and sediment to be used. Generally, at the completion of mining, the waste piles are leveled and spread around the mine site. This is not always true since there are no required reclamation procedures for peat

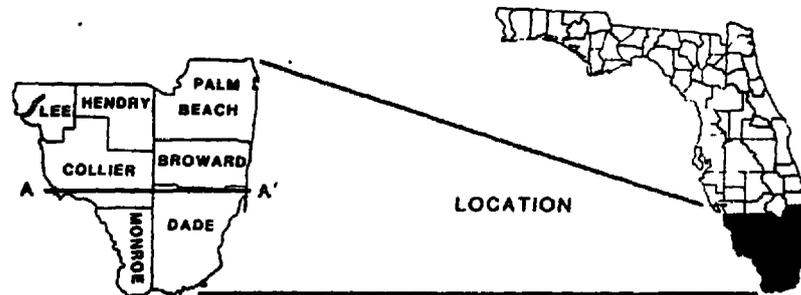
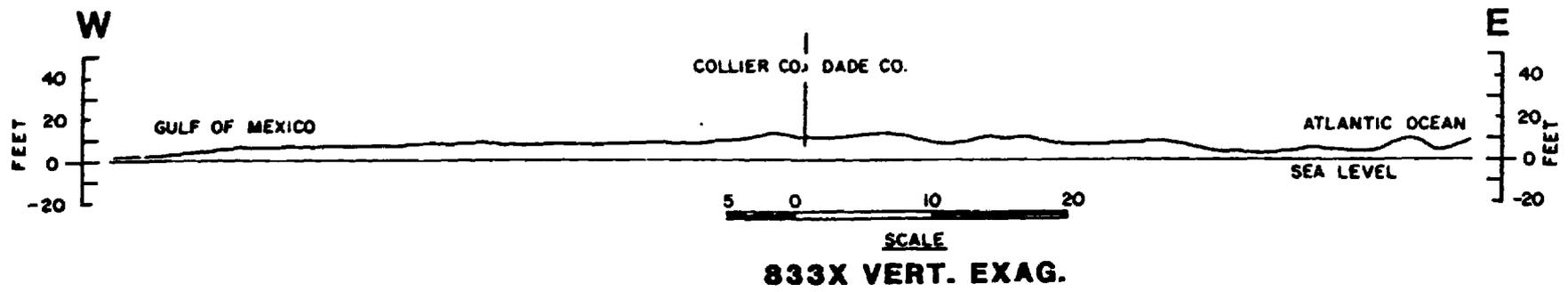


Figure 28. Topographic profile of the Everglades in Collier and Dade counties. (Prepared by Bureau of Geology staff for this study)

mines. Field investigations suggest, however, that most operators level the site at the completion of mining.

The post-mining topography resembles the pre-mining topography if the waste piles are removed. The notable exception is that an open body of water may be present where the peat has been removed.

#### ENDANGERED SPECIES ASSOCIATED WITH AREAS OF POTENTIAL PEAT MINING

Areas of peat accumulation are associated with specific wetland habitats and contain specific faunal and floral communities. The mining process, of necessity, removes existing vegetation and significantly alters the immediate environment of the active mine. As a result of these altered habitats, indigenous fauna may be forced out while native flora is destroyed.

The major wetland habitats in Florida are coastal marshes, freshwater marshes, wet prairies, cypress swamps, hardwood swamps and mangrove swamps. These are briefly discussed below using information taken from Hartman (1978) and Gilbert (1978).

The coastal marshes occur along shorelines characterized by low wave energy. Coastal marshes are generally found north of the range of mangroves but are interspersed with mangroves in some areas. These marshes may extend into tidal rivers and sometimes exist as a narrow zone between mangroves and freshwater in south Florida.

Freshwater marshes consist of herbaceous plant communities

in areas of water-saturated soils which may be characterized by standing water during portions of the year. Freshwater marshes grade into wet prairies with the characteristic differences being shallower water and more abundant grasses in the wet prairie.

Cypress swamps generally have water at or above ground level a significant portion of the year. Cypress swamps occur along rivers and lake margins and may be scattered among other environments. This habitat contains fewer grasses and significantly more abundant trees.

Hardwood swamps occur in lake basins and along rivers where the substrate is saturated or submerged for at least part of the year. Two important variations of this habitat are the bayhead swamp and the titi swamp.

Bayhead swamps are very similar to cypress swamps except the vegetation is more dense. The growth may be so dense as to be impenetrable in some areas. The plants of the bayheads are mostly small trees with shrubs and cypress. Standing water is present most of the year within these areas. These swamps are dominated by varieties of bay trees.

Titi swamps are similar to the bayhead swamps. They are dominated by the presence of titi rather than bay trees.

Mangrove swamps occur along low energy coastlines in central and southern Florida. Mangroves dominate with red mangrove furthest seaward, black mangroves closer to shore and white mangroves furthest inland. These swamps support large estuarine areas.

The Nature Conservancy has inventoried the plant communities in Florida and assigned each community a rank in relation to how commonly it occurs. The plant communities of concern are listed in Table 7 (Linda Deuver, personal communication, 1983).

It was suggested that specific native communities with tropical affinities might be of such limited extent that peat mining in south Florida could possibly lead to the destruction of certain groups (Linda Deuver, personal communication, 1983).

The existence of endangered, threatened, rare or species of special concern in areas of potential peat mining should be determined on a site-by-site basis rather than a general habitat basis. Each site should be investigated and the presence of species in question documented (R. Kautz, personal communication, 1983). The site specific investigations are necessary to avoid over generalization concerning the occurrence (or nonoccurrence) of endangered species.

Table 8 is a compilation of species which are endangered, threatened, rare or of special concern. This information was gathered from the series entitled "Rare and Endangered Biota of Florida," from the official list of the Florida Game and Fresh Water Fish Commission entitled "Endangered and Potentially Endangered Fauna and Flora in Florida" and from data supplied by the Nature Conservancy. Species whose habitats contain areas of potential peat accumulation were included. This listing should not be considered all encompassing and up-to-date on species status. The Game and Fresh Water Fish Commission updates their list

periodically and should be consulted for the most recent compilation.

Comments concerning individual endangered species in relation to peatlands have been received by the staff of the Bureau of Geology. Charles Lee (Florida Audubon, personal communication, 1983) expressed concern for the Florida Panther and the Ivory-billed Woodpecker. He suggested that peat mining might disrupt portions of the panther's habitat. Lee also noted that if any Ivory-billed Woodpeckers remain they could be severely affected by peat mining activities. Randy Kautz (Game and Fresh Water Fish Commission, personal communication, 1983) expressed concern for selected habitats of the Florida Black Bear.

TABLE 7: PLANT COMMUNITIES OF CONCERN - BASED ON NATURE  
CONSERVANCY RECOMMENDATIONS.

Floodplain Swamp

Water Elm/Ash Swamp

Slash Pine Swamp

Streambank Thicket

White Cedar Bog

Strand Swamp

Cypress/Royal Palm Strand

Slough

Water Elm/Pop Ash Slough

Pond Apple/Pop Ash Slough

Basin Swamp

Slash Pine Swamp

Baygall

Everglades Bayhead

TABLE 8: ENDANGERED, THREATENED AND RARE SPECIES ASSOCIATED  
WITH AREAS OF POTENTIAL PEAT ACCUMULATION (Compiled  
by the Bureau of Geology Staff)

MAMMALS

Bobcat

Lynx rufus

Cudjoe Key Rice Rat

Oryzomys sp.

Everglades Mink

Mustela vision evergladensis

Florida Black Bear

Ursus americanus floridanus

Florida Panther

Felis concolor coryi

Florida Weasel

Mustela frenata peninsulae

Homosassa Shrew

Sorex longirostris eionis

Key Deer

Odocoileus virginianus clavium

Key Vaca Raccoon

Procyon lotor auspicatus

Lower Keys Cotton Rat	<u>Sigmodon hispidus exsputus</u>
Mangrove Fox Squirrel	<u>Sciurus niger avicennia</u>
Round-Tailed Muskrat	<u>Neofiber alleni</u>
Sherman's Fox Squirrel	<u>Sciurus niger shermani</u>
Southeastern Shrew	<u>Sorex longirostris longirostris</u>
Southeastern Weasel	<u>Mustela frenata olivacea</u>
Southern Mink	<u>Mustela vision mink</u>

#### FISH

Blackbanded Sunfish	<u>Enneacanthus chaetodon</u>
Cypress Darter	<u>Etheostoma proeliare</u>
Cypress Minnow	<u>Hybognathus hayi</u>
Eastern Mud Minnow	<u>Umbra pygmaea</u>
Mudsunfish	<u>Acantharchus pomotis</u>
Opossum Pipefish	<u>Oostethus lineatus</u>
Rivulus	<u>Rivulus marmoratus</u>
Sailfin Molly	<u>Polcilia latipinna</u>

#### REPTILE AND AMPHIBIANS

##### AMPHIBIANS

Carpenter Frog	<u>Rana virgatipes</u>
Florida Gopher Frog	<u>Rana areolata aesopus</u>
Four-toed Salamander	<u>Hemidactylium scutalum</u>
Gulf Hammock Dwarf Siren	<u>Pseudobranchus striatus lustricolus</u>

Many-lined Salamander	<u>Stereochilus marginatus</u>
One-toed Amphiuma	<u>Amphiuma pholeter</u>
Pine Barrens Tree Frog	<u>Hyla andersoni</u>
Seal Salamander	<u>Desmognathus monticola</u>
Striped Newt	<u>Notophthalmus perstriatus</u>

#### REPTILES

Alabama Red-bellied Turtle	<u>Chrysemys alabamensis</u>
Alligator Snapping Turtle	<u>Macioclemys temmincki</u>
American Alligator	<u>Alligator mississippiensis</u>
American Crocodile	<u>Crocodylus acutus</u>
Atlantic Salt Marsh Watersnake	<u>Nerodia fasciata taeniata</u>
Eastern Indigo Snake	<u>Drymarchon corais couperi</u>
Florida Ribbon Snake	<u>Thamnophis sauritus sackeni</u>
Gulf Salt Marsh Watersnake	<u>Nerodia fasciata clarki</u>
Key Mud Turtle	<u>Kinosternon bauri bauri</u>
Mangrove Terrapin	<u>Malaclemys terrapin rhizophorarum</u>
Short-tailed Snake	<u>Stilosoma extenuatum</u>
Southern Coal Skink	<u>Eumeces anthracinus pluvialis</u>
Spotted Turtle	<u>Clemmys guttata</u>
Suwannee Cooter	<u>Pseudemys concinna suwanniensis</u>

BIRDS

Black-crowned Night Heron	<u>Nycticorax nycticorax</u>
Florida Sandhill Crane	<u>Grus canadensis pratensis</u>
Glossy Ibis	<u>Plegadis falcinellus</u>
Great Egret	<u>Casmerodius albus</u>
Ivory-billed Woodpecker	<u>Campephilus principalis</u>
Least Bitter	<u>Ixobrychus exilis</u>
Limpkin	<u>Aramus guarauna</u>
Little Blue Heron	<u>Florida caerulea</u>
Louisiana Heron	<u>Hydranassa tricolor</u>
Mangrove Clapper Rail	<u>Rallus longirostris insularum</u>
Marian's Marsh Wren	<u>Cistothorus palustris marianae</u>
Osprey	<u>Pandion haliaetus carolinensis</u>
Reddish Egret	<u>Dichromanassa rufescens</u>
Roseate Spoonbill	<u>Ajaia ajaia</u>
Snail (Everglades) Kite	<u>Rostrhamus sociabilis plumbeus</u>
Snowy Egret	<u>Egretta thula</u>
Southern Bald Eagle	<u>Haliaeetus leucocephalus leucocephalus</u>
Southern Hairy Woodpecker	<u>Picoides villosus audubonii</u>
White Ibis	<u>Eudocimus albus</u>
White-tailed Kite	<u>Elanus leucurus majusculus</u>
Wood Stork	<u>Mycteria americana</u>
Worthington's Marsh Wren	<u>Cistothorus palustris griseus</u>
Yellow-crowned Night Heron	<u>Nyctanassa violacea</u>

PLANTS

Acuna's Epidendrum	<u>Epidendrum acunae</u>
Anise (Unnamed)	<u>Illicium floridanum</u>
Auricled Spleenwort	<u>Asplenium auritum</u>
Bartran's Ixia	<u>Sphenostigma coelestinum</u>
Birds-nest Spleenwort	<u>Asplenium serratum</u>
Black Mangrove	<u>Avicennia germinans</u>
Cedar Elm	<u>Ulmus crasifolia</u>
Chapman's Butterwort	<u>Pinguicula planifolia</u>
Climbing Dayflower	<u>Commelina gigas</u>
Coastal Parnassia	<u>Parnassia caroliniana</u>
Corkwood	<u>Leitneria floridana</u>
Coville's Rush	<u>Juncus gymnocarpus</u>
Cow-Horn Orchid	<u>Cyrtopodium punctatum</u>
Cuplet Fern	<u>Dennstaedtia bipinnata</u>
Delicate Ionopsis Orchid	<u>Ionopsis utricularioides</u>
Dollar Orchid	<u>Encyclia boothiana</u>
Dwarf Epidendrum	<u>Encyclia pygmaea</u>
Fall-flowering Ixia	<u>Nemastylis floridana</u>
Florida Merrybells	<u>Uvularia floridana</u>
Florida Willow	<u>Salix floridana</u>
Fuzzy-Wuzzy Air-Plant	<u>Tillandsia pruinosa</u>
Ghost Orchid	<u>Polyrrhiza lindenii</u>
Giant Water-Dropwort	<u>Oxypolis greenmanii</u>
Golden Leather Fern	<u>Acrostichum aureum</u>

Grass-of-Parnassus	<u>Parnassia grandifolia</u>
Hanging Club Moss	<u>Lycopodium dichotomum</u>
Harper's Beauty	<u>Harperocallis flava</u>
Harper's Yellow-eyed Grass	<u>Xyris scabrifolia</u>
Harris' Tiny Orchid	<u>Lepanthopsis melantha</u>
Hartwrightia	<u>Hartwrightia floridana</u>
Hidden Orchid	<u>Maxillaria crassifolia</u>
Holly (Unnamed)	<u>Ilex amelanchier</u>
Karst Pond Xyris	<u>Xyris longisepala</u>
Lakeside Sunflower	<u>Helianthus carnosus</u>
Leafless Orchid	<u>Campylocentrum pachyrrhizum</u>
Lily (unnamed)	<u>Lilium catesbaei</u>
Lythrum (Unnamed)	<u>Lythrum curtissii</u>
Lythrum (Unnamed)	<u>Lythrum flagellare</u>
Manchineel	<u>Hippomane mancinella</u>
Mexican Tear-Thumb	<u>Polygonum meisnerianum</u>
Naked-stemmed Panic Grass	<u>Panicum nudicaule</u>
Narrow Strap Fern	<u>Campyloneurum angustifolium</u>
Night-scent Orchid	<u>Epidendrum nocturnum</u>
Nodding Catopsis	<u>Catopsis nutans</u>
Okeechobee Gourd	<u>Cucurbita okeechobeensis</u>
Panhandle Lily	<u>Lilium iridollae</u>
Piedmont Water Milfoil	<u>Myriophyllum laxum</u>
Pinewoods Aster	<u>Aster spinulosus</u>
Pink Root	<u>Spigelia loganioides</u>
Pond Spice	<u>Litsea aestivalis</u>

Prickley Apple	<u>Cereus gracilis</u>
Quillwort Yellow-eyed Grass	<u>Xyris isoetifolia</u>
Rat Tail Orchid	<u>Bulbophyllum pachyrhachis</u>
Red-flowered Pitcherplant	<u>Sarracenia rubra</u>
Red Mangrove	<u>Rhizophora mangle</u>
Red-flowered Ladies'-tresses	<u>Spiranthes landceolata</u> var. <u>paludicola</u>
Slender-leaved False Dragonhead	<u>Physotegia leptophyllum</u>
Small-flowered Meadowbeauty	<u>Rhexia parviflora</u>
Snake Orchid	<u>Restrepiella ophiocephala</u>
Southern Milkweed	<u>Asclepias viridula</u>
Spoon Flower	<u>Peltandra sagittifolia</u>
Thick-leaved Water-willow	<u>Justicia crassifolia</u>
Tiny Orchid	<u>Lepanthopsis melantha</u>
Tropical Curly-grass Fern	<u>Schizaea germanii</u>
Tropical Waxweed	<u>Cuphea aspera</u>
Turks Cap Lily	<u>Lilium superbrum</u>
Violet-flowered Butterwort	<u>Pinguicula ionantha</u>
Water Sundew	<u>Drosera intermedia</u>
White top Pitcherplant	<u>Sarracenia leucophylla</u>
Worm Vine Orchid	<u>Vanilla barbellata</u>
Yellow Anise	<u>Illicium parviflorum</u>
Yellow Fringeless Orchid	<u>Platanthera integra</u>
Yellow-eyed Grass (Unnamed)	<u>Xyris drummondii</u>

## RECLAMATION OF MINED PEATLANDS

Farnham (1979) notes that in a number of European nations reclamation of mined peatlands has been common practice for many years. Mined areas are used for crop production, tree production, conservancy areas, wildlife habitats and lakes or ponds. Ireland and Poland commonly use mined peatlands for forage and grass production. In a recent consideration of reclamation of mined peatlands (King, et al., 1980), primary purposes were cited as provision for long-term erosion control and drainage and mitigation of environmental and socioeconomic effects of mining by improving the value of the land.

