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TECHNICAL REPORT Y-78-3

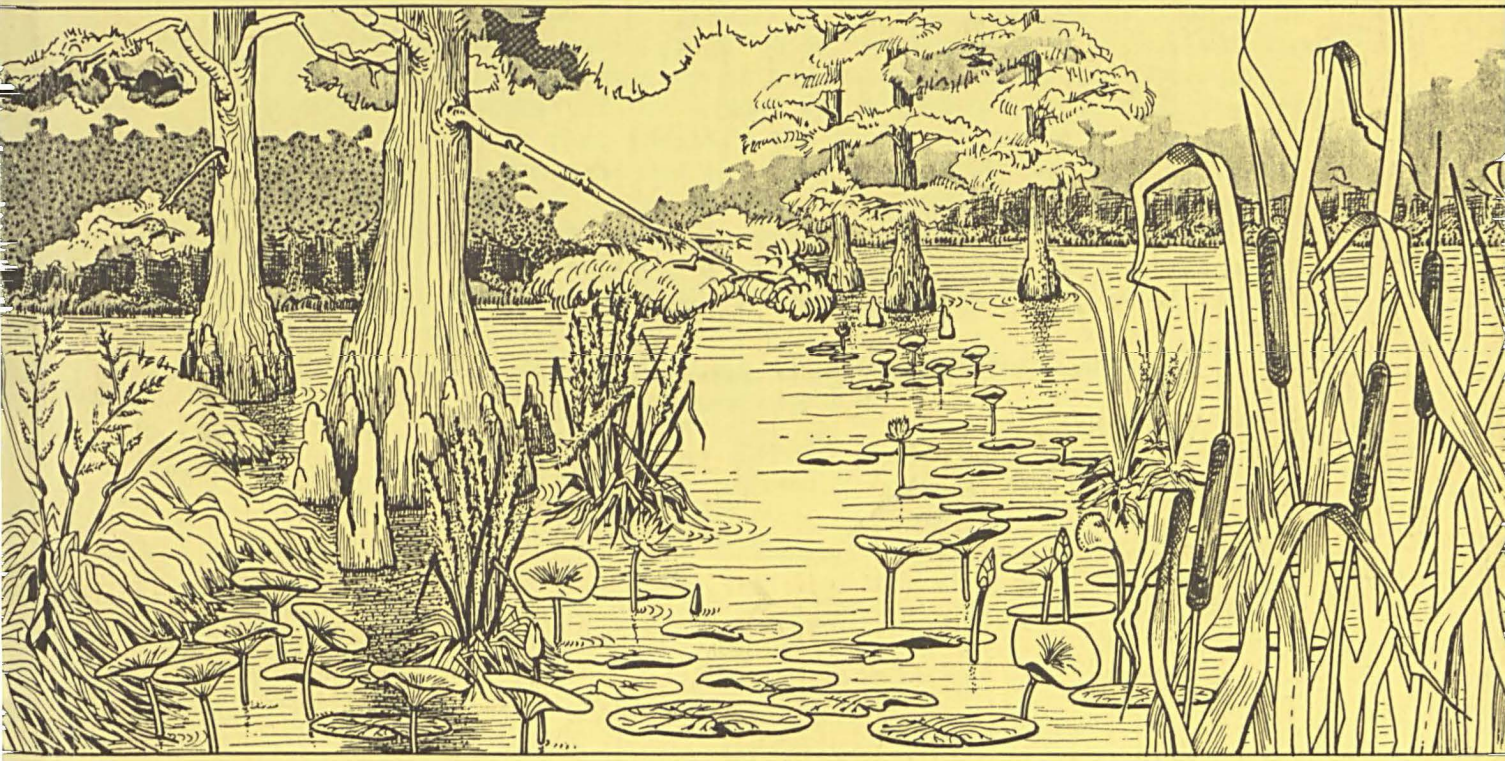
PRELIMINARY GUIDE TO WETLANDS OF PUERTO RICO

Major Associations and Communities Identified

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

April 1978
Final Report

Approved For Public Release; Distribution Unlimited



Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

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SUBJECT: Transmittal of Technical Report Y-78-3

TO: All Report Recipients

1. The report transmitted herewith provides preliminary guidance on wetland determination to Corps of Engineers personnel responsible for the implementation of Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) in Puerto Rico. This guide, sponsored by the Office, Chief of Engineers, represents one of a series of eight guides to the major wetland associations of the United States. Other guides include peninsular Florida, West Coast States, Alaska, South Atlantic States, Gulf Coastal Plain, North Atlantic States, and Interior-Great Lakes.