Farnham and others (1980) note that reclamation should preferably be considered before removing peat for energy purposes. King and others (1980) optimistically suggest that reclamation programs could create lands with superior recreational and wildlife habitat values. These researchers also note that drained organic soils may have great economic value as agricultural or forest lands. It should be noted that experience gained in the Everglades Agricultural Area supports the economic viability of farming drained organic soils. However, the rate of subsidence of organic soils in the Florida Everglades Agricultural Area is well known and suggests that this type of reclamation might not be a feasible long-term solution for use in Florida's mined peatlands. In order to achieve an approved reclamation plan, clean-up and possible permanent drainage

control may be indicated (King, et al., 1980).

King and others (1980) have prepared a list of environmental parameters affecting reclamation options. They include 1) seasonal fluctuations in ground water level, 2) soil fertility and drainage characteristics, 3) the amount of residual peat remaining after mining, 4) trafficability (the ability of the bog surface to support vehicles and machinery and 5) number and types of lakes and streams. In addition, factors which control site specific reclamation programs are tabulated by the same authors. That information is presented in Table 9. In examining Table 9, it is important to note that factors tabulated are independent of each other. Thus, a small development might be harvested by wet methods. The private single owner of this small development might choose to let the mined-out area become a lake (open water), since drainage could prove difficult and undesirable assuming water tables in the area were high.

#### PEATLAND RECLAMATION IN MINNESOTA

It is estimated that the state of Minnesota contains 173 million acres of wetlands, 3 million hectares of which are categorized as peatlands (Farnham, et al., 1980). In 1975, Minnesota received requests for six leases of peatlands. (A general description of this leasing procedure is included in Appendix E.) Minnesota Gas Company requested a lease for 200,000 acres of peatlands and five other large leases were requested in

TABLE 9: INDEPENDENT FACTORS GOVERNING SITE SPECIFIC RECLAMATION PROGRAMS

DEVELOPMENT	PEAT HARVEST TECHNIQUE	LAND OWNERSHIP STATUS	LANDOWNER FUTURE USE POTENTIALS	POST HARVESTING SITE CONDITIONS ENVIRONMENTAL	EXTERNAL FACTORS
SMALL 25 ACRES	DRY	PRIVATE SINGLE OWNER	FORESTRY	CLIMATE	RECLAMATION LAWS
MEDIUM 3,500 ACRES +	WET	LARGE INDUSTRIAL OWNER	AGRICULTURE	SOIL FERTILITY	LAND USE PERMITS
LARGE 100,000 ACRES +	COMBINATION	PUBLIC LAND	WILDLIFE/ RECREATION	VEGETATION	WATER DISCHARGE PERMITS
		TRIDAL OR NATIVE LANDS	OPEN WATER	DRAINAGE	OTHER
		COMBINATION OF ABOVE	MULTIPLE LAND USE	TRAFFICABILITY	
				OTHER	

(after King, et al., 1980)

which peat was destined for horticultural usage.

The Minnesota Legislature responded by funding the Minnesota Department of Natural Resources to study some implications of peat mining (Malterer, 1980). The Minnesota Study included consideration of the following topics: 1) socioeconomic implications, 2) policy, 3) leasing, 4) environmental baseline studies and 5) a separately funded resource estimation of the state's peatlands. Environmental baseline studies included air, water, vegetation and wildlife. Studies of utilization opportunities and constraints as well as studies of opportunities for reclamation following mining were completed (Asmussen, 1980). These studies pointed out a number of land-use options including: 1) preservation of peatlands, 2) use of peatlands for agriculture, 3) forestry, 4) mining of peat for horticulture, 5) mining and processing of peat for industrial chemicals and 6) mining of peat for energy and conversion. A panel of peatland ecologists is working toward identification of bogs with preservation value based on uniqueness, representativeness and recreation value. Reclamation of peatlands for use as wildlife habitat has been investigated in a study which monitored the evolution of recently excavated ponds in peat.

Farnham and others (1980) note that the stability of any given crop depends on climate, hydrology, chemical and physical properties of peat and marketability of final products. The major limit to agricultural development in northern Minnesota is the relatively short, frost-free period each year (June 1 -

August 15). These authors (Farnham, et al., 1980) report that studies dealing with grasses and grains show no significant difference in yield and quality between crops grown on the surface of developed or excavated peatlands.

Two reclamation options being considered by Minnesota researchers, as well as worldwide workers, are agriculture and bioenergy (Farnham, et al., 1980). Reclamation research aimed at agriculture has identified vegetable and agronomic crops adaptable to northern Minnesota. Species have been placed in mined and unmined environments with species and fertilizer treatments varied to allow recognition of factors which enhance productivity (Amussen, 1980). Bioenergy crops (cattails, willows and alders, among others) are currently under investigation for cultivation in wetlands since production of these crops would provide a renewable energy resource. S.R.I.C. ("short rotation intensively cultivated") refers to the application of agricultural techniques developed to promote growth of selected bioenergy crops (Farnham, et al., 1980).

The extensive peatlands of Minnesota have been the subject of intensive research since 1975. The research program was devised to provide information on which to base leasing decisions. One continuing thrust of this research has been the identification of reclamation methods specifically adapted to the climate and geologic setting of Minnesota's peatlands.

## PEATLAND RECLAMATION OF NORTH CAROLINA

North Carolina contains an estimated 1,000 square miles of peatlands (640,000 acres). The peat is usually black, fine-grained and highly decomposed with ash contents that are often less than .5 percent, low sulfur contents and high heating values (Ingram and Otte, 1980). This peat occurs in three major geologic settings: 1) pocosins which are broad, shallow depressions characterized by peats varying in thickness from 1 to 8 feet in thickness; 2) river flood plains which are of unknown extent but contain peats which may attain thicknesses of 25 feet and 3) Carolina Bays which are elliptical depressions of unknown origin. The 500 to 600 Carolina Bays sometimes contain high quality peats up to 15 feet in depth (Ingram and Otte, 1980).

In April of 1983, the U.S. Synthetic Fuels Corporation approved a loan of \$820,750 for the First Colony peat-to-methanol project in North Carolina. The 15,000 acre site is expected to supply peat for methanol conversion for 30 years (Robinson, et al., 1983).

Peat Methanol Associates (PMA) is the group planning to construct and operate North Carolina's synthetic fuel plant. It is believed by PMA, based on their studies of the peat deposits and ground water conditions, that natural drainage will be adequate to return the land to agricultural use. PMA also plans a land restoration program which will include tree and vegetation planting to provide wildlife refuge and nesting areas (PMA

Update, February 1983).

In response to the major peatland development proposed by Peat Methanol Associates, the state of North Carolina created a Peat Mining Task Force in December 1980. An initial report was issued in March 1981. The task force was reconvened in June 1983, as interest in the state's peatlands escalated. The original recommendations of the task force were reviewed, updated and published in January 1983 (Owens, et al., 1983).

The sixteen member task force was drawn from all divisions within the Department of Natural Resources and Community Development which were involved with peat mining. The task force reviewed peat mining and its impacts on the state's natural resources. It also reviewed the ability of the state's management program for peat mining to deal with potential impacts (Owens, et al., 1983).

Reclamation methods are categorized as "wet reclamation" or "perpetual pumping." Constant pumping may be required to maintain land dry enough for certain uses. Intensive agriculture is believed to be the only use which can financially justify the continual pumping (Owens, et al., 1983).

"Wet reclamation includes all forms of reclamation which could permanently or periodically cause the reclaimed area to be under salt or fresh water. Uses which are included comprise paddy culture, reversion to swamp forest or pocosin, reservoirs, aquaculture of fish or shell fish, artificially-created nursery areas, waterfowl impoundments, marinas and recreational lakes.

It is recommended that acceptance of mined-out peatlands as reclaimed be on a case-by-case basis (Owens, et al., 1983). (Recommendations of the North Carolina Peat Mining Task Force are included in Appendix E of this document.)

In response to growing interest in North Carolina's peat deposits by developers, a Peat Mining Task Force was created to review permitting procedures for peat mining. Recommendations pertinent to all phases of peat mining including permits, reclamation, evaluation of environmental impacts and monitoring of environmental impacts were prepared.

#### PEATLAND RECLAMATION IN FINLAND

Mires are estimated as occupying 24 million acres or 31.9 percent of the total land area of Finland (Lappalainen, 1980). Development of peatlands in Finland is encouraged as Finland imported 70 percent of its energy needs in 1979 (Harme, 1980). Indigenous energy sources which accounted for 31 percent of Finland's energy include hydro power, peat, industrial waste woods, waste liquors and normal firewood. Finland's fuel grade resources are estimated to be  $32.7 \times 10^9$  cubic yards (Lappalainen, 1980) and the nation pays subsidies to new users of domestic fuels equal to 5 percent to 20 percent of the total investment required for new plants (Harme, 1980).

Annual (1979) peat usage in Finland was approximately 6.5-7.8 million cubic yards or about 2.5 percent of the nation's

energy consumption. The aim for the 1980's is to raise consumption to 33-39 million cubic yards per year. It is thought that the 26 million level is reasonable based on rising coal and oil prices (Harme, 1980).

Pohjonen (1980) notes that by the end of the century mined-out soil surface area will occupy 123,550 acres and the problem of future use for those lands must be solved. It is suggested that a number of characteristics of mined peatlands in Finland make reclamation to "growing environment" an attractive option. The bottom peat layer is exceptionally sterile and no weeds, diseases or insects are present. This layer is rich in nitrogen and calcium and an underlying mineral soil provides nutrients lacking in the bottom peat layer. It is noted that energy willow production would be extremely efficient since burning the willow in heating plants yields a nutrient-rich ash which may be returned as a fertilizer to the willow plantations (Pohjonen, 1980).

Finland is actively pursuing development of its peat resource for energy use in order to offset its dependence on imported energy. Researchers are beginning to explore reclamation options which make use of residual peats remaining after mining in combination with underlying mineral soils. The cultivation of energy willows is seen to be an attractive option, given the renewable nature of that resource.

## PEATLAND RECLAMATION IN NEW BRUNSWICK

New Brunswick's peat resources are estimated to be in excess of 247,000 acres. Approximately 80 percent of New Brunswick's peatlands are owned by the province which classes peat as a quarriable substance (Keys, 1980).

Peats are extracted for horticultural purposes and producers hold peat leases and pay acreage rentals and royalties on production. The horticultural producers use a vacuum method of milled peat production. This peat is in turn used as baled Spagnum peat, soil mixes, artificially dried and compacted peat and compressed peat pots (Keys, 1980). Additionally, a small amount of peat is used as fuel to heat a greenhouse.

Nonextractive uses for New Brunswick peatlands include protection of peats within Kouchibouquac National Park, use as wildlife management areas and artificially developed waterfowl nesting areas. Management objectives for future use of the peat resource include: 1) consideration of the needs of existing industry, 2) conservation areas, 3) optimum use of various qualities of peat and 4) long-term versus short-term economic development (Keys, 1980).

An idealized case for management of New Brunswick's peatlands would be such that surface layers of peat could be removed for horticultural use exposing underlying fuel peats. On removal of the fuel peats, the basal unminable layer (20 inches thick with high ash content and rocks and other irregularities),

with a suitably designed drainage system, could allow utilization of the depleted peatland for agriculture and afforestation (Keys, 1980).

Selective use of New Brunswick's peat resources are encouraged. The need for conservation areas is acknowledged. Reclamation is viewed as an integral step in the exploitation of peatlands. A summary of the leasing procedure applied to peatlands of New Brunswick is presented in Appendix E of this document.

#### RECLAMATION IN PEATLANDS OF FLORIDA

In Minnesota, North Carolina, Finland and New Brunswick ongoing research is aimed at devising reclamation techniques which are workable for specific regions. For instance, North Carolina cannot assume that reclamation methods suitable to Minnesota may be successfully applied to the soil conditions and climate of North Carolina. Minnesota (Asmussen, 1980) has appointed a panel of peatland ecologists to identify peatlands with preservation value. The Peat Mining Task Force of North Carolina notes that some areas in peatlands should be left entirely in their natural state (Owens, et al., 1983). It is recommended that those areas be identified as quickly as possible and a program for their preservation be instituted.

If Florida determines to allow mining of its peatlands, a number of factors will require research so that successful recla-

mation programs may be instituted. Florida's climate is unlike the climates of other peat producing areas in which extensive research has been done. Peat in Florida frequently lies directly over limestone or quartz sand. This relationship coupled with subsidence rates measured in Florida must be considered carefully with respect to reclamation to agriculture. If reclamation to agriculture or silviculture is considered, the fertility of the residual peat and its thickness must be investigated. A number of site specific hydrologic characteristics will require consideration including the number and types of lakes and streams as well as the relationship of the site to groundwater resources in its area.

## SUMMARY AND CONCLUSIONS

### Mineral Versus Non-Mineral

Peat, like coal, petroleum and natural gas, does not comply with the principal conditions set forth in the academic definition of the term mineral. Peat represents an early stage in a series of products resulting in the conversion of vegetable matter to pure carbon (peat-lignite-coal-graphite), the end product of which fits all the requirements of a true mineral. In classifying peat as a mineral or non-mineral, there has been a tendency toward allowing use to play an important role in the classification, that is, if used as an agricultural product peat

would be treated as a non-mineral or if used as an energy source or fossil fuel peat would be treated as a mineral. Classification based on use can create considerable confusion especially with mineral products used as fertilizers. Peat has been historically classified by the U.S. Bureau of Mines and the U.S. Geological Survey as a mineral resource, a somewhat broader category than just "mineral," along with coal, oil and natural gas. Peat is generally regarded as nonrenewable by earth science professionals, requiring in excess of 1,000 years to generate a commercially extractable deposit of fuel grade peat.

This study would conclude that because of peat's genetic relationship to the mineral graphite, its general classification by the U.S. Bureau of Mines and the U.S. Geological Survey as a mineral resource, and emphasizing its nonrenewability, peat should be classed as a mineral, mineral resource, or mineral product. Consequently, any classification based on use should be discouraged.

#### Harvesting versus Mining

Harvesting and mining have been used synonymously to refer to the extraction of peat. Literature searches reveal the term harvesting correctly refers to the nearly obsolete practice of selectively removing living Sphagnum from the surface of the bog. In this practice, Sphagnum was allowed to grow back, permitting successive harvests in a single location. Peat (unlike living Sphagnum) is considered nonrenewable and the term harvesting is

inappropriate when applied to peat extraction. Additionally, the method and equipment utilized in peat extraction and the environmental impacts of peat extraction are synonymous with those commonly attributed to mining, not harvesting.

This study would conclude that harvesting should be applied only to the removal of living Sphagnum or other living plants and that the extraction of peat should be categorized as mining.

### Environmental Impacts of Peat Mining

Peat occurrence in Florida is, in nearly every case examined, coexistent in and beneath a current wetland area. For this reason, peat mining and wetland mining are virtually synonymous terms in Florida. The environmental impacts associated with peat mining may vary widely depending on the type of wetland, the location of the wetland, the function of the wetland, the extent of mining, the type of mining, and other physical parameters of the site.

This study would conclude that an accurate assessment of the environmental impacts of peat extraction will be site specific and can be anticipated to range from minor to severe.

### Reclamation of Peat Mining

Reclamation or the return of mined land to a beneficial use is applicable to most mining operations and would be so with peat mining. Restoration or the return of mined land to the pre-mining function is only partially applicable to most mining

operations and would not be practical with peat mining. The higher the ratio of overburden to the mined product, the higher the percentage of original landform and contour that can be achieved in reclamation. In peat mining, where the mined product typically has no overburden, the extraction leaves a void space with no material available for filling, and therefore, no original landform and contour can be achieved in reclamation.

This study would conclude that reclamation of mined peatlands to a beneficial use as an aquatic or uplands system is achievable, however, the restoration of mined peatlands to pre-mining contour and function is not feasible.

#### Agricultural Use of Peat

The in-place use of peat and related organics for agricultural purposes such as the Everglades Agricultural Area appear to be a nonconsumptive use of peat. In fact, the exposure of peat to air allows aerobic bacteria to oxidize the peat causing a gradual loss of peat accompanied by subsidence of the land surface. It is predicted that by the year 2000, approximately 250,000 acres in the Everglades Agricultural Area will have subsided to depths of less than one foot.

This report would conclude that agricultural uses of in-place peat be viewed as a consumptive use of peat and that companion to the use, research and planning be carried out to determine the systems impact resulting from peat loss and land subsidence for management to better transition into future land uses.

## REFERENCES

- American Society for Testing and Materials, 1969, Standard Classification of Peats, Mosses, Humus, and Related Products: ASTM, Philadelphia, Pa., Designation D2607-69.
- Asmussen, D., 1980, The Minnesota Peat Program, in Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.: sponsored by Institute of Gas Technology, pp. 647-655.
- Aspinall, F., 1980, Peat Harvesting - State of the Art, in Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.: sponsored by Institute of Gas Technology, pp. 159-173.
- Bel'Kevich, P. I., 1977, Citation in Fuchsman, 1978, pp. 37-38.
- Boyle, J. R. and C. W. Hendry, Jr., 1982, The Mineral Industry of Florida, 1980: Florida Bureau of Geology Information Circular 95, Tallahassee, Fl., 11 p.
- Boyle, J. R. and C. W. Hendry, Jr., 1984, The Mineral Industry of Florida, 1982, U. S. Bureau of Mines, Mineral Yearbook.
- Brobst, D. A. and W. P. Pratt, eds., 1973, United States Mineral Resources, United States Geological Survey, Professional Paper 820, 722 p.
- Brooks, K. and S. Predmore, 1978, Phase II - Peat Program, Hydrologic Factors of Peat Harvesting (Final Report): Department of Forest Resources, College of Forestry, University of Minnesota, for the Minnesota Department of Natural Resources, St. Paul, Mn., 49 p.
- Brown, M. T., et al., 1983, A Wetlands Study of Seminole County: Identification, Evaluation, and Preparation of Development Standards and Guidelines: Center for Wetlands Technical Report 41, University of Florida, Gainesville, Fl., 248 p.
- Cameron, C., 1973, Peat: United States Geological Survey Professional Paper 820, Washington, D.C., 722 p.
- Carter, V., M. S. Bedinger, R. P. Novitzki, and W. O. Wilen, 1978, Water Resources and Wetlands, in Wetland Functions and Values: The State of Our Understanding: American Water Resources Association, pp. 344-376.
- Christ, K. D., et al., 1981, Florida Energy Resources: State of Florida, Governor's Energy Office, Tallahassee, Fl., 111 p.

- Clausen, J. C., 1979, The Potential Effects of Peat Mining, in Management Assessment of Peat as an Energy Resource: Symposium Papers, July 22-24, 1979, at Arlington, Va.: sponsored by Institute of Gas Technology.
- Cohen, A. D., 1974, Evidence of Fires in the Ancient Everglades and Southern Everglades, in P. J. Gleason, ed., Environments of South Florida: Present and Past: Miami Geological Society, Memoir 2, pp. 213-218.
- Cohen, A. D. and W. Spackman, 1977, Phytogenic Organic Sediments of Sedimentary Environments in the Everglades - Mangrove Complex of Florida: Part II, The Origin, Description and Classification of the Peats of Southern Florida: in Paleontographica, p. 71.
- Cohen, A. D. and W. Spackman, 1980, Phytogenic Organic Sediments of Sedimentary Environments in the Everglades - Mangrove Complex of Florida: Part III, The Alteration of Plant Materials in Peats and the Origin of Coal Macerals: in Paleontographica, p. 125.
- Cowardin, L. M., V. Carter, F. Golet, and E. T. LaRoe, 1979, Classification of Wetlands and Deepwater Habitats of the United States: U. S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, D.C.
- Crawford, R., 1978, Effect of Peat Utilization on Water Quality in Minnesota: The Minnesota Department of Natural Resources, St. Paul, Mn., 18 p.
- Davis, J. H., 1946, The Peat Deposits of Florida, Their Occurrence, Development and Uses: Florida Geological Survey Bulletin 30, Tallahassee, Fl., 247 p.
- DRAVO Engineers and Constructors, 1981, Synfuels Glossary: DRAVO, Pittsburgh, Pa., 10 p.
- Eckman, E., 1975, Citation in Fuchsman, 1978, p. 102.
- Environmental Science and Engineering, 1982, Appendix A - Physical, Chemical and Ecological Data, in NPDES Permit Application, Wastewater Discharge Assessment: ESE, Gainesville, Fl., 297 p.
- Farnham, R. S., 1979, Peatland Reclamation, in Management Assessment of Peat as an Energy Source: Symposium Papers July 22-24, 1979, at Arlington, Va.: sponsored by Institute of Gas Technology.

- Farnham, R. S. and T. Lever, 1980, Agricultural Reclamation of Peatlands: Minnesota Department of Natural Resources, St. Paul, Mn., 70 p.
- Farnham, R. S., W. E. Berguson, T. E. Levar, and D. B. Sherf, 1980, Peatland Reclamation - The Energy Crop Option, in Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.: sponsored by Institute of Gas Technology, pp. 635-642.
- Fuchsman, C. H., 1978, The Industrial Chemical Technology of Peat: Minnesota Department of Natural Resources, St. Paul, Mn., 190 p.
- Gary, M., et al., eds., 1974, Glossary of Geology: American Geological Institute, Alexandria, Va., 805 p.
- Georgia-Pacific Corporation, 1982, Cow Bay Pilot Peat Project: Supplemental Information Submitted to Florida Department of Environmental Regulation for Amended Dredge and Fill Permit and Industrial Wastewater Permit Application.
- Gilbert, C.R., 1978, Analysis of the Florida Aquatic Ecosystems, in Rare and Endangered Biota of Florida, Vol. 4 - Fishes: Florida Game and Fresh Water Fish Commission, Tallahassee, Fl.
- Gleason, P. J., A. D. Cohen, H. K. Brooks, P. Stone, R. Goodrick, W. G. Smith, and W. Spackman, Jr., 1974, The Environmental Significance of Holocene Sediments from the Everglades and Saline Tidal Plain, in P. J. Gleason, ed., Environments of South Florida: Present and Past: Miami Geological Society, Memoir 2, pp. 287-341.
- Griffin, G., et al., 1982, Assessment of the Peat Resources of Florida, With a Detailed Survey of the Northern Everglades: State of Florida, Governor's Energy Office, Tallahassee, Fl., 190 p.
- Gurr, T., 1972, The Geology of a Central Florida Peat Bog Section 26, Township 30 South, Range 25 East, Polk County, Florida: Unpublished M. S. Thesis, University of South Florida, Tampa, Fl.
- Harme, P., 1980, Peat and Finland, in Proceedings of the 6th International Peat Congress, August 17-23, 1980: International Peat Society, Duluth, Mn., 735 p.
- Harper, R., 1910, Preliminary Report on the Peat Deposits of Florida: Florida Geological Survey, 3rd Annual Report, Tallahassee, Fl., 397 p.

- Hartman, B., 1978, Description of Major Terrestrial and Wetland Habitats of Florida, in Rare and Endangered Biota of Florida, Vol. 1 - Mammals: Florida Game and Fresh Water Fish Commission, Tallahassee, Fl.
- Heikurainen, L., 1976, The Concepts of Trophy and Production: Commission I of International Peat Society Transactions of the Working Group for Classification of Peat, Helsinki, Finland, p. 31.
- Ingram, R. L. and L. J. Otte, 1980, Assessment of North Carolina Peat Resources, in Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.: sponsored by Institute of Gas Technology, pp. 123-131.
- Institute of Gas Technology, 1980, Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.:  
777 p.
- International Peat Society, 1980, Proceedings of the 6th International Peat Congress, August 17-23, 1980: Duluth, Mn., 735 p.
- Keys, D., 1980, Assessment and Management of the Peatlands in New Brunswick, Canada: in Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.: sponsored by Institute of Gas Technology, pp. 131-143.
- King, R., et al., 1980, Preliminary Evaluation of Environmental Issues on the Use of Peat as an Energy Source: prepared for the U.S. Department of Energy, Division of Fossil Fuel Processing, Washington, D. C.
- Kopstein, M., 1979, Peat-Prospectus: United States Department of Energy, Division of Fossil Fuel Processing, Washington, D. C., 79 p.
- Kuehn, D. W., 1980, Offshore Transgressive Peat Deposits of Southwest Florida: Evidence for a Late Holocene Rise of Sea Level: Unpublished M. S. Thesis, Pennsylvania State University, College Park, Pa.
- Langbein, W. B. and K. T. Iseri, 1960, General Introduction and Hydrologic Definitions, United States Geological Survey, Water Supply Paper 1541-A, 29 p.
- Lappalainen, E., 1980, The Useful Fuel Peat Resources in Finland, in International Peat Society, Proceedings of the 6th International Peat Congress, August 17-23, 1980: Duluth, Mn., pp. 59-63.
- Lishtvan, I. I. and N. T. Korol, 1975, Citation in Fuchsman, 1978, pp. 36-37.

- Lucas, R., 1980, Mobility of Phosphorus and Potassium in Everglades Histosols, in Proceedings of the 6th International Peat Congress, August 17-23, 1980: International Peat Society, Duluth, Mn., p. 413.
- Malterer, T. J., 1980, Peat Resource Estimation Project, in Peat as an Energy Alternative: Symposium Papers, December 1-3, 1980, at Arlington, Va.: sponsored by Institute of Gas Technology, pp. 69-75.
- Mason, B. and L. G. Berry, 1968, Elements of Mineralogy: W. H. Freeman and Company, San Francisco, Ca., 550 p.
- McPherson, B. F., et al., 1976, The Environment of South Florida, A Summary Report: United States Geological Survey Professional Paper 1101, Washington, D. C., 81 p.
- Minnesota Department of Natural Resources, 1981, Minnesota Peat Program Final Report: The Minnesota Department of Natural Resources, St. Paul, Mn., 93 p.
- Moore, P. and D. Bellamy, 1974, Peatlands: Elek Science, London, 221 p.
- Naucke, W., 1966, Citation in Fuchsman, 1978, p. 35.
- Neilson, W. A., T. A. Knott, and P. W. Carhart, eds., 1939, Webster's New International Dictionary of the English Language, 2nd ed. unabridged, G & C Merriam Company, Publishers, Springfield, Ma., 3210 p.
- Nichols, D. S., 1980, Citation in Minnesota Department of Natural Resources, 1981, p. 44.
- Norit, N. V., Citation in Fuchsman, 1978, p. 112.
- North Carolina Department of Natural Resources and Community Development, 1983, Peat Mining and Natural Resources: Peat Mining Task Force Report.
- Olson, D., et al., 1979, Inventory of Peat Resources in Southwest St. Louis County, Minnesota: The Minnesota Department of Natural Resources, Hibbing, Mn., 76 p.
- Parker, G. G., 1974, Hydrology of the Pre-Drainage System of the Everglades in Southern Florida, in P. J. Gleason, ed., Environments of South Florida: Present and Past: Miami Geological Society, Memoir 2, p. 18.
- Peat Methanol Associates, 1983, PMA Update: News From Peat Methanol Associates, Vol. 1, No. 1, Peat Methanol Associates, Creswell, N.C.

- Pennsylvania State University, Coal Research Section, 1976, A Field Guide to Aid in the Comparative Study of the Okefenokee Swamp and the Everglades - Mangrove Swamp - Marsh Complex of Southern Florida: Coal Research Section, University Park, Pa.
- Pohjounen, V. M., 1980, Energy Willow Farming on Old Peat Industry Areas, in Proceedings of the 6th International Peat Congress, August 17-23, 1980: International Peat Society, Duluth, Mn., pp. 439-440.
- Press, F. and R. Siever, 1974, Earth: W. H. Freeman and Company, San Francisco, Ca., 945 p.
- Pritchard, P. C. H., ed., 1978, Rare and Endangered Biota of Florida: Vol. 1 - Mammals, Vol. 2 - Birds, Vol. 3 - Amphibians and Reptiles, Vol. 4 - Fishes: Florida Game and Fresh Water Fish Commission, Tallahassee, Fl.
- Quinny, A. W. and H. D. Glass, 1958, Rank of Coal and Metamorphic Grade of Rocks of the Narragansett Basin of Rhode Island: Economic Geology, V. 53, pp. 563-576.
- Robinson, C. W., R. L. Schneider, and A. B. Allen, 1983, Harvesting and Converting Peat to Methanol at First Colony: In Mining Engineering, July, pp. 723-726.
- Searls, J. P., 1980, Peat: United States Bureau of Mines Bulletin 671, Washington, D. C., pp. 641-650.
- Shih, S.F., 1980, Impact of Subsidence on Water Management in Everglades Agricultural Area, in Proceedings of the 6th International Peat Congress, August 17-23, 1980: International Peat Society, Duluth, Mn., 473 p.
- Snyder, G. H., et al., 1978, Water Table Management for Organic Soil Conservation and Crop Production in the Florida Everglades: Institute for Food and Agricultural Science, University of Florida, Gainesville, Fl., 22 p.
- Soper, E. K. and C. C. Osbon, 1922, The Occurrence and Uses of Peat in the United States: United States Geological Survey Bulletin 728, Washington, D. C., 207 p.
- Spackman, W., et al., 1964, Field Guidebook to Environments of Coal Formation in Southern Florida: Printed for the Geological Society of America Pre-Convention Fieldtrip, November, 67 p.
- Stein, J., L. C. Hauck, and P. Y. Su, eds., 1975, Random House College Dictionary, Random House, Inc., New York, N.Y., 1568 p.

- Stephens, J.C., 1974, Subsidence of Organic Soils in the Florida Everglades - A Review and Update, in P. J. Gleason, ed., Environments of South Florida: Present and Past: Miami Geological Society, Memoir 2, pp. 352-361.
- Stephens, J. C. and L. Johnson, 1951, Subsidence of Organic Soils in the Upper Everglades of Florida: Soil Science Society of Florida Proceedings, Vol. XI, pp. 191-237.
- Tate, R. L., 1980, Environmental Factors Limiting Microbial Activity in Histosols, in Proceeding of the 6th International Peat Congress, August 17-23, 1980: International Peat Society, Duluth, Mn., p. 695.
- Tebeau, C. W., 1974, South Florida Water Management District, in P. J. Gleason, ed., Environments of South Florida: Present and Past: Miami Geological Society, Memoir 2, p. 362.
- Turner, F. J. and J. Verhoogen, 1960, Igneous and Metamorphic Petrology, 2nd ed., McGraw-Hill, New York, 545 p.
- U.S. Bureau of Mines, 1972-1981, Minerals Yearbook: U. S. Department of Interior, Washington, D.C.
- University of Florida Agricultural Experiment Station, 1978, Water Table Management for Soil Conservation and Crop Production in the Florida Everglades: University of Florida Agriculture Experiment Station Bulletin 801, Gainesville, Fl.
- Weast, R. C., ed., 1973, Handbook of Chemistry and Physics, 54th ed., CRC Press, Cleveland, Oh.
- White, W.H., 1970, The Geomorphology of the Florida Peninsula: Florida Bureau of Geology Bulletin 51, Tallahassee, Fl., 164 p.

## GLOSSARY OF TECHNICAL TERMS

**absorption** Taking up, assimilation, or incorporation; e.g. of liquids in solids or of gasses in liquids, sometimes incorrectly used in place of adsorption.

**acetone** A volatile flammable liquid,  $(\text{CH}_3)_2\text{CO}$ , used as a solvent and in organic synthesis.

**acid** A compound, capable of neutralizing alkalis, containing hydrogen that can be replaced by a metal or an electropositive group to form a salt or containing an atom that can accept a pair of electrons from a base.

**acid hydrolysis** Decomposition process in which peat is broken down into component compounds. Peat is slurried with water and sulfuric acid at elevated temperatures and pressure and allowed to react.

**activated carbon** Carbon which has been expanded by treating coke with steam at 1652-2012°F. The reaction causes generation of hydrogen gas and carbon monoxide with the physical effect of expanding the pore spaces in the coke, greatly increasing the surface area available for adsorption.

**adsorption** Adherence of gas molecules or of ions or molecules in solutions to the surfaces of solids with which they are in contact.

**aldehydes** A class of organic compounds containing the group  $-\text{CHO}$ , which yield acids when oxidized and alcohols when reduced.

**alkali** Any strongly basic substance, such as a hydroxide or carbonate of an alkali metal (e.g. sodium, potassium) that neutralizes acid to form salts.

**anhydrite** A mineral consisting of an anhydrous calcium sulfate:  $\text{CaSO}_4$ . It represents gypsum without its water of crystallization, and it alters readily to gypsum, from which it differs in crystal form (anhydrite is orthorhombic) and in being harder and slightly less soluble.

**anthracite** Coal of the highest metamorphic rank, in which fixed-carbon content is between 86 percent and 98 percent. It is hard, black, and has a semi-metallic luster and semiconchoidal fracture. Anthracite ignites with difficulty and burns with a short, blue flame and without smoke. Syn: hard coal, stone coals.