2. This guide is intended to assist in the field recognition of major wetland communities as they relate to the determination of jurisdictional boundaries in the implementation of the Section 404 permit program. It is neither a regional flora manual nor a general classification system. Several manuals that identify the flora of Puerto Rico are referenced in this document and personnel requiring species identification are referred to those works. Personnel requiring a detailed wetland classification system may wish to consult "Classification of Wetland and Deep-Water Habitats of the United States (an operational draft)," prepared by the National Wetland Inventory Project of 1975-79 of the U. S. Fish and Wildlife Service.

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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SUMMARY

This report represents one of a series of eight preliminary guides to the dominant plant associations and communities found in the major wetlands of the United States. The primary purpose of the guidebook is to aid regulatory functions personnel in recognizing and delineating wetlands subject to permit regulation under Section 404 of Public Law 92-500 (Federal Water Pollution Control Act Amendments of 1972).

The guidebook is designed to be self-contained and consists of three parts. An introduction covers the purpose and use of the guidebook as well as general information about Section 404 wetlands. The second part, entitled "Wetlands of Puerto Rico," consists of three major sections: Regional Environment, Regional Botanical References, and Wetland Types. The section on regional environment is brief and provides a broad context for the more detailed descriptions of the dominant plant associations and communities found in the major wetlands of the region. Because of synonymy of many scientific names, the nomenclature standard used for the guide is presented in the section on regional botanical references. Detailed description of wetland vegetation is based upon data in the literature and information from scientists having familiarity with the region. The goal of this section is to provide a description sufficiently detailed for field use but not to report minor variations of each wetland. Thus, the descriptions are a compromise between site-specific reports and extremely general discussions. The third part contains references to pertinent publications and is specific to the region, and Appendices A, B, and C, which include a glossary that is common to all guides in the series, have been added to aid in the user's clarity of understanding.

PREFACE

At the request of the Office, Chief of Engineers (OCE), the Environmental Laboratory (EL) of the Waterways Experiment Station (WES) initiated production of this report, one of a series of eight preliminary guides to the dominant plant associations and communities found in the country's major wetlands. Other reports in the series apply to Alaska, West Coast, Interior, Gulf Coast, North Atlantic, South Atlantic, and Peninsular Florida. The reports are listed on the inside of the front cover. Funding was provided by OCE.

Dr. Howard J. Teas, Professor of Botany, University of Miami, provided a manuscript for initial construction of the draft guide under Purchase Order No. DACW39-76-M-6504. Mr. Roy Woodbury, Professor of Botany, University of Puerto Rico, Rio Piedras, offered many helpful suggestions. Preparation of the guide was initiated by Dr. Luther F. Holloway, Research Botanist, EL. Dr. Gary E. Tucker, Research Botanist, EL, provided revisions and directed the production of the guide with the assistance of Dr. Robert Terry Huffman, Research Botanist, EL. Ms. Dorothy P. Booth, EL, served as technical editor. The illustration used on the covers of this series of reports was drawn by Ms. Jane Barnes, Russellville, Arkansas.

The guide project was under the general supervision of Dr. H. K. Smith, Project Manager, Habitat Development Project; Dr. C. J. Kirby, Chief, Environmental Resources Division; Dr. Roger T. Saucier, Special Assistant, Dredged Material Research Program; and Dr. John Harrison, Chief, EL.