**ash content** The percentage of incombustible material in a fuel.

**bioenergy crops** Crops which are grown for plant biomass to produce renewable energy sources. Plant biomass can be harvested and burned directly or may be gasified to produce liquid and gaseous fuels.

**biogasification** A process which utilizes bacteria to produce methane gas from organic material.

**bituminous** Coal which contains up to 86 percent fixed carbon and which generates at least 8300 BTU/lb on combustion. It is dark brown to black in color and is the most abundant rank of coal. Lower grades burn with a smokey flame, however, higher grades burn without smoke.

**BOD (Biological Oxygen Demand)** The amount of oxygen (measured in parts per million) removed from aquatic environments rich in organic matter by the metabolic requirements of aerobic microorganisms.

**bog** A waterlogged, spongy groundmass, primarily mosses, containing acidic, decaying vegetation or peat.

**brackish water** An indefinite term for water, the salinity of which is intermediate between that of normal sea water and normal fresh water.

**BTU (British Thermal Unit)** The amount of heat required to raise the temperature of one pound of water one (1) degree F.

**carbohydrate** A polyhydroxy aldehyde or ketone or a compound that can be hydrolyzed to such a compound. Carbohydrates, of which sugars, starches and cellulose are examples, are produced by all green plants and form an important animal food.

**carbonization** (a) In the process of coalification, the accumulation of residual carbon by the changes in organic matter and decomposition products; (b) The accumulation of carbon of a carbonaceous substance such as coal by driving off the other components, either by heat under laboratory conditions or by natural processes.

**carbon-14 dating** A method of determining an age in years by measuring the concentration of carbon-14 remaining in an organic material, usually formerly living matter, but also water bicarbonate, etc. The method, worked out by Willard F. Libby, U.S. chemist (1908- ), in the years 1946-1951, is based on the assumption that assimilation of carbon-14 ceased abruptly on removal of the material from the Earth's carbon cycle (i.e. the death of an organism) and that it thereafter remained a closed system. Most carbon-14 ages are calculated using a half-life of 5570+30 years, thus the method is useful in determining ages in the range of 500-30,000 or 40,000 years, although it may be extended to 70,000 years by using special techniques involving controlled enrichment of the sample in carbon-14. Syn: radiocarbon dating; carbon dating.

**carcinogen** A substance which tends to produce a cancer.

**cellulose** A polymeric carbohydrate composed of glucose units, formula  $(C_6H_{10}O_5)_x$ , of which the permanent cell walls of plants are formed, making it the most abundant carbohydrate.

**coalification** The alteration or metamorphism of plant material into coal; the biochemical processes of diagenesis and the geochemical process of metamorphism in the formation of coal. See also: carbonization.

**COD (Chemical Oxygen Demand)** The amount of oxygen required for the oxidation of all oxidizable compounds in a water body. Cf: biochemical oxygen demand. Var: oxygen demand.

**colloidal gel** A translucent to transparent, semisolid, apparently homogeneous substance being elastic and jelly-like (or sometimes more or less rigid), offering little resistance to liquid diffusion, and containing a dispersion or network of fine particles that have coalesced to some degree. Colloidal particles are less than .0000094 inches in size (i.e. smaller than clay sized).

**core** A cylindrical or columnar piece of solid rock or section of soil, usually 1.75-4.0 inch or so in diameter and from an inch up to 50 feet or so in length, taken as a sample of an underground formation by a special hollow-type drill bit, and brought to the surface for geologic examination and/or chemical analysis. It records a section of the rock or soil penetrated.

**crystal** A homogeneous, solid body of a chemical element, compound or isomorphous mixture having a regularly repeating atomic arrangement that may be outwardly expressed by plane faces.

**desiccation** A complete or nearly complete drying out or drying up, or a deprivation of moisture or of water not chemically combined; e.g. the loss of water from pore spaces of soils or sediments as a result of compaction or evaporation.

**dewatering** Processing which reduces the amount of water within peat or a peat deposit prior to mining and processing. Ditching and pumping are used prior to mining. Solar, mechanical and thermal drying along with wet carbonization and wet oxidation can be used prior to or in conjunction with processing.

**dichloroethane** A heavy, colorless, flammable liquid,  $C_2H_4Cl_2$ , a non polar organic solvent.

**element** Any of a class of substances that cannot be separated into simpler substances by chemical means. Elements are the building blocks from which all chemical compounds are formed.

**enstatite** A common rock-forming mineral of the orthopyroxene group:  $MgSiO_3$ . It is isomorphous with hypersthene and may contain a little iron replacing the magnesium. Enstatite varies from grayish white to yellowish, olive green and brown. It is an important primary constituent of intermediate and basic igneous rocks.

**ester** A compound produced by the reaction between an acid and an alcohol with the elimination of a molecule of water.

**estuary** (a) The seaward end or the widened funnel-shaped tidal mouth of a river valley where freshwater mixes with and measurably dilutes seawater and where tidal effects are evident; e.g. a tidal river, or a partially enclosed coastal body of water where the tide meets the current of a stream; (b) A portion of an ocean, as a firth or an arm of the sea, affected by freshwater; e.g. the Baltic Sea; (c) A drowned river mouth formed by the subsidence of land near the coast or by the drowning of the lower portion of a nonglaciated valley due to the rise of sea level.

**ethane** A colorless, odorless, water-insoluble, gaseous paraffin hydrocarbon, formula  $C_2H_6$ , which occurs in natural gas or can be produced as a by-product in the cracking of petroleum.

**ethanol (alcohol)** A colorless, volatile, flammable liquid,  $C_2H_5OH$ , produced by fermentation of certain carbohydrates, used chiefly as a solvent, and in organic synthesis, beverages, medicine, colognes and antifreeze.

**ethyl acetate** A volatile, flammable liquid,  $CH_3COOC_2H_5$ , used as solvent for paints and lacquers.

**eutrophication** The process by which waters become more eutrophic; the artificial or natural enrichment of a lake by an influx of nutrients required for the growth of aquatic plants such as algae that are vital for fish and animal life.

**evapotranspiration** Loss of water from a land area through transpiration of plants and evaporation from the soil. Also, the volume of water lost through evapotranspiration.

**fen** A waterlogged, spongy groundmass containing alkaline, decaying vegetation characterized by reeds or peat. It sometimes occurs in the sinkholes of karst regions. Cf: bog.

**fiber** A plant fragment in a peat or soil which is greater than .15mm in any dimension.

**fuel grade peat** (U. S. Department of Energy definition) Peat with less than 25 percent ash content, heat value greater than 8,00 BTU/lb (dry weight) and which is found in areas with more than 80 acres per square mile of peat, at least 5 feet thick. Generally, hemic peats have the greatest heat value.

**fibric peat** (U. S. Department of Agriculture classification) Peat containing more than 66.66 percent plant fibers (see also hemic and sapric).

**fixed carbon** In coal, coke and bituminous materials, the remaining solid, combustible matter after removal of moisture, ash and volatile matter, expressed as a weight percentage, following the procedures specified by the American Society of Testing and Materials.

**fluidized bed boiler** A boiler design in which the fuel is agitated or "boiled" by the introduction of air from beneath the fuel bed.

**gasification** In fuel technology, the conversion of a solid or liquid hydrocarbon to a fuel gas.

**geology** The study of the planet Earth. It is concerned with the origin of the planet, the material and morphology of the Earth, and its history and the processes that acted (and act) upon it to affect its historic and present forms.

**graphite** A hexagonal mineral, representing a naturally occurring crystalline form of carbon dimorphous with diamond. It is opaque, lustrous, very soft, greasy to the touch and iron black to steel gray in color; it occurs as crystals or as flakes, scales, laminae or grains, in veins or bedded masses or as disseminations in metamorphic rocks. Graphite conducts electricity and heat, and is used in lead pencils, paints, and crucibles, as a lubricant and an electrode and as a moderator in nuclear reactors. Syn: plumbago; black lead.

**grate fired boiler** Boiler design in which the fuel load is supported by framework of metal bars.

**gypsum** A widely distributed mineral consisting of hydrous calcium sulfate:  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ . It is the commonest sulfate mineral and is frequently associated with halite and anhydrite in evaporites or forming thick, extensive beds interstratified with limestone, shales and clays. Gypsum is very soft (hardness of 2 on Mohs' scale) and is white or colorless when pure, but can be tinted grayish, reddish, yellowish, bluish or brownish. It occurs massive (alabaster), fibrous (satin spar) or in monoclinic crystals (selenite). Gypsum is used chiefly as a soils amendment, as a retarder in portland cement and in making plaster.

**harvesting** The gathering of a crop or yield of one growing season. Commonly refers to vegetable matter which can be replanted at will. In reference to peat, this term is used as a synonym for mining.

**hectare** A metric unit of land area equal to 10,000 square meters or 2.471 acres.

**hemic peat** (U. S. Department of Agriculture classification) Peat in which plant fibers compose between 33.33 and 66.66 percent of the material; more decomposed than fibric peat.

**humic acid** Black, acidic, organic matter extracted from soils, peat, low rank coals and other decayed plant substances by alkalis. It is insoluble in acids and organic solvents.

**hydraulic peat mining** Peat mining methods which do not require prior drainage of the deposit. Typically, high pressure water guns or dredges are used to cut peat from the deposit.

**hydrocracking** A process in which relatively heavy hydrocarbons are broken up by heat into lighter products (such as gasoline) in the presence of hydrogen.

**hydrologic budget** An accounting of the inflow to, outflow from and storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake or reservoir (Langbein and Iseri, 1960); the relationship between evaporation, precipitation, runoff and the change in water storage, expressed by the hydrologic equation. Syn: water balance, water budget, hydrologic balance.

**hydrology** The science that deals with continental water (both liquid and solid), its properties, circulation and distribution, on and under the Earth's surface and in the atmosphere, from the moment of its precipitation until it is returned to the atmosphere through evapotranspiration or is discharged into the ocean.

**hydroperiod (of a wetland community)** A measure of the time (usually in days per year) that water is at or above the soil surface.

**hydrostatic head** The height of a vertical column of water, the weight of which, if of unit cross section, is equal to the hydrostatic pressure at a point; static head, as applied to water. See also: artesian head.

**hypnum moss peat** (American Society of Testing and Materials (ASTM) classification) Peat which contains at least 33.33 percent plant fibers with one-half of those identifiable as Hypnum moss. NOTE: ASTM is presently in the process of revising this classification; the above term will no longer be used.

**ion** An atom or group of atoms with an electric charge.

**isopach map** A map that shows the thickness of a bed, formation, sill or other tabular body throughout a geographic area, based on a variety of types of data.

**karst** A type of topography that is formed by the dissolution of limestone, dolomite or gypsum rock by rainwater or rivers. The topography is characterized by closed depressions, sinkholes, caves and underground drainages.

**ketone** Any of a class of organic compounds containing a carbonyl group,  $>C=O$ , attached to two organic groups, such as  $CH_3COCH_3$ .

**lagoon** A shallow stretch of seawater, such as a sound, channel, bay, or salt-water lake, near or communicating with the sea and partly or completely separated from it by a low, narrow, elongate strip of land, such as a reef, barrier island, sandbank or spit. It often extends roughly parallel to the coast, and it may be stagnant.

**lignin** An organic substance somewhat similar to carbohydrates in composition that occurs with cellulose in woody plants.

**lignite** A brownish-black coal that is intermediate in coalification between peat and bituminous coal; consolidated coal with a calorific value less than 8300 BTU/pound, on a moist, mineral-matter-free basis. Cf: brown coal.

**marine environment** Areas directly influenced by normal salinity seawater (approximately 35 parts per thousand).

**marl** An old term loosely applied to a variety of materials most of which occur as soft, loose, earthy and semifriable or crumbling unconsolidated deposits consisting chiefly of an intimate mixture of clay and calcium carbonate in varying proportions, formed under either marine or freshwater conditions.

**marsh** A water saturated, poorly drained area, intermittently or permanently water-covered, having aquatic and grasslike vegetation. Cf: swamp; bog.

**megawatt** A unit of power equal to 1 million watts.

**metamorphism** The mineralogical and structural adjustment of solid rocks to physical and chemical conditions which have been imposed at depth below the surface zones of weathering and cementation and which differ from the conditions under which the rocks in question originated (Turner and Verhoogen, 1960, p. 450).

**methane** A colorless, odorless, flammable gas which is the simplest paraffin hydrocarbon, formula  $CH_4$ . The principal constituent of natural gas.

**methanol** A colorless, volatile, water soluble, poisonous liquid,  $CH_3OH$ , used primarily as a solvent, fuel, automobile antifreeze and in the synthesis of formaldehyde. Also called methyl alcohol, wood alcohol.

**milled peat mining** Process in which the leveled bog is scraped to a depth of approximately one-half inch to 2 inches. The scraped material collected.

**mineral** A naturally occurring, homogeneous solid, inorganically formed, with a definite chemical composition and an ordered atomic arrangement.

**mineral** A naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form. A mineral is generally considered to be inorganic, though organic compounds are classified by some as minerals. Those who include the requirement of crystalline form in the definition of a mineral would consider an amorphous compound such as opal to be a mineraloid.

**mineraloid** A naturally occurring, usually inorganic substance that is not considered to be a mineral because it is amorphous and thus lacks characteristic physical and chemical properties; e.g. opal. Syn: gel mineral.

**minerotrophic** Peatlands which are connected with the regional groundwater system and are nourished both by precipitation and groundwater flow; contains alkaline, decaying vegetation on peat (see also fen).

**mining** The process of extracting mineral deposits or building stone from the Earth. The term may also include preliminary treatment of the ore or building stone; e.g. cleaning, sizing, dressing.

**mire** A general term for a section of wet swampy ground.

**montan wax** A bituminous wax extracted from lignite, used as an industrial lubricant and as an ingredient in furniture polish, shoe polish and electrical insulation.

**morbidity** The proportion of sickness or a specific disease in a geographical area.

**mortality** The relative frequency of death in a district or community.

**muck** Dark, finely divided, well decomposed, organic material intermixed with a high percentage of mineral matter, which forms surface deposits in some poorly drained areas.

**naphthalene** A white, crystalline, water insoluble hydrocarbon,  $C_{10}H_8$ , contained in coals, peat tar and some crude oils.

**NPDES Permit (National Pollutant Discharge Elimination System)** A U. S. Environmental Protection Agency permit required for any operation which results in a discharge into the surface waters of the U.S.

**oils** See benzene, naphthalene and phenol.

**ombrotrophic** Peatlands which are isolated from the regional groundwater system and receive moisture only from precipitation; contains acidic decaying vegetation or peat (see also bog).

**opal** A mineral (or mineral gel):  $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ . It is an amorphous (colloidal) form of silica containing a varying proportion of water (as much as 20 percent but usually 3-9 percent) and occurring in nearly all colors. Opal is transparent to nearly opaque and typically exhibits a definite and often marked iridescent play of color. It differs from quartz in being isotropic, having a lower refractive index and being softer and less dense.

**organic soil** A general term applied for a soil or a soil horizon that contains at least 30 percent organic matter, such as peat soils, muck soils and peaty soil layers.

**oxidation** The process of combining with oxygen.

**ozone** A form of oxygen,  $\text{O}_3$ , having three atoms per molecule, produced when an electric spark is passed through air or oxygen.

**peat** An unconsolidated deposit of semicarbonized plant remains occurring in a water-saturated environment, such as a bog or fen. It is considered an early stage or rank in the development of coal; carbon content is about 60 percent and oxygen content is about 30 percent (dry weight). When dried, peat burns freely.

**peat bitumens** Those peat components which are soluble in nonpolar organic solvents (gasoline, benzene, dichloroethane, etc.). The peat bitumens of commercial interest are waxes and resins.

**peat coal** A fuel, derived from the wet carbonization of peat, containing a heat value of 12,000-14,000 BTU/lb dry weight.

**peat coke** A carbon residue produced by the pyrolysis of peat which is a raw material for the production of activated carbon, in the production of high purity silicon and in the production of ferrochrome and ferrosilicon alloys.

**peat-humus** (American Society of Testing and Materials (ASTM) classification) Peat which contains less than 33.33 percent plant fiber. NOTE: ASTM is presently in the process of revising this classification; the above term will no longer be used.

**peat resin** A peat bitumen, a byproduct of peat wax production utilized primarily as a source of steroids for use by the pharmaceutical industry.

**peat tar** A water immiscible condensate produced by the pyrolysis of peat. It is often recycled as fuel for the coking (pyrolysis) process.

**peat wax** See peat bitumen.

**petroleum ether** A flammable, low boiling point, hydrocarbon mixture produced by the fractional distillation of petroleum, used as a solvent.

**pH** The negative logarithm of the hydrogen ion activity (less correctly concentration), indicates the acidity or alkalinity of a substance.

**phenol** A white poisonous substance,  $\text{C}_6\text{H}_5\text{OH}$ , derived from coal or peat tar or as a derivative of benzene; used primarily as a disinfectant, as an antiseptic and in organic synthesis; also called carboic acid.

**physiognomy** External aspect; characteristic or quality as revealed outwardly.

**polynuclear aromatic hydrocarbons** Nonmethane hydrocarbons produced by the incomplete combustion of peat; they are carcinogenic at very low levels and are stable in the environment.

**potassium dichromate** An orange-red poisonous powder,  $K_2Cr_2O_7$ , used as a laboratory reagent, in dyeing and in photographic chemicals.

**power gas** Gas utilized as fuel.

**proximate analysis** Alpha for coal, the determination of moisture, volatile matter, fixed carbon, and ash using procedures prescribed by the American Society of Testing and Materials.

**pulverized fired boiler** A boiler design which uses fuel which has been finely ground.

**pyrolysis** Decomposition of organic substances by heat in the absence of air.

**quartz (mineral)** Crystalline silica, an important rock-forming mineral:  $SiO_2$ . It is, next to feldspar, the commonest mineral. Quartz forms the major proportion of most sands.

**radiocarbon dating** See carbon -14 dating.

**radiometric dating** Calculating an age in years for geologic materials by measuring the presence of a short-life radioactive element, e.g. carbon-14; or by measuring the presence of a long-life radioactive element plus its decay product, e.g. potassium-40/argon-40. The term applies to all methods of age determination based on nuclear decay of natural elements.

**reduced** To change a chemical compound by removing oxygen or adding hydrogen so that the valence of the positive element is lower.

**reed-sedge peat** (American Society of Testing and Materials (ASTM) classification) peat containing at least 33.33 percent plant fibers, half of which are reed-sedge and other nonmosses. NOTE: ASTM is presently in the process of revising this classification. The above term will no longer be used.

**salt-water encroachment** Displacement of fresh surface or groundwater by the advance of saltwater due to its greater density, usually in coastal and estuarine areas, but also by movement of brine from beneath a playa lake toward wells discharging freshwater. Encroachment occurs when the total head of the saltwater exceeds that of adjacent freshwater. Syn: encroachment saltwater intrusion; seawater encroachment.

**sapric peat** (U. S. Department of Agriculture classification) Peat containing less than 33.33 percent recognizable plant fragments of any type; consists of the most extensively decomposed plant material.

**sapropel** An unconsolidated, jelly-like ooze or sludge composed of plant remains, most often algae, macerating and putrifying in an anaerobic environment on the shallow bottoms of lakes and seas. It may be a source material for petroleum and natural gas.

**sheet flow** An overland flow or downslope movement of water taking the form of a thin, continuous film over relatively smooth soil or rock surfaces and not concentrated into channels larger than rills.

**silviculture** The cultivation of forest trees.

**sod peat mining** Peat mining process in which the top layer of peat is cut and compressed by the machinery before being extended onto the field to dry.

**soil** A natural, three dimensional body at the Earth's surface which has properties resulting from the integrated effect of climate and organic matter on present rock material, as conditioned in response to topography; capable of supporting plant material.

**solvent extraction** Process which selectively separates components of an organic substance by means of reacting with a solvent. The absorbed compounds are subsequently stripped from the solvent.

**spagnum moss peat** (American Society of Testing and Materials (ASTM) classification) Peat which must contain at least 66.66 percent Spagnum moss fibers, by weight. NOTE: The ASTM is presently in the process of revising this classification. The above term will no longer be used.

**stoichiometric proportions** With reference to a compound or a phase, pertaining to the exact proportions of its constituents specified by its chemical formula. It is generally implied that a stoichiometric phase does not deviate measurably from its ideal composition.

**subsidence** The lowering of the upper surface of a peat deposit due to a reduction in volume, caused by a number of factors: shrinkage due to dessication, consolidation due to loss of bouyant force of water or loading, compaction due to tillage, erosion by wind, fire damage or biochemical oxidation.

**sulfur** An orthorhombic mineral, the native nonmetallic element S. It occurs in yellow crystals or in masses or layers often associated with limestone, gypsum and other minerals; used in the production of sulfuric acid, in petroleum refining, chemical production, iron and steel, paper, industrial explosives and many other uses.

**swamp** A water-saturated area, intermittently or permanently covered with water, having shrub and tree-type vegetation. CF: marsh; bog.

**synthesis gas** Those gases produced during gasification of peat which can be upgraded by hydrocracking to produce synthetic natural gas.

**talc** An extremely soft, whitish, greenish or grayish monoclinic mineral:  $Mg_3Si_4O_{10}(OH)_2$ . It has a characteristic soapy or greasy feel and a hardness of 1 on Mohs' scale, and it is easily cut with a knife. Talc is a common secondary mineral derived by alteration (hydration) of nonaluminous magnesium silicates (such as olivine, enstatite and tremolite) in basic igneous rocks or by metamorphism of dolomite rocks; and it usually occurs in foliated, granular or fibrous masses. Talc is used as a filler, coating pigment, dusting agent, and in ceramics, rubber, plastics, lubricants and talcum powder.

**tar** A thick, brown to black, viscous organic liquid, free of water, which is obtained by condensing the volatile products of the destructive distillation of coal, wood, oil, etc. It has a variable composition, depending on the temperature and material used to obtain it.

**volatile matter** In coal, those substances, other than moisture, that are given off as gas and vapor during combustion. Standardized laboratory methods are used in analysis. Syn: volatiles; volatile combustible.

**wet carbonization** A process in which a peat slurry is heated to 572-752°F at 50-100 atmospheres of pressure, produces a "peat coal" with a heat content of 12,000-14,000 BTU/lb dry weight.

**wetland** Areas inundated or saturated by surface water or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands can often be a transition zone between aquatic and terrestrial communities.

**wet mining methods** See hydraulic mining.

**wet oxidation** Process for oxidation of many wet organic materials in which air or oxygen is fed to the wet organic material in a closed, heated vessel. Combustion is controlled by the rate of oxygen feed and can be carried to completion to produce energy or can be stopped after the material is carbonized.

**wet reclamation** Any reclamation process which results in a permanently or periodically flooded reclaimed area.

Definitions and information on terms in this glossary are taken from the following references:

Diamond, et al., 1983  
Dravo Engineers and Constructors, 1981  
Fuchsman, 1978  
Gary, et al., 1972  
Kopstein, 1979  
Langbein and Iseri, 1960  
Minnesota Department of Natural Resources, 1981  
Neilson, et al., 1939  
Stein, et al., 1975  
Turner and Verhoogen, 1960  
Weath, 1973

APPENDIX A - FEDERAL ENVIRONMENTAL LEGISLATION  
(Appendix A is taken from R. King and others, 1980)

Legislation

Applicability to Peat Energy

National Legislation  
Policy Act of 1969  
(NEPA) PL 91-190

Environmental Impact Statements (EIS) must be prepared for all major federal actions significantly affecting the quality of the human environment. Environmental Impact Assessments (EIA) are usually done to determine which actions require an EIS.

Clean Air Acts as amended  
PL 91-604  
as amended by  
PL 92-157  
PL 93-15  
PL 93-319  
PL 95-95

Ambient air quality standards have been set to SO<sub>2</sub> TSP, NO<sub>2</sub>, CO, and O<sub>3</sub>; more are being considered. Affects all peat energy facilities. New Source Performance Standards (NSPS) apply to coal-fired boilers and regulate SO<sub>2</sub>, NO<sub>2</sub>, and particulates. Lower emission levels are being considered, as are regulations for small particulates. Stricter standards specific to coal liquefaction may be forthcoming.

Standards for hazardous air pollutants limit mercury, beryllium, and lead emissions, and currently limit coal types that can be used for demonstration plants.

NSPS and regulations for the prevention of significant deterioration may affect plant siting. Nonattainment criteria may be extended to NO<sub>3</sub>, which could affect plant siting.

Best Available Control Technology (BACT) may be required for peat energy demonstration facilities.

Federal Water Pollution  
Control Act Amendments  
of 1972  
PL 92-500

National Pollutant Discharge Elimination System (NPDES) permits are required to treat wastewater discharges.

Since effluent guidelines have not been developed for most fossil energy technologies, permit requirements are determined on a case-by-case basis by states or by EPA.

A "No Discharge" goal has been set for 1985.

Toxic Substances Control  
Act (TOSCA)  
PL 94-469

Disposal of specific materials used in peat energy processes may be regulated.

Legislation

Applicability to Peat Energy

Noise Control Act 1972  
PL 92-574

Control of ambient noise levels and recommended standards for facilities regulated by state and local governments may be required in the near future.

National Historic Preservation Act of 1966  
PL 89-665

Federally financed, assisted, or permitted projects cannot impact important historic or culture sites unless no alternative exists.

Endangered Species Act  
PL 93-205

Identification of endangered aquatic and terrestrial species at a potential construction site is required. May effect peat energy facility siting.

Fish and Wildlife Coordination Act  
PL 85-624

Any project requiring modification of bodies of water must be reviewed to prevent or reduce loss or damage to fish and wildlife.

MOU-1967 DOD & DOI  
EO-1977

Controls permit action by Corps of Engineers.

Wildlife and Scenic Rivers Act  
PL 90-542

Project must not degrade the quality of wildlife habitats and scenic rivers.

Coastal Zone Management Act of 1972  
PL 92-583

State coastal zone management plans developed with Federal financial assistance may affect siting and design of harvesting and conversion plant.

Rivers and Harbors Act  
33 U.S.C. 401--413  
Section of the 1899 Act

Permits are required for dredge and fill activities in navigable waters.

Projects must be integrated with flood control, river, and dam projects.

Marine Protection, Research and Sanctuaries Act of 1972  
PL 92-532

Permits are required for locating plants in wetlands areas, which may restrict extraction opera-areal (sic) peat conversion plant siting.

Occupational Safety and Health Act (OSHA)  
PL 91-596

Health and safety regulations must be met for workers in peat energy products. Noise levels for compressors, pumps, etc., are limited and must be controlled. Health regulations will be forthcoming.

Energy Reorganization Act of 1974  
PL 93-438

DOE is required to ensure environmental acceptability of the fossil energy and other technologies under development.

## Legislation

## Applicability to Peat Energy

Non-nuclear Energy  
Research and Development  
Act of 1974 (Section 13)  
PL 93-577

Water availability assessments are required for demonstration and commercial plants; assessments are reviewed by Water Resources Council (WRC).

Resource Conservation  
and Recovery Act of 1976  
PL 89-272

Solid waste disposal must comply with most stringent air and water standards; monitoring is required; state or EPA permits required for all landfills by April 1, 1988; must comply with states programs for non-hazardous materials.

Floodplain Management  
Executive Order 11988

Designated to reduce as much as possible long and short term impacts associated with floodplain development.

Requires each Federal agency to review policies concerning acquiring and managing Federal lands, federally regulated programs, and Federal activities affecting land use.

Reduce floodplain hazards and apply floodplain management practices.

Protection of Wetlands  
Executive Order 11990

Each agency will provide leadership and action to minimize the destruction and loss of wetlands and will conduct activities so as not to adversely affect land use and water resource planning efforts.

Each agency must review possible alternatives and designate practicable measures to mitigate the impacts.

Protection and Enhancement  
of Environmental Quality  
Executive Order 11514  
as amended by Executive  
Order 11911

The Federal government shall provide leadership in protecting and enhancing the environmental and quality of life.

Each agency must: monitor and evaluate its activities to protect the environment; develop procedures to issue public information on Federal plans and programs; develop research and demonstration testing programs; and engage in data and research exchange with other agencies.

Surface Mining Control  
and Reclamation  
Act of 1977  
30 USC 1201

Provides a mechanism for Federal and State review of all surface extraction of coal and other minerals (Peat may be considered to be a mineral).

Legislation

Applicability to Peat Energy

Designed to issue and enforce regulations for the surface mining industry, reduce environmental degradation, and force reclamation of a surface mine area.

The act declares that surface mining when conducted in an environmentally safe and diligent manner is a legally permitted activity.

Mineral Leasing Act  
of 1920, as amended  
by 30 USC 181

Provides the controls and regulation of surface and subsurface minerals extraction from Federal Public Lands.

Safe Drinking Water Act

Wastewater discharges may require additional treatment for heavy metals or organic waste if they impact drinking water supplies.

## APPENDIX B

### CLASSIFICATION OF WETLANDS IN FLORIDA

(Taken from Brown and others, 1983)

#### State Level

Several classification schemes have been developed for use in Florida. Monk (1968) classified communities by forest vegetation types. He states, "seven major forest vegetation types exist in North Central Florida: (1) Climax Southern Mixed Hardwood; (2) Sand Pine Scrub; (3) Sand Hills; (4) Pine Flatwoods; (5) Cypress Swamps; (6) Bayheads; and (7) Mixed Hardwood Swamps." Of these, three are used for wetlands classification--Mixed Hardwood Swamps, Bayheads, and Cypress Swamps.

In a classification scheme developed by Craig (1981), wetland areas were broken down into 11 categories. These include (1) Sloughs; (2) Freshwater Marsh and Ponds; (3) Pitcher Plant Bogs; (4) Shrub Bogs; (5) Swamp Hardwoods; (6) Cypress Swamps; (7) Cabbage Palm Hammocks; (8) Wetland Hardwood Hammocks; (9) Cutthroat Seeps; (10) Cabbage Palm Flatwoods; and (11) Bottomland Hardwoods.

Laessle (1942) used associations for classifying vegetation types. He defines association as, "a characteristic combination of plant species which is repeated in numerous stands with but little if any change in the vigor and proportions of its principle components."

Laessle's classification scheme for wetlands included:

I. Hydric Communities Dominated by Trees

1. Bayhead (Gordonia-Tamala pubeslens-Magnolia virginia Association)
2. River Swamp (Taxodium distichum-Nyssa biflora Association)

II. Herbaceous Aquatic Communities Bordering the River and Its Tidal Tributaries

1. Submerged Associations (Naias-Ceratophyllum Association and Vallisneria Association)
2. Floating Associations (Piaropus Association and Pistia-Salvina Association)
3. Emergent Vegetation

A report developed in part by the Northeast Regional Planning Council classifies several communities associated with wetland areas. These include Swamp Hammock, Hardwood Swamp, Riverine Cypress, Cypress Pond, Bayhead and Bog, Wet Prairie, Freshwater Marsh (shallow and deep), and Tidal Flat (Jacksonville Area Planning Board, 1977).

Under the aegis of the Florida Department of Administration, the State Division of Planning, and the Bureau of Comprehensive Planning a committee was created to increase the efficiency of land use planning by coordinating the collection, interpretation, and other use of land resource data. The result was the Florida Land Use and Cover Classification System (1976). Inventory of state land resources would be achieved through the coordination

of remote-sensing techniques (including aerial photography) and ground-based observations. Computer storage of such vast quantities of information could permit organization of the data in a variety of ways that would expedite management decisions. Within this scheme, information from various sensors is organized into various levels of classification ranging from Level I to Level IV. The levels are summarized as follows in the technical report describing the classification system:

Level I classification uses satellite imagery with very little supplemental information. The mapping is usually at a ratio of 1:1,000,000. At this ratio only a general classification based on major differences in land cover can be made.

Level II classifications are based on high altitude and satellite imagery combined with topographic maps. The mapping is normally at a ratio of 1:100,000 and transferable to a 1:24,000 ratio.

Level III classification are based on medium altitude remote sensing at a scale of less than 1:24,000 combined with detailed topographic maps and substantial amounts of supplemental information, i.e., field observation.

Level IV classification uses low altitude imagery with most of the information being derived from supplemental sources. (This level is not included within this document.)

#### 600 Wetlands: (Level I)

Forested wetlands are areas that are subject to permanent or

prolonged periods of inundation or saturation and/or exhibit vegetative communities characteristic of this hydroperiod.

610 WETLAND-CONIFEROUS FOREST: (Level II).

These wetlands have a tree crown areal density of 10% or more (crown closure requirement), have a dominant tree crown of the coniferous species, and are a result of natural seeding.

611 Cypress: (Level III)

These forested areas are dominated by a crown closure in either bald cypress or pond cypress. Principal associates are tupelo, gum, and maple.

612 Pond Pine: (Level III)

These are forested areas dominated by a crown closure in pond pine. Pond pine dominates wetter flats with low pH, often associated with the inland reaches of marshes or muck swamps.

620 WETLAND-HARDWOOD FOREST: (Level II)

These wetlands have a dominant tree crown of the hardwood species meeting the crown closure requirement and are a result of natural seeding.