The Commanders and Directors of WES during the study were COL G. H. Hilt, CE, and COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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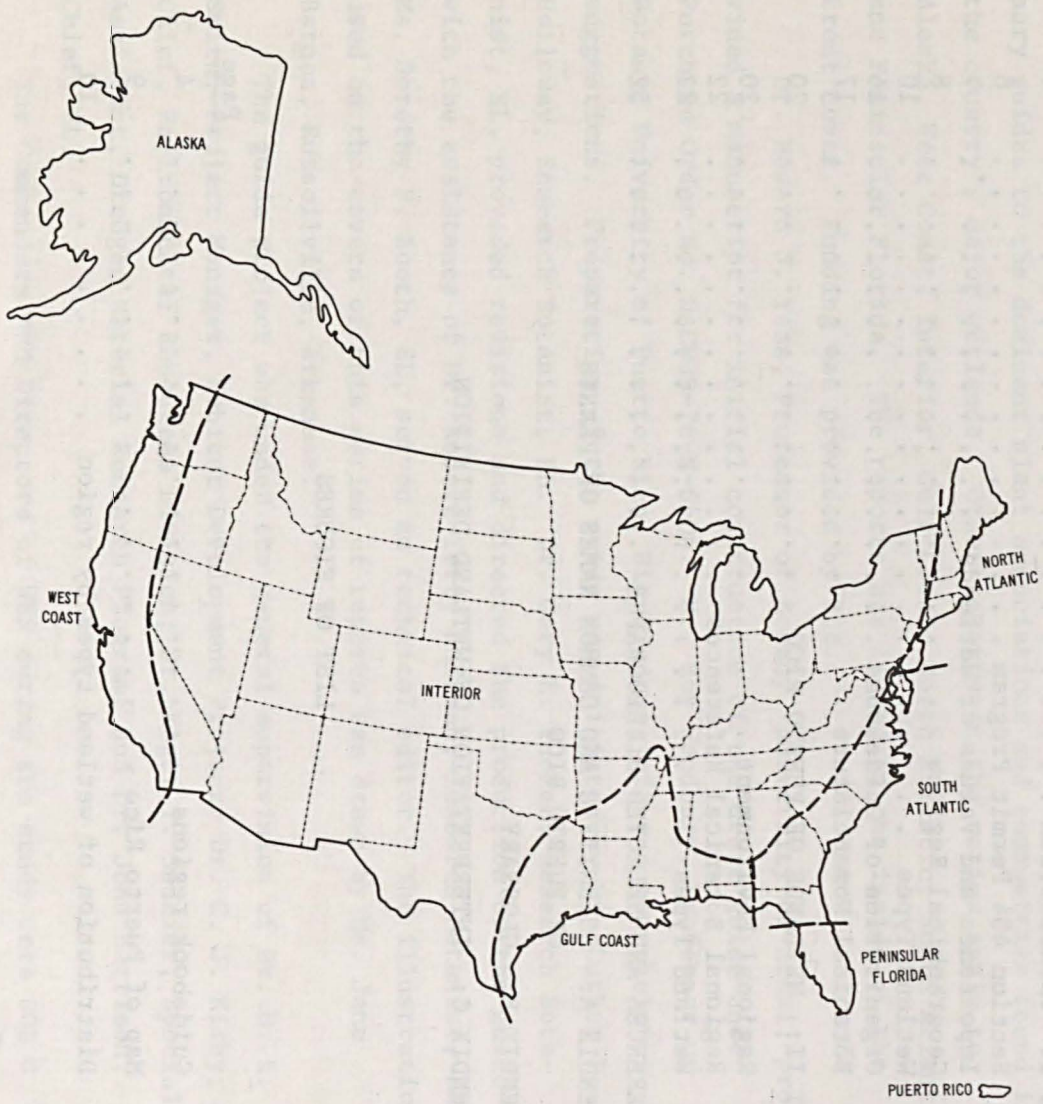