621 Freshwater Swamps: (Level III)

River, creek, and lake overflow areas. These com-

munities will have predominantly one or more of the following species:

Pond cypress, Taxodium ascendens

River cypress, Taxodium distichum

Red maple, Acer rubrum

River birch, Betula nigra

Black willow, Salix nigra

Coastal plain willow, Salix caroliniana

Blackgum, Nyssa biflora

Ogeechee tupelo, Nyssa ogeeche

Water hickory, Carya aquatica

Water ash, Fraxinus caroliniana

Buttonbush, Cephalanthus occidentalis

Bogs and bayheads. These communities will have predominantly one or more of the following species:

Pond pine, Pinus serotina

Lobolly bay, Gordonia lasianthus

Sweet bay, Magnolia virginiana

Swampbay, Persea palustris

Titi, Cyrilla racemiflora

Sphagnum moss, Sphagnum sp.

Inland ponds and sloughs. These communities will have predominantly one or more of the following species:

Pond cypress, Taxodium ascendens

Black gum, Nyssa biflora

Water tupelo, Nyssa aquatica

Titi, Cyrilla racemiflora, C. parviflora

Black titi, Cliftonia monophylla

Willow, Salix sp.

Primrose willow, Ludwigia peruviana

Pond apple, Annona glabra

## APPENDIX C

### FLORIDA STATUTES CONCERNING WETLANDS

(Taken from Brown and others, 1983)

#### How Wetlands are Perceived in Florida Law

"A marsh or a swamp which is not physically connected to a lake or stream by even occasional overflow is treated as surface water in spite of its permanence" (Maloney 1971). Therefore, it is common to see wetlands characterized as "surface water" in the Florida Statutes, which administers authority to the various agencies. It is not until such agencies mandate specific actions that the actual term of "wetlands" is used.

Florida Statutes that Administer Wetland Authority Chapter 380--The Florida Environmental Land and Water Management Act of 1972

#### Section 380.021--Purpose:

It is the intent that, in order to protect natural resources and environment of this state as provided in s. 7, Art. II of the State Constitution, insure a water management system that will reverse the deterioration of water quality and provide optimum utilization of our limited water resources, facilitate orderly and well-planned development, and protect the health, welfare, safety, and quality of life of the residents of this state, it is necessary adequately to plan for and guide growth and development

within this state. In order to accomplish these purposes, it is necessary that the state establish land and water management policies to guide and coordinate local decisions relating to growth and development; that such state land and water management policies should, to the maximum possible extent be implemented by local governments through existing processes for the guidance of growth and development; and that all the existing rights of private property be preserved in accord with the constitutions of this state and of the United States.

Section 380.05--Areas of critical state concern:

(1) (a) The state land planning agency may from time to time recommend to the Administration Commission specific areas of critical state concern. In its recommendation, the agency shall include recommendations with respect to the purchase of lands situated within the boundaries of the proposed area as environmentally endangered lands and outdoor recreation lands under the Land Conservation Act of 1972. The agency also shall include any report or recommendation of a resource planning and management committee appointed pursuant to s. 380.045; the dangers that would result from uncontrolled or inadequate development of the area and the advantages that would be achieved from the development of the area in a coordinated manner; a detailed boundary description of the proposed area; specific principles for guiding development within the area; and an inventory of lands owned by the state, federal, county, and municipal governments with the

proposed area.

(2) An area of critical state concern may be designated only for:

(a) An area containing, or having a significant impact upon, environmental or natural resources or regional or statewide importance, including, but not limited to, state or federal parks, forests, wildlife refuges, wilderness areas, aquatic preserves, major rivers and estuaries, state environmentally endangered lands, Outstanding Florida Waters, and aquifer recharge areas, the uncontrolled private or public development of which would cause substantial deterioration of such resources. Specific criteria which shall be considered in designating an area under this paragraph include:

1. Whether the economic value of the area, as determined by the type, variety, distribution, relative scarcity, and the condition of the environmental or natural resources within the area, is of substantial regional or statewide importance.

2. Whether the ecological value of the area, as determined by the physical and biological components of the environmental system, is of substantial regional or statewide importance.

3. Whether the area is a designated critical habitat of any state or federally designated threatened or endangered plant or animal species.

4. Whether the area is inherently susceptible to substantial development due to its geographic location or natural aesthetics.

5. Whether any existing or planned substantial development within the area will directly, significantly, and deleteriously affect any or all of the environmental or natural resources of the area which are of regional or statewide importance.

Chapter 259--Land Conservation Action of 1972

Section 259.04--Powers and duties of "Board":

Definition: "Board" means the governor and cabinet, sitting as the Board of Trustees of the Internal Improvement Trust Fund. [(259.03(4))].

(1) For state capital projects for environmentally endangered lands:

(a) The board is given the responsibility, authority, and power to develop and execute a comprehensive plan to conserve and protect environmentally endangered lands in this state. This plan shall be kept current through continual reevaluation and revision.

Chapter 163--Local Government Comprehensive Plan Act of 1975

Section 163.3161--Intent and Purpose:

(1) This act shall be known and may be cited as the "Local Government Comprehensive Planning Act of 1975."

(2) In conformity with, and in furtherance of, the purpose of the Florida Environmental Land and Water Management Act of 1972, chapter 380, it is the purpose of this act to utilize and strengthen the existing role, processes, and powers of local

governments in the establishment and implementation of comprehensive planning programs to guide and control future development.

(3) It is the intent of this act that its adoption is necessary so that local governments can preserve and enhance present advantages; encourage the most appropriate use of land, water, and resources consistent with the public interest; overcome present handicaps; and deal effectively with future problems that may result from the use and development of land within their jurisdictions. Through the process of comprehensive planning, it is intended that units of local government can preserve, promote, protect, and improve and public health, safety, comfort, good order, appearance, convenience, law enforcement and fire prevention, and general welfare; prevent overcrowding of land and avoid undue concentration of population; facilitate the adequate and efficient provision of transportation, water, sewage, schools, parks, recreational facilities, housing, and other requirements and services; and conserve, develop, utilize, and protect natural resources within their jurisdiction.

Section 163.3177 (7) and (8)--Required and Optional Elements of Comprehensive Plan:

(7) Such other elements as may be peculiar to, and necessary for, the area concerned and as are added to the comprehensive plan by the governing body upon the recommendation of the local planning agency.

(8) All elements of the comprehensive plan, whether man-

datory or optional, shall be based upon data appropriate to the element involved.

Chapter 581--Plant Industry

Section 581.185--Preservation of flora of Florida:

(1) PROHIBITIONS; PERMITS:

(a) With regard to any plant on the Endangered Plant List provided in subsection (2), it is unlawful for any person:

1. To willfully injure or destroy any such plant growing on the private land of another without first obtaining the written permission of the owner of the land or his legal representative.

2. To willfully harvest, collect, pick, or remove three or more individual plants of a given species listed on the Endangered Plant List from any native habitat without first obtaining the written permission of the owner of the land or his legal representative or, in the case of public land or water, the written permission of the superintendent or custodian of such land or water, and a permit from the department as provided in this section.

(2) ENDANGERED PLANT LIST:

The following plants shall be included in the Endangered Plant List:

- (a) Asimina pygmacea (pink pawpaw).
- (b) Asimina tetramera (four-petal pawpaw).
- (c) Asplenium auritum (auricled spleenwort) (fern).
- (d) Blechnum occidentale (sinkhole fern).

- (e) Campyloneurum angustifolium (narrow swamp fern).
- (f) Cassia keyensis (Key cassia).
- (g) Catesbacea parviflora (dune lily-thorn).
- (h) Catopsis sp. (bromeliad).
- (i) Cereus gracilis (prickly apple cactus).
- (j) Cereus robinii (tree cactus)
- (k) Chionanthus pygmaeus (fringe tree or granny-graybeard).
- (l) Clusia rosea (balsam apple).
- (m) Coccothrinax argentata (silver palm).
- (n) Cucurbita okeechobeensis (Okeechobee gourd).
- (o) Cupania glabra (cupania).
- (p) Cyrtopodium punctatum (cowhorn or cigar orchid).
- (q) Dennstaedtia bipinnata (cuplet fern).
- (r) Encyclia boothiana (Epidendrum boothianum) (dollar orchid).
- (s) Epigaea repens (trailing arbutus).
- (t) Guaiacum sanctum (lignum vitae).
- (u) Guzmania sp. (bromeliad).
- (v) Ionopsis utricularioides (delicate ionopsis orchid).
- (w) Magnolia ashei (Ashe magnolia).
- (x) Magnolia pyramidata (pyramidal magnolia).
- (y) Maxillaria crassifolia (orchid).
- (z) Ophioglossum palmattum (hand fern).
- (aa) Parnassia grandifolia (grass-of-Parnassus).
- (bb) Polyrrhiza lindenii (ghost orchid).
- (cc) Rhododendron austrinum (orange azalea).

- (dd) Rhododendron chapmanii (Chapman's rhododendron).
- (ee) Ribes echinellum (Moccasukee gooseberry).
- (ff) Roystonea elata (Florida royal palm).
- (gg) Sarracenia leucophylla and Sarracenia rubra  
(pitcher plants).
- (hh) Scaevola plumieri (scaevola).
- (ii) Strumpfia martima (scaevola).
- (jj) Suriana maritima (bay cedar).
- (kk) Taxus floridana (Florida yew).
- (ll) Tillandsia fasciculata (wild pine bromelaid)  
(included because of very high harvest rate).
- (mm) Torreya taxifolia (Florida torreya).
- (nn) Tournefortia gnaphalodes (sea lavender).
- (oo) Trillium lacifolium (trillium).
- (pp) Zephyranthes simpsonii (zephyr lily).

#### Chapter 403--Environmental Control

Section 403.021 declares that "the public policy of the state is to conserve the waters of the state to protect, maintain, and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and other aquatic life, and for domestic, agricultural, industrial, recreational, and other beneficial uses. It also prohibits the discharge of waste into Florida waters without treatment necessary to protect those beneficial uses of the water."

Section 403.062 deals with pollution control; underground, surface, and coastal waters. "The Department of Environmental Regulation and its agents shall have general control and supervision over underground water, lakes, rivers, streams, canals, ditches, and coastal water under the jurisdiction of the state insofar as their pollution may affect the public health or impair the interest of the public or persons lawfully using them."

Chapter 373--Florida Water Resources Act of 1972

Section 373.016 declares it to be the policy of the legislature:

(a) To provide for the management of water and related land resources;

(b) To promote the conservation, development, and proper utilization of surface groundwater;

(d) To prevent damage from floods, soil erosion, and excessive drainage;

(e) To preserve natural resources, fish and wildlife;

(g) Otherwise to promote the health, safety, and general welfare of the people of this state.

It is the intent of the Legislature to vest in the Department of Environmental Regulation or its successor agency the power and responsibility to accomplish the conservation, protection, management, and control of the waters of the state and with sufficient flexibility and discretion to accomplish these ends through delegation of appropriate powers to the various water management districts.

St. Johns River Water Management Districts:

Chapter 40C-4--(Florida Administrative Code, hereafter referred to as F.A.C.)--Management and Storage of Surface Water

Chapter 40C-4 is currently under extensive modification. It is recommended that, upon adoption by the St. Johns River Water Management Board, Chapter 40C-4 be thoroughly reviewed by Seminole County Staff, and policy, goals and objectives, and ordinances made to conform.

Chapter 372--Game and Fresh Water Fish

Section 372.072--Endangered and Threatened Species Act of 1977:

(2) Declaration of Policy--The Legislature recognizes that the State of Florida harbors a wide diversity of fish and wildlife and that it is the policy of this state to conserve and wisely manage these resources, with particular attention to those species defined by the Game and Fresh Water Fish Commission, the Department of Natural Resources or the U.S. Department of Interior, or successor agencies, as being endangered or threatened. As Florida has more endangered and threatened species than any other continental state, it is the intent of the Legislature to provide for research and management to conserve and protect these species as a natural resource.

(4) Establishment of an Advisory Council--

(a) The director of the Game and Fresh Water Fish Commission

shall establish an Endangered and Threatened Species Advisory Council consisting of 10 members.

Case Law:

The Graham v. Estuary Properties Inc. (Fla. 399 So. 2d 1374) decision in Florida is the most progressive decision to date concerning the use of land use regulations as an effective means of protecting wetlands via development control.

Background:

In compliance with Florida Land and Water Management Act of 1972, Estuary Properties submitted an application for a development permit for their development of regional impact (DRI) to Lee County Board of County Commissioners. The permit was denied due to an 1800 acre black mangrove forest which would be destroyed and therefore cause an adverse environmental impact. The developers appeal to the Florida Land and Water Adjudicatory Commission was denied.

Estuary Properties contended that the Commission had improperly denied its application because the various impacts of the development had not been balanced nor had the Commission made suggestions concerning ways to correct the inadequacies of the DRI.

The developers also attacked the Commission's denial of the permit as an unconstitutional taking because the owner's right to use his property had been violated.

Following denial by the Florida Land and Water Adjudicatory Commission, the developer next turned to the Florida District Court of Appeals (Estuary Properties v. Askew [Fla. App. 381 So. 2d 1126]).

In December 1979, the Florida District Court of Appeals ruled (later to be overturned by the Florida Supreme Court) that a government agency that denies an application for development of regional impact in an environmentally sensitive area must prove that the project has an adverse affect on the environment and moreover, a local government cannot deny an owner of wetlands all reasonable use of property without paying compensation (Land Use Law and Zoning Digest, April 1980). The court reasoned that: benefits to the general public should not be borne by a few property owners, therefore, the development permit could not be denied unless compensation was administered.

The case pinpoints the judicial uneasiness over ad hoc regulations of particular geographic areas for the purpose of promoting public benefits but without recognition of the obligation to compensate the owner. The case underscores the need for government to establish balanced management programs--such as development rights transfers or bonuses and incentives to guide growth away from heavily restricted areas to desired areas--rather than requiring a single owner to suffer the cost of providing community benefits (Land Use Law and Zoning Digest, April 1980).

The constitutional question which arose from Estuary

Properties v. Askew of "a taking" versus a valid exercise of the police power, with regard to the regulation of development in wetlands, was further reviewed by the Florida Supreme Court in April of 1981 as Graham v. Estuary Properties, Inc. The Florida Supreme Court held that the permit denial in response to Estuary's DRI application as a valid exercise of the police power but the Land and Water Adjudicatory Commission must provide Estuary Properties with the changes which would make the development eligible for approval. Regarding balancing of public versus private interests (protecting public health, safety, and welfare versus protection of private property interests), the court found that the adverse environmental impact and deviation from the policies of the planning council could outweigh other more favorable findings in deciding a development approval.

The court also reasoned that:

if the regulation preventing the destruction of the mangrove forest was necessary to avoid unreasonable pollution of the water thereby causing attendant harm to the public, the exercise of police power would be reasonable.

Since the Land and Water Adjudicatory Commission found that the development would cause pollution in the bays and effect the county's economy, the court ruled that:

The regulation at issue here promotes the welfare of the public, prevents public harm and has not been arbitrarily applied.

In discussing the reasonableness of the regulation the court

also relies on the "magnitude of Estuary's proposed development and the sensitive nature of the surrounding lands and water to be affected by it. In this situation it is not unreasonable to place some restrictions on the owner's use of the property." Furthermore the court found that Estuary did not have legitimate investment-backed expectations for use of the property but only "its own subjective expectation that the land could be developed in the manner it now proposes."

In answer to the taking issue the court said that "Estuary purchased the property in question...with full knowledge that part of it was totally unsuitable for development." The court said that there was no evidence supporting the claim that Estuary could make no beneficial use of the land.

It seems that in the Estuary case the court did not agree that the property was rendered worthless by the exercise of police power. In addition it found that reduction of the development by half was a valid exercise of police power. "The owner of private property is not entitled to the highest and best use of his property if that use will create public harm." Further:

We agree with the Wisconsin Supreme Court's observation in Just v. Marinette County, 56 Wis. 2d 7, 201 N.W. 2d 761 (1972), where that court pointed out the involvement of exceptional circumstances because of the interrelationship of the wetlands, swamps and natural environment to the purity of the water and natural resources such as fishing. The court also noted the close proximity of the land in

question to navigable waters which the state holds in trust for the public. Similar factors are present in the case at bar. We agree with the Wisconsin court that [a]n owner of land has no absolute and unlimited right to change the essential natural character of his land so as to use it for a purpose for which it is unsuited in its natural state and which injures the right of others, 56 Wis. 2d at 17, 201 N.W. 2d at 768.

APPENDIX D  
WATER QUALITY

Water Quality Parameters Measured in Conjunction with Peatland Development; Minnesota, North Carolina and Florida

Water Quality Characteristics Targeted for Baseline Studies by Minnesota. (Taken from Minnesota Department of Natural Resources, 1981).

acidity	magnesium
alkalinity	manganese
aluminum	mercury
ammonia	nickel
arsenic	nitrate
boron	nitrite
cadmium	organic nitrogen
calcium	pH
chemical oxygen demand	selenium
chromium	sodium
color	specific conductivity
copper	suspended sediment
dissolved oxygen	temperature
fulvic acid	total nitrogen
humic acid	total phosphorous
iron	zinc
lead	

Water Quality Characteristics Targeted for Monitoring in  
Conjunction with a Peat Mining Operation, Department of  
Environmental Regulation, State of Florida.

Alkalinity	Ortho Phosphate
Aluminum	pH
Beryllium	Phenols
Cadmium	Selenium
Chromium	Specific Conductance
Color	Temperature
Copper	Total Dissolved Solids
Dissolved Ortho-Phosphate	Total Kjeldahl Nitrogen
Dissolved Oxygen	Total Organic Carbon
Iron	Total Phosphorus
Lead	Total Suspended Solids
Mercury	Turbidity
Nickel	Zinc

Water Quality Measurements Prepared for Wastewater Discharge  
Assessment Peat to Methanol Plant, Creswell, North Carolina.

In situ:

Dissolved Oxygen, Field (mg/L)  
pH, Field (standard units)  
Seechi Depth (m)  
Specific Conductance, Field (umhos/cm)  
Water Temperature (C)

Classicals:

Alkalinity, Total (mg/L as CaCO<sub>3</sub>)

Ammonia (mg/L-N)

Antimony (ug/L)

BOD (mg/L, 20 day-20 deg C)

BOD (mg/L, 3 day-20 deg C)

BOD (mg/L, 30 day-20 deg C)

BOD (mg/L, 40 day-20 deg C)

BOD (mg/L, 50 day-20 deg C)

BOD (10 day mg/L)

BOD (5 day mg/L)

BOD, CARB. (mg/L, 10 day-20 deg C)

BOD, CARB. (mg/L, 20 day-20 deg C)

BOD, CARB. (mg/L, 3 day-20 deg C)

BOD, CARB. (mg/L, 30 day-20 deg C)

BOD, CARB. (mg/L, 40 day-20 deg C)

BOD, CARB. (mg/L, 5 day-20 deg C)

BOD, CARB. (mg/L, 50 day-20 deg C)

Calcium, Total (mg/L)

Chloride (mg/L)

Chlorophyll a (ug/L, corrected)

Cobalt

Color (CPU)

Copper, Total (ug/L)

Cyanide (mg/L)

Dissolved Reactive Silica

Fluoride (mg/L)  
Hardness (mg/L)  
Iron, Total (ug/L)  
Lead, Total (ug/L)  
Magnesium, Total (mg/L)  
Mercury, Total (ug/L)  
Nickel (ug/L)  
NO<sub>2</sub>, (mg/L-N)  
NO<sub>3</sub>, (mg/L-N)  
NO<sub>3</sub>, NO<sub>2</sub> (mg/L-N)  
Ortho-Phosphate, Dissolved (mg/L as P)  
Phosphorus, Total (mg/L as P)  
Silica, Total (Mg/L as SiO<sub>2</sub>)  
Silver, Total (ug/L)  
Sodium, Total (mg/L)  
Solids, Dissolved (mg/L)  
Solids, Total Suspended (mg/L)  
Sulfate (mg/L)  
T. Org. N. (mg/L-N)  
Thiocyanate (mg/L as SCN)  
TKN (mg/L-N)  
Turbidity (NIU)  
Zinc, Total (ug/L)

Metals:

Arsenic, Total (ug/L)

Chromium, Total (ug/L)

Chromium, (+6) (ug/L)

Cadmium, Total (ug/L)

Magnesium, Total (mg/L)

Selenium, Total (ug/L)

## APPENDIX E

### PEATLANDS MANAGEMENT

#### PEATLANDS MANAGEMENT, STATE OF MINNESOTA

Elements of a Management Program for the Peatlands (Taken from Asmussen, 1980)

Following legislative review and response in 1981 the Minnesota Peat Program must create a long-term management program for the peatlands. Some of the elements of a program are already in place, for example, the leasing of horticultural peat. Should the energy and other peatland development proposals discussed above be realized, management concerns and responsibilities will multiply.

One important element in an on-going program is a routine site-selection process. Criteria are being established for identifying peatland areas suitable for one or another type of utilization. A list of possible site selection criteria is presented in Table 3, below.

#### Table 3 Peatland Utilization Site Selection Criteria

1. Peat quality and depth
2. Accessibility
3. Watershed configuration
4. Ownership pattern
5. Proximity to existing development
6. Existing bog disturbance

7. Presence of unique features
8. Presence of conflicting uses or management status
9. Regional benefit of proposed development
10. Regional costs of proposed development

Site selection processes must be complemented with the designation of management units. In Minnesota, management units will be defined primarily by watershed boundaries because water flow and direction are the most critical impact vectors in the peatland ecosystem. Management units might coincide with smaller watersheds. In larger watersheds it may be possible to site developments at the downstream part of the watershed, thereby limiting total watershed disturbance.

The mechanism for allocating peatland to various utilizations has been, and will probably continue to be, leasing. The state of Minnesota owns or manages over 50% of the peatland in the state and about 70% of the peat in northern Minnesota considered most suitable for energy developments. Traditionally, the Department of Natural Resources has leased areas of peat for horticultural and agricultural uses and is likely to use this mechanism for energy utilization should it occur.

The lease is more than a simple covenant between owner and lessee. It specifies the financial terms of the right to use land (rents and royalties) as well as minimum production levels required. In addition, a lease may stipulate reclamation staging and type and requirements to monitor a peat mining or processing venture. Thus, the lease is a complex management tool.

Other management elements include environmental review procedures and permitting processes. These are shared by responsible agencies, in Minnesota: the Department of Natural Resources, Pollution Control, the Minnesota Energy Agency, and the Environmental Quality Board. Between them are administered water withdrawal and drainage permits, air quality permits, certificates of need for energy proposals, and environmental impact statements.

From the above elements a comprehensive management program for Minnesota peatlands can emerge. Through proper site selection procedures it should be possible to allocate peatland uses to avoid resources conflicts, areas of environmental sensitivity, and unnecessary social and economic costs. A careful leasing process should assure a fair return to the state for making the resource available to the private sector and insure that the land is returned, or reclaimed, to a useful condition. Permits and environmental review procedures are the final safeguard against developments inimical to the environment.

PEATLANDS MANAGEMENT, PROVINCE OF NEW BRUNSWICK (From Keys, 1980)

#### Ownership of Peatlands

Peat is classed as a surficial deposit in New Brunswick under the provisions of the Quarriable Substance Act. As such, ownership of the deposits rests with the landowner. However, few peatlands were included in the original applications for land

grants. Hence, ownership of an estimated 80% of New Brunswick peatlands remains with the province under the administration of the Department of Natural Resources.

The twelve companies presently producing horticultural peat products in New Brunswick lease all or parts of their production areas from the province. An acreage rental and a royalty on production is paid annually. The regulations governing leasing of peatlands were recently revised to ensure optimum management of the resource (3). The objectives of the leasing policy are to maximize the contribution of the resource to the economic development of the province and to have development in a manner which does not jeopardize future utilization or rehabilitation of the peatlands.

To obtain a peat production lease, it is first necessary to obtain a peatland exploration license. This license effectively reserves an area of 800 hectares (2,000 acres) to allow the applicant sufficient time to ascertain that the quality and amount of peat in the proposed lease is suitable for the intended use. The exploration license is renewable annually to a maximum of three years provided all requirements are met. Approval of a peatland exploration license is granted only if the applicant: has no other license in effect; can demonstrate the proposed development will not adversely affect the future availability of peat for an existing leaseholder; and can market the product without jeopardizing the existing industry in the province.

After determining the portion of the exploration area best

suitable for the proposed use, the applicant may then apply for a peat lease of 250 hectares (620 acres). This application must include a drainage plan, a harvesting and future expansion plan, and an abandonment plan. If all requirements are met a lease can be granted for a period of ten years. Renewal for further ten year periods is possible if certain minimum production requirements and other conditions are met. A security deposit to ensure compliance with production and abandonment plans is required.

The size and term of leases is designed to avoid the holding and under-utilization of large tracts of peatlands for extended periods. However, to ensure the opportunity for expansion, the holder of a lease may negotiate a time limited option on an adjacent buffer zone.

#### PEATLANDS MANAGEMENT STATE OF NORTH CAROLINA

(Recommendations prepared by the Peat Mining Task Force, Department of Natural Resources and Community Development, State of North Carolina, January 1983)

The DNRC Peat Mining Task Force has completed its review of the department's permitting procedures for peat mining. It has also reviewed its own 1981 recommendations, updating them as necessary. In the recommendations below, whenever a 1981 recommendation has been updated or repeated, it is so noted and major changes are explained. The task force considered the issues of

peat use and has reconsidered the overall impacts of peat mining. From this effort have come the conclusions and recommendations in this report. Specific recommendations follow.

#### 1. Existing Permits

The review of the five existing mining permits for peat mines has led the task force to conclude that all five of them should be revised to include the recommendations in this report. The three existing peat mines which do not have NPDES, air quality, and water use permits should be required to apply immediately for these permits. The Division of Land Resources, in coordination with the Division of Environmental Management, should immediately notify permit holders of this determination. In the case of these three, the revision of the mining permit and the applications for the three DEM permits should be treated as a package and public meetings held. In addition to the mining permit revisions, the other two mines (PEATCO and Whitetail) should have their water and air permits revised to reflect the contents of Table III.

#### 2. Role of Mining Permit

The mining permit should be the department's primary management tool for peat mining. The four principal state permits required for peat mining--the mining permit, NPDES permit, air quality permit, and water use permit--should be processed as a package.

A public scoping meeting should be held on each package where there is significant public interest to identify the speci-

fic issues to be addressed in the permit applications and supporting information. A coordinated public hearing should be held on these draft permits in each package before they are issued.

The laws requiring these permits allow the State to require submission of detailed analyses of environmental impacts as part of the permit applications and this should be required in all cases. While the information submittal need not be in the same format as a formal environmental impact statement, it should be detailed and complete enough to provide the department with sufficient information to assess the impacts of the proposed project prior to a permit decision. A standard set of information requirements for this analysis should be prepared by the Division of Land Resources in close coordination with all other affected divisions, and supplied to applicants early in preapplication counseling.

Under the Mining Act of 1971, the significant impacts of peat mining can be addressed by a mining permit. Table III (in Chapter IV) identifies these issues and specifies which permits cover them directly and indirectly. The requirements of the other permits can and should be incorporated into the mining permit, strengthening its umbrella or coordinating role.

Treating the four permits for a peat mine as a package will ensure that all significant impacts will be addressed in a timely and consistent manner. It will also increase the predictability of the permitting schedule. The most efficient possible use of specialized resources in all for example, DEM's water quality

expertise is needed to advise Land Resources on specific water quality issues and conditions which must be handled in the mining permit. Different statutory timetables for various permits and the variations with individual projects may make complete coordination impossible. Natural Resources Planning and Assessment, on behalf of the Assistant Secretary for Natural Resources, should prepare a detailed flow chart of permit hearing, meeting, and decision deadlines for each proposed peat mine operation. The department's existing peat permit application review group can extend its function to review the four-permit package with little change of membership.

The package concept will also enhance the opportunities for public involvement in the permitting process for peat mines. Shortly after applications for a peat mine are received, a public scoping meeting maybe convened by the department to discuss the questions and issues which should be addressed in reviewing permit applications. The scoping meeting, which is not required by statute, represents an innovation for dealing routinely with permits in this department. In final review stages, the package of draft permits should be the subject of a public hearing to receive comments on the draft. The public hearing on a draft permit is already done for some DEM permits, and the 1981 amendments to the Mining Act provide for a public hearing on any new mining application when significant revisions of existing mining permits where there is significant public interest.

The task force recommends that the Division of Land

Resources, with the Division of Environmental Management's assistance, prepare packets of application materials and information, a NPDES permit application, an air quality permit application, a water use permit application, a list of contacts on permitting matters, and a copy of this report. The task force does not recommend the development of any new combined application.

Use of the mining permit as the state's primary management tool for peat mining requires that additional information be included in mining permits. Table III (in Chapter IV) enumerates the issues related to peat mining and specifies which permit covers each issue. Each issue which can be addressed by the Mining Act should be included in a mining permit for peat.

Inasmuch as is possible, permits from other departments and permits for peat use activities should be included in this comprehensive review recommended for the mining and related permits.

### 3. Impacts of Peat Use

Each proposed facility which will use peat should be carefully studied on its own merits. These facilities, by their highly specialized nature, are expected to have process-specific and site-specific impacts. For example, in addition to DNRCD permit requirements, any electric generating plants will be closely controlled under North Carolina's utilities laws, and the proposed methanol plant is subject to the special stipulations of the federal Energy Security Act. Other uses, such as industrial

process heat, are not so obviously covered.

All uses of peat, except horticultural peat, will probably involve facilities which require NPDES, air, and water use permits. The task force expects that these permits will cover the most serious impacts of peat transportation from mines to users should be covered under comprehensive mining permits.

In the specific case of Peat Methanol Associates' proposed methanol plant, the task force found no impacts which could not be covered by either these permits or by the comprehensive mining permit to be applied to the mine supplying peat for the plant. The special environmental monitoring plans required under the federal Energy Security Act for this project should be specifically incorporated into the related mining permit. These data will provide critical additional information regarding impacts of peat mining and use.

The task force recommends that DNRCD continue to track closely the development of peat-using facilities and to consider their impacts as more experience is gained.

#### 4. General Policy on the Siting of Peat Mines

The task force recommends a four part general policy on the siting of peat mines:

1. Permits for peat mining should not be issued for stream valley deposits which directly contribute organic matter to estuarine ecosystems and for floodplain peat deposits along major rivers.

2. Permits for peat mining in areas where the bottom

of the peat deposit lies at or below sea level should not be issued unless and until adequate environmental safeguards are developed.

3. Permits for peat mining should not be issued on state parks and state-owned state gamelands, and no leases for peat mining on any state-owned lands should be issued without a full review of the environmental impacts.

4. Mining in the rest of the peat deposits should be permitted under careful monitoring.

This basic recommendation is repeated from the 1981 task force report. In the interim no mining permits have been issued which are not in accord with the recommendation, even though DNRC has officially promulgated only the state parks portion of part (3). Careful mining with close monitoring has been the principle followed in issuing all five permits now in effect.

The permit for Whitetail Farms, at least on the northern half of the tract, is the only example thus far of a permit falling under part (2), not issuing permits pending adequate environmental safeguards. The Whitetail Farms mining permit incorporates several safeguards which the peat mining permit application review group found to satisfy the requirement for "adequate environmental safeguards." In order to mine peat in a deposit which partly extends below sea level, Whitetail Farms is required to, among other things, mine no lower than an elevation of one foot above mean sea level, direct all surface drainage from the part of the tract outside the Boundary Canal, build and

maintain a dike reaching eight feet elevation above mean sea level around the area in which the post-mining elevation will be between one and eight feet, install floodgates, and maintain a 300-foot wide buffer between the waterway and the mine.

These extensive measures should be taken as an example rather than a general policy statement. The principal concern addressed part (2) is what type of reclamation is feasible and should be permitted where the peat deposits extend below sea level. If mining is stopped above sea level, deep organic soils may be left which make some types of reclamation very difficult to implement. If mining extends below sea level, issues of wet reclamation and perpetual pumping are raised. The Whitetail Farms mine does not involve either of the special issues--wet reclamation or perpetual pumping--which are addressed below. These special issues will require expert consideration beyond the scope of this report or of previous mining permit actions. In any event, the reclamation question presented by mining in such areas warrant the detailed attention called for in part (2).

The State can implement all four parts of this general policy on siting peat mines under the Mining Act on grounds of "unduly adverse" effects on freshwater, estuarine, or marine fisheries. General Statute 113-230 may also permit the secretary to designate buffer zones to protect estuarine resources. The most noticeable effect of this recommendation, particularly part (2), would be to create a buffer zone for peat mining along both shores of the Alligator River in Dare, Hyde and Tyrrell counties.

Implementation of part (2) should be related closely to implementation of several recommendations of the Governor's Coastal Water Management Task Force. The resources inventory and mapping effort recommended there will be most useful in future peat deliberations.

This recommendation does not specifically address questions related to peat mining on federal lands in North Carolina. Most of the land in national wildlife refuges and in the bombing range in Dare County would fall under part (2). However, the large peat deposits in the Croatan National Forest would not. The task force recommends that coordination should be initiated with federal agencies concerning peat mining on federal lands, and that special attention be given to any changes proposed in the Croatan National Forest management plan. The pocosin in the Great Lake area of the national forest has been relatively undisturbed and the area may be a prime candidate for preservation as a natural area.

The task force has not specifically addressed the question of mining peat in Carolina bays. As the recommendation is worded, Carolina bays would fall in part (4) and mining would be permitted. It seems unlikely that large-scale mining will occur in Carolina bays because of the relatively small amount of peat in any one bay. However, a ready market for peat to fuel power plants could put pressure on the bays due to their proximity to power plants. The task force suggests that the Carolina bays be included in those areas for which mining permits not be issued

pending the completion of an ecological inventory of them as natural areas and the development of a protection and conservation plan for Carolina bays.