Figure 1. Eight geographical regions defined for the wetland guidebook series

PRELIMINARY GUIDE TO THE WETLANDS OF PUERTO RICO

Major Associations and Communities Identified

PART I: INTRODUCTION

1. This guide to the major plant communities and associations found in wetlands within Puerto Rico is one of a series of eight such regional guides, each prepared by a specialist or specialists familiar with the wetlands in the region covered by the guide. Other regional guides include Alaska, West Coast, Interior, Gulf Coast, North Atlantic, South Atlantic, and peninsular Florida (Figure 1). The guides are intended for distribution to the various U. S. Army Engineer District regulatory functions personnel for use in identification of wetlands for the implementation of Section 404 of the Federal Water Pollution Control Act Amendments of 1972. The information provided is intended solely for use in the Section 404 permit program and is not considered a definitive classification system for other purposes.

2. Field personnel having need of a more detailed and definitive system of classification per se should consult one of the several wetland classification systems currently in use in the United States and Canada. The work of Beard (1944) has been used widely in the tropics. The well-known Circular 39 (Shaw and Fredine, 1956) of the U. S. Fish and Wildlife Service has met with widespread use nationally despite its well-documented shortcomings. A recently published operational draft by the Fish and Wildlife Service (Cowardin et al., 1977) represents the most recent product of the National Wetland Inventory Project of 1975-79, an intensive effort that will result ultimately in the publication of a detailed and refined classification system to the wetlands of the entire nation. Numerous regional systems of classification also are available. Among the more significant regional classification systems are those of Golet and Larson (1974), Millar (1976), Odum et al. (1974), Penfound (1952), Stewart and Kantrud (1971), and Zoltai et al. (1975).

Section 404 Permit Program

Authority

3. Under the laws of the United States, Congress has assigned a number of nonmilitary functions to the U. S. Army Corps of Engineers. In addition to the well-known and more traditional roles in flood control, hydropower production, navigation, water supply storage, and recreation, the Corps has responsibility for some activities that are not so well known. Congress has given the Corps of Engineers regulatory responsibility to protect navigation channels and harbors against encroachments and also to preserve and restore water quality by regulating the discharge of dredged or fill material into waterways and wetlands.

4. The primary legislative basis for the Corps' regulatory authority for the disposal of dredged or fill material is the Federal Water Pollution Control Act Amendments of 1972. Section 404 of that Act gives authority to the Secretary of the Army, acting through the Chief of Engineers, to regulate the discharge of dredged or fill material in the waters of the United States.

5. Regulatory authority under Section 404 was initially considered limited to waters that are used presently, were used in the past, or could be used through reasonable improvements to transport interstate commerce. Limitation of the Corps' regulatory authority under Section 404 to navigable waters of the United States was successfully challenged in the District Court for the District of Columbia. On 27 March 1975, the Court ordered the Corps to extend its jurisdictional responsibility for the discharge of dredged or fill material under Section 404 to all waters of the United States (including the territorial seas) and adjacent wetlands and to revise its regulations accordingly.

6. In accordance with the Court's 1975 directive, the Corps of Engineers published an interim regulation in the Federal Register on 25 July 1975. The final set of permit regulations, considerably revised and reorganized, was published in the Federal Register on 19 July 1977.

Scope

7. The Corps of Engineers permit program under Section 404 is extended to many areas that have never been regulated before. In addition

to the navigable waters of tradition, the Corps has been given jurisdictional authority over tributaries to navigable waters, including adjacent wetlands; interstate waters and their tributaries, including adjacent wetlands; and all other waters of the United States, such as lakes and rivers and streams that are not interstate waters or part of a tributary system to navigable waters of the United States; impoundments; perched wetlands; intermittent streams; and prairie potholes, the degradation or destruction of which could affect interstate commerce. In the absence of adjacent wetlands that are a part of the waters described previously, the landward limit of jurisdiction in tidal waters shall be the high tide line and the shoreward limit of jurisdiction in all other waters shall be the ordinary high water mark.

8. The term "wetlands" is a very crucial part of Section 404 and refers to those areas that are inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (Appendix C).