5. Need for Long-Range Policy on Peat Mining and Its Cumulative Impacts

DNRCD should develop a long-range policy on the ultimate extent of peat mining which will be allowed and on the total land area which can be disturbed at any given time. The issues of impacts on wildlife and primary nursery areas should receive special attention in this respect. This policy should be developed for the Secretary's consideration by the Department's peat working group, working under the direction of the Assistant Secretary for Natural Resources.

A policy on the ultimate extent of peat mining will result, in large part, from DNRCD's implementation of the preceding recommendation in areas suitable for mining. Details--e.g., the width of buffer zones along estuaries or the precise nature of environmental safeguards developed for mining and reclamation in low-lying areas--of this implementation and of permitting decisions will shape the ultimate boundaries of the parts of peat deposits which may be mined. The other major DNRCD action which will influence the ultimate extent of peat mining will be the preservation or protection of natural areas and special wildlife populations.

The task force discussed the concept that limits should be

placed on the total acreage actually disturbed by all active peat mines at any given time, but the task force did not find that sufficient information yet exists to provide the basis for a sound standard requiring this. Since aggregated disturbed area would most likely express its cumulative impacts most quickly in particulate air pollution, or perhaps eventually groundwater impacts, the task force concluded that air quality standards would operate to limit additional mining. This would happen, the task force projected, before other impacts create problems. However, the regular evaluation of monitoring results should endeavor to detect effects which contradict this conclusion. The Mining Act's provisions can be invoked to revise or revoke existing mining permits should unsatisfactory cumulative effects be detected.

A specific long-term strategy is needed to ensure development compatible with the survival of wildlife. It should embody two distinct approaches: (1) identification and preservation of critical natural areas, and (2) establishment of wildlife habitat by conditions imposed on mining and reclamation.

There are areas in the peatlands which should be left entirely in their natural state. These areas should be identified as quickly as possible, and a program to ensure the preservation of these areas should be developed. State policy towards black bear habitat, in particular, could greatly affect the extent of peat mining. The task force recommends that the Division of Parks and Recreation be directed to move as soon as

possible to convert the recently completed natural areas inventories in most of the peatlands counties into a specific program for preservation or conservation. Also, as a comprehensive wildlife protection program will necessarily involve some land acquisition, the Division of Parks and Recreation and the Wildlife Resources Commission should be directed to prepare specific alternatives in this regard, including identification of areas needed to be protected, priorities for acquisition, and mechanisms for acquisition. Particular attention should be given to alternatives such as donations, tax incentives, fee purchase, and conservation easements. In close coordination with this review, the Division of Land Resources should be directed to review and establish a clear policy on the possible requirement, as a mining permit condition, to leave part of the area covered by a mining permit in its natural state if needed to prevent undue adverse effects on wildlife. This specific alternative should be considered by the Division of Land Resources during the processing of each mining permit.

Specific standards and permit conditions are needed for the establishment of wildlife habitat as a required part of all reclamation plans. A mechanism should be implemented by the Division of Land Resources to ensure that these wildlife mitigation measures continue on reclaimed land after reclamation is formally completed, even if ownership changes. Conservation easements may well be the most promising approach for general application.

Wildlife is not amenable to monitoring standards as permit conditions. A modest wildlife research effort should be instituted, the financial cooperation of the mine operation should be encouraged, and mitigation of impacts on wildlife included both in permit conditions and research efforts.

The recommendations of the Governor's Coastal Water Management Task Force for the protection of nursery areas should be extended to include the impacts of peat mining, and the recommendations should be implemented as soon as possible. Mining permit and NPDES permit conditions should be used to protect nursery areas by means of monitoring, control structures, buffer strips, and limits on the local and ultimate extent of mining. Reclamation plans should be designed to promote the long-term protection of nursery areas and other estuarine resources. The advice of the Division of Marine Fisheries should be sought in formulating these permit conditions.

This recommendation reflects the task force's view that the overall, long-term impacts of mining peat in North Carolina will be greatly influenced by the impacts of the reclamation activities that follow mining. The Mining Act of 1971 recognizes the importance of careful reclamation and allows the mining permit to be conditioned upon state acceptance of reclamation plans and procedures to avoid and minimize reclamation problems. Its reclamation provisions are adequate to ensure that reclamation will include appropriate measures to prevent or reduce these impacts.

The same measures recommended for wildlife can also be used to maintain the long-term preventive measures necessary for protection of primary nursery areas. An example of this is the use of conservation easements to protect forested buffer strips installed to fulfill mining permit conditions. Similarly, estuarine buffer strips to protect nursery areas' water quality could come under a conservation easement. Other approaches also need to be investigated and, when appropriate, implemented. The Division of Land Resources should receive the active cooperation of the Division of Marine Fisheries in identifying key nursery areas, assessing the impacts of individual project proposals and mitigation plans, and setting priorities for actions necessary to protect these vital areas.

#### 6. Completion of Reclamation

The acceptance of mined-out land as reclaimed should be done on a case-by-case basis. Each permit is likely to have many site-specific aspects in its reclamation plan. This specificity has led the task force to change its 1981 recommendation to incorporate a general policy on reclamation release in the mining regulations. The task force is confident that the permitting process, review procedures, and monitoring reviews will supply adequate information to support case-by-case decisions on the release from reclamation bonds. The Division of Land Resources should, however, continue to monitor closely this question and, if it appears that general policies on reclamation completion can

be formulated, present appropriate recommendations to the Mining Commission.

The particular issue of the release of part of a tract on a single mining permit as reclaimed while mining continues on other portions is difficult, but the task force concluded that case-by-case consideration is the best way to resolve it. Monitoring results on existing mines should eventually allow a sound decision on the best patterns--e.g. checkerboard, long strips, whole-area of shallow peat mining, and reclaimed areas to minimize environmental impacts.

#### 7. Expansion of Capacity Use Area

Capacity Use Area #1, which covers the existing permitted areas for mining, should now be extended eastwards by the Environmental Management Commission to include the rest of Tyrrell, Hyde, and mainland Dare counties as well as Roanoke Island. This action is necessary to ensure that the provisions of this law, particularly its water use permit requirement, fully apply to all future mining proposals. Expansion of Capacity Use Area #1 should be considered if mining is proposed south or west of its present extent.

The water use permit, under the Water Use Act of 1971, is the Department's primary means of controlling dewatering and excavation activities in capacity use areas. It is the basis for the requirement of monitoring freshwater discharge volumes from peat mines. Until NPDES and groundwater regulations are revised

to include volume controls and reporting requirements, the capacity use concept remains important. As groundwater classifications and standards are completed by the Division of Environmental Management, they should be incorporated in the peat mine permit package.

Development of nutrient and salinity standards should continue by the Division of Environmental Management, with active consultation with the Division of Marine Fisheries and the Office of Coastal Management. The task force, however, is aware of the difficulties in developing workable salinity standards and urges that in the interim preventive measures such as outlet location and water control measures be fully implemented as part of the mining permit conditions.

#### 8. On-Site and Regional Monitoring Systems

Since the Mining Act addresses the full range of peat mining impacts, the Division of Land Resources should apply its provisions to require monitoring of the full range of impacts. These expanded requirements should be incorporated as conditions on the mining permit. Also, the Division of Environmental Management should continue to expand its ambient air, surface water, and groundwater monitoring system in the peat mining region.

Incorporation of surface water, air, and groundwater monitoring requirements in conditions of mining permits does not diminish the primary role of the Division of Environmental Management in setting these requirements and in analyzing the

results. An advantage of the package approach to permits for peat mines is that monitoring can be fully coordinated among the concerned agencies. The peat permit application review group should play a central role in this coordination.

As soon as the results of Skaggs and Gregory's peat hydrology project (See Table I) are available, they should be thoroughly evaluated by the Department and, where appropriate, incorporated in monitoring requirements. The surface and groundwater hydrology model developed by Skaggs and Broadhead may allow a predictive capability sound enough to relax some monitoring requirements. Even so, several years of very detailed monitoring results will be needed to verify the model. Further effort will be needed to expand the model for general applicability since it is presently rather site-specific for the 15,000 acre First Colony Farms site.

Since the task force's 1981 report, mercury in drainage water from peat mines has arisen as a major concern. In preparing their applications and analysis, PMA found mercury levels exceeding state standards in the waters receiving drainage from the First Colony Farms peat mine, and PMA reported their data to the state. Questions have arisen about the sampling and analytical methodology which produced these values, and a new sampling series has been proposed. PMA has not yet applied for nor received an NPDES permit for the First Colony Farms mine.

The mercury issue reemphasizes the need to require an NPDES permit for each peat mine. The department should require

detailed analysis of mercury issue as part of each peat mining permit and NPDES permit application. All mining permits should require monitoring on-site and in receiving waters by the mine operator. Laboratory and field experiments should be initiated by the Division of Environmental Management, assisted by N.C. State University, to identify the chemical species of mercury present, mechanism of release, and transport mechanisms of mercury. These experiments should be supplemented with further and continuous biological monitoring and the Division of Environmental Management should develop any needed water treatment standards for mine drain water.

The results of these efforts should be carefully evaluated by the state. If the resulting data show that mercury is not actually a problem in the region, some of the efforts can be terminated and the issue referred to the Division of Environmental Management for resolution of permitting questions which remain.

#### 9. Evaluation of Monitoring Results

Monitoring results from peat mines should be reported at least quarterly by the Division of Land Resources in cooperation with the Division of Environmental Management. It is crucial to identify unacceptable trends as soon as possible, in order to incorporate remedial actions into the permitting process. Evaluation of monitoring results will be especially critical when monitoring is required in a mining permit for substance or variables for which there are no presently established water

quality standards.

Although the Department already has in-house experts in a large number of disciplines which may be involved in peat evaluation, it is likely that some outside expertise may be needed to assist in evaluating monitoring results and to verify trends. The Assistant Secretary for Natural Resources should be charged with assuring that the requisite intradepartmental and outside expert review are secured in a timely fashion.

In addition to these technical monitoring reports, the Division of Land Resources, in consultation with other divisions, should be directed to prepare an annual report on environmental changes in the peat mining region. This report should include a description of the year's activity in peat mining, monitoring, use, and research. It should also include the evaluations of the monitoring results for the year. The report should also include an evaluation of the effectiveness of departmental policies on peat mining and use.

#### 10. Departmental Evaluation Plan

A DNRCD evaluation plan on the overall environmental impacts of peat mining and the control of these impacts should be developed as soon as possible.

The Department has sponsored or had access to a number of peat research projects, (See Table I), but these have for the most part been aimed at major, generalized issues rather than at the specific issues. The mercury research effort represents the

first of the highly focused studies that may increasingly be needed. Others will be needed as questions arise from monitoring results and other observations. The peat mining working group should provide the Assistant Secretary for Natural Resources with an overall research evaluation plan which gives priorities for research projects to address specific identified issues. Such a plan would allow the most efficient allocation of effort and funds, and it would minimize delays in allocating research funds which often become available at very short notice, such as the Coastal Energy Impact Program (CEIP) which is administered by the Office of Coastal Management.

CEIP has funded most of the department's recent and current research on peat impacts, but CEIP's future funding is in doubt due to federal cutbacks. Should OCS revenue sharing pass Congress, it is likely that CEIP will be able to fund a significant portion of future research.

The task force believes that the most urgent detailed research needs now apparent are:

- o sources and mechanisms of mercury release into drainage water;
- o delineation of the specific areas where peat mining should be prohibited;
- o development of improved water control techniques;
- o development of improved reclamation schemes;
- o impacts of wet reclamation;
- o legal and institutional issues of perpetual pumping;

- o impacts of perpetual pumping;
- o cumulative impacts of multiple mining activities.

Research efforts outside DNRCD should be closely followed, and interagency cooperation should be sought. Peat-related issues have been the focus of a recently intensified research effort by several federal agencies and other states (Minnesota, in particular). A continuing, long-term effort to stay informed of their efforts, and to communicate our results to them, is recommended.

11. Additional Resources Needed to Carry Out State Responsibility

The Department will experience significant costs for regional monitoring, research, supervising on-site monitoring by permit holders, evaluating monitoring results, and the development of adequate environmental safeguards. Funds to pay these cost should be sought.

Possible sources of these funds are permit fees, legislative appropriations, federal grants, severance taxes, and voluntary contributions from peat mine operators.

In addition to increased costs, DNRCD's responsibilities towards peat mining may impose significantly increased workloads and personnel requirements. These may create problems in the regional DNRCD field offices which deal with peat mines; this particularly applies to the Washington office. These needs should be carefully reviewed by the appropriate divisions and action taken prior to major crises arising.

## 12. Technical Advisory Assistance

DNRCD will soon face technical issues related to peat mining and use which will require the advice of outside experts. The evaluation of monitoring results and the resolution of the questions of wet reclamation and perpetual pumping are two such matters. The Assistant Secretary for Natural Resources should be charged with oversight in securing the necessary outside technical expertise. It is anticipated that this expertise can be secured on an ad hoc basis from universities, industry, federal agencies, and state agencies outside DNRCD. In the future, advisory committees or consulting services may be needed.

## 13. Technical Advisory Assistance

The state Energy Policy Council should be informed on peat mining impacts and urged to consider them in regard to developments which would stimulate or direct peat mining.

DNRCD can directly control essentially all of the impacts of peat mining and most of the impacts of peat use, but DNRCD cannot unilaterally develop a state policy on peat in general. Although the Council of State and the Cabinet would ultimately develop such a general policy, the Energy Policy Council would likely be the initial interdepartmental forum for discussions leading to a draft policy. Since energy needs and economics usually drive the development of energy-related policies, it is important that DNRCD use every appropriate opportunity in the council to inform other agencies of the status of permitting and regulatory issues.

DNRCD and the Department of Commerce should also cooperate closely on the siting of peat-using industrial facilities.

During the past thirty-months, Commerce's Industrial Development Division has worked very closely with DNRCD on the Peat Methanol Associates project. This cooperation has apparently been satisfactory to both departments and to the developer. It should serve as the model for future cooperation, and such cooperation should become a matter of routine.

14. Public Information and Education Program on Peat

A public information and education program on peat mining and impacts should be developed and carried out.

This program should be designed to reach the general public, the public schools, landowners in the peat region, and potential researchers. A variety of approaches may be needed. The industry should be involved in this effort. The Office of Natural Resource Planning and Assessment, with assistance from the Division of Land Resources, should be assigned responsibility by the Assistant Secretary for Natural Resources for developing and implementing the public information and education program for peat.

15. Need for Permanent DNRCD Peat Working Group

A peat working group will continue to be needed within the department to assure full coordination among divisions on permitting, monitoring, research, and policy development.

A peat working group, appointed by the Assistant Secretary for Natural Resources and staffed by the Division of Land Resources, could serve a significant portion of this work, as it is already established and designed to handle intra-department coordination regarding the mining permit. Strong coordination will be even more urgently needed in the future, both to assure incorporation of other divisions' expertise in the mining permit and to assure a coordinated permit package. Coordination is needed beyond permitting issues per se, however. Monitoring and research coordination should be closely related to permitting needs, but the involvement of other issues may well necessitate the involvement of personnel beyond the Land Resources peat working group. In these areas, as well as the overall policy development and coordination area, the central coordinating role should be played by the Assistant Secretary for Natural Resources with such supporting service from the divisions as is deemed appropriate.

16. Recommended Approach to Resolve Issues of Wet Reclamation and Perpetual Pumping

DNRCD, through the peat working group, with appropriate outside advice and expertise, should scope the issues which should be addressed in any permit applications for a peat mine which involve either wet reclamation or perpetual pumping. These are very important emerging issues which need to be addressed now, so that appropriate research and policy development can take place

prior to review of individual permit applications. The list of issues, or questions, thus produced would have to be addressed in the permit applications. Site-specific solutions to these problems would then be addressed in the individual permit applications and reviews.

"Wet reclamation" includes all forms of reclamation which permanently or periodically put the reclaimed area under either fresh or saltwater. Such uses as paddy culture, reversion to swamp forest or pocosin, reservoirs, aquaculture of fish or shell fish, artificially created nursery areas, waterfowl impoundments, marinas, and recreational lakes would fall in this category. None of these has yet appeared on a mining permit application, but they may do so as soon as 1983.

"Perpetual pumping" applies to any reclamation schemes which will require constant pumping to maintain land dry enough for productive use. Intensive agriculture is apparently the only reclamation use which can financially justify the cost of pumping. In addition to hydrological questions, perpetual pumping raises many legal and institutional questions which must be resolved before a permit should be issued which involves perpetual pumping.

The approach suggested in this recommendation is fully consistent with the general permit package processing procedure recommended above. The only difference comes from having advance scoping done prior to permit applications.