Purpose

9. The purpose of the Section 404 program, which is a part of the Corps of Engineers' overall regulatory authority, is to ensure that the chemical and biological integrity of waters of the United States is protected from unregulated discharges of dredged or fill material that could permanently alter or destroy the character of these invaluable natural resources.

Importance and Values of Wetlands

10. Wetlands are valuable and productive natural resources of national significance, and some of their major functions include the following:

a. The provision of feeding, cover, and reproduction habitat for a great diversity of species, including endangered and threatened species.

b. The provision of educational, study, refuge and sanctuary, and recreational areas.

c. The maintenance of drainage, salinity, sedimentation, flushing, and current patterns.

d. Cycling of nutrients.

e. Reduction of contaminant loading.

f. Protection from erosion and storm damage.

Geographical Regions

10. Eight geographical regions have been defined for the wetlands guidebook series: Alaska, West Coast, Interior, Gulf Coast, North Atlantic, South Atlantic, Peninsular Florida, and Puerto Rico. The geographical regions are based on both physiographic and pragmatic considerations; the boundaries were influenced significantly by the works of Fenneman (1931, 1938). The use of natural units rather than artificial ones, such as political boundaries, minimizes the number of wetland types described in each guidebook. Several states are covered by a combination of two guidebooks, and a very few are covered by three guidebooks. Physiographic parameters were used where possible, since both hydrologic and biotic patterns are related closely to landscape features. Each of the regions will be covered in a separate guidebook. Geographic descriptions for the guides are as follows:

a. Alaska. The state of Alaska is the sole subject of an entire guide. Particular emphasis is placed on coastal wetlands; much of the interior region is "wet", but further study is necessary to determine the exact jurisdictional limits of Section 404.

b. West Coast. This region includes most of California (exclusive of the southeastern part), western Oregon, and western Washington.

c. Interior. The area covered by this region consists of the vast interior of the United States, including much of the Southwest, the Rockies and some of the intermontane region, the Central Plains, and the Midwest. States contained within the region are numerous.

d. Gulf Coast. The Gulf Coast region extends from the coastal plain of Texas to western Georgia. Inland, the coastal plain extends to southern Missouri in the Mississippi embayment; other states included in the region

are all or parts of Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Florida, and Tennessee.

e. North Atlantic. This region extends north from Sandy Hook, New Jersey, to the Canadian border and west to the Appalachian highlands. Included within the region is northern New Jersey, New York, and New England.

f. South Atlantic. Included within this region is everything north from peninsular Florida to Sandy Hook, New Jersey, and west to the Appalachian highlands. The separation of this region from the North Atlantic region is based largely on substrate features; the exposures of bedrock throughout the North Atlantic region are strikingly different from the thick mantle of Coastal Plain sediments predominating in most of the South Atlantic region. Additionally, most of the species of the "southern" swamp forest are restricted to the South Atlantic region as defined here.

g. Peninsular Florida. There is no clear physiographic distinction between peninsular Florida and the Gulf Coast and Atlantic Coast regions, but the vegetation of peninsular Florida has strong enough tropical affinities to warrant separate treatment. The peninsular region has been delineated by an arbitrary boundary extending from Jacksonville west to Steinhatchee, with all of Florida south of the boundary included in the region. "Subtropical Florida" as defined by Fenneman (1931) and Braun (1964) is essentially conspecific with this region.

h. Puerto Rico. The guidebook is intended for use in Puerto Rico (Figure 2); however, its utility may extend to the

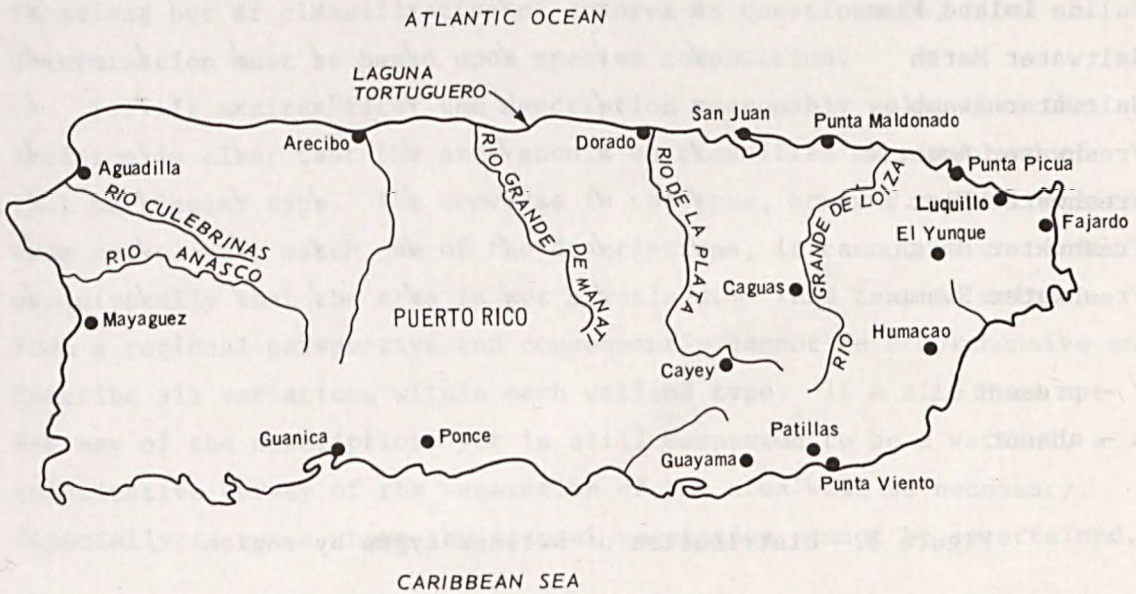

Figure 2. Map of Puerto Rico

U. S. Virgin Islands because the vegetation of the two regions has many similarities.

Wetland Types

General information

12. Nine basic wetland types are recognized in the United States (Figure 3). An interpretation of the definition of wetlands is given in Appendix C. The number of wetland types in each guidebook region, however, is either seven or eight, since no region has all possible types. The nine basic wetland types have been distinguished by a combination of differences in physiognomy (e.g., marsh versus swamp),

	Alaska	West Coast	Interior	Gulf Coast	North Atlantic	South Atlantic	Peninsular Florida	Puerto Rico
Saltwater Aquatic	✓	✓	✓	✓	✓	✓	✓	✓
Saltwater Coastal Flat	✓	✓	x	✓	✓	✓	✓	✓
Saline Inland Flat	x	x	✓	x	x	x	x	x
Saltwater Marsh	✓	✓	✓	✓	✓	✓	✓	✓
Saltwater Swamp	x	✓	x	✓	x	x	✓	✓
Freshwater Aquatic	✓	✓	✓	✓	✓	✓	✓	✓
Freshwater Flat	✓	✓	✓	✓	✓	✓	✓	✓
Freshwater Marsh	✓	✓	✓	✓	✓	✓	✓	✓
Freshwater Swamp	✓	✓	✓	✓	✓	✓	✓	✓

✓ - present

x - absent

Figure 3. Distribution of wetland types by region

growth form (e.g., herbaceous plants versus trees), and environmental factors (such as degree of salinity in soil and water). Terms used on a regional basis in the description and definition of wetlands, such as bog and pocosin, are discussed in the text at appropriate points.

Identification

13. The approach to the identification of wetlands in this guidebook series is to provide general classifications for each region of the country. For purposes of this series, the country has been divided into six large regions plus Alaska and Puerto Rico (as described earlier). Within each regional guide, a key (Table 1) is provided for classification of any site in question. The reader is then referred to a brief description of the type (Wetland Types, next section) for a preliminary check to see if the site was properly classified. Finally, the reader is referred to the text for a more complete description of the communities and associations in the wetland. The description of each wetland association is concluded with a section entitled "Field Identification," which briefly explains how to distinguish the wetland from other wetland types and from adjacent uplands. The entire description of a wetland should be studied prior to using the field identification section, however, to familiarize the user with its major variations. Wherever feasible, characteristics of growth forms are highlighted for identification, but if classification of an area is questionable, final determination must be based upon species composition.

14. If a site "fits" the description reasonably well, then the decision is clear that the area should be classified as a wetland of that particular type. The converse is not true, however. (If the site does not closely match one of the descriptions, it cannot be concluded unequivocally that the area is not a wetland.) This text is written from a regional perspective and consequently cannot be comprehensive and describe all variations within each wetland type. If a site does not fit any of the descriptions yet is still suspected to be a wetland, a quantitative survey of the vegetation of the area will be necessary. Especially in cases where the natural vegetation cannot be ascertained,

Table 1

Key to Wetland Types

A. Aquatic vegetation predominant (dominant plants free-floating or attached and having poorly developed tissues of structural support, supported and buoyed up by the water); flooded usually for long periods or permanently	
B. Coastal; below the intertidal zone; seaward to limits of vascular plant growth; permanently flooded	SALTWATER AQUATIC
B. Inland; flooded permanently or semipermanently by fresh water	FRESHWATER AQUATIC
A. Terrestrial vegetation predominant (dominant plants rooted and with well-developed tissues of structural support) or sometimes barren of vegetation; flooded at least occasionally, often for prolonged periods	
C. 25 percent or less vegetative cover	
D. Subject to saltwater influence	
E. Coastal, tidal	SALTWATER COASTAL FLAT
E. Inland, nontidal	SALINE INLAND FLAT*
D. Freshwater	FRESHWATER FLAT
C. More than 25 percent vegetative cover	
F. Nonsaline soils	
G. 40 percent or less cover by woody plants	FRESHWATER MARSH
G. More than 40 percent cover by woody plants	FRESHWATER SWAMP
F. Saline (including brackish) soils	
H. 40 percent or less cover by woody plants	SALTWATER MARSH
H. More than 40 percent cover by woody plants	SALTWATER SWAMP

* The saline inland flat does not occur in Puerto Rico.

How to use the key: A key is an artificial device constructed for the purpose of identifying an unknown object. Keys traditionally have been used in the field of biology for the identification of unidentified plant and animal species, but in this guidebook the key will be used for the identification of unidentified wetland types.

The key to wetland types consists of a series of contrasting statements or descriptions, and the user of the key is required to make decisions based on the comparison of statements in the key as related to observations on the unidentified wetland type. The user must work carefully through the key from its beginning until a wetland type has been selected for the area in question.

The key is constructed around a series of pairs of leads. The second lead of a pair usually repeats the data given in the first lead but in a negative sense. Let us assume that you, the user of the guidebook, have located a grass-dominated area that obviously is "wet" during the better part of the year and obviously under the jurisdiction of the Section 404 program. Proper use of the key should enable you to determine just what type of wetland is involved.

In order to begin use of the key, you must start with the first pair of lead sentences, in this case labelled "A." Read each lead carefully, weighing one against the other with relation to your grass-dominated area. Grasses normally do not grow as free-floating organisms nor do they depend on water to buoy them upright, since they normally have sufficient supporting tissues to grow erect; in this case, then, the second lead of the pair of choices is better descriptive of the grass-dominated area with which you are concerned. You are now ready to consider a second pair of leads. This time you will consider the leads labelled "C" (of course, if your habitat were dominated by aquatic vegetation rather than terrestrial grasses, you would be considering the choices labelled "B"). Read the two "C" leads carefully, look at your grassy area, and try to determine how much of the ground surface is covered by vegetation. If less than 25 percent of the ground surface is covered by vegetation and more than 75 percent of the area is bare ground, you will select the first "C" as indicated; if vegetative cover accounts for more than 25 percent cover, you will take the second choice labelled "C." Let us assume that your area has only 10 percent cover. You will select the first "C" and then proceed to the "D" possibilities. Is the area in question flooded by fresh water or salt water? Let us make the assumption that you are in a freshwater area; look at the key carefully and note that the second "D" lead has a series of dotted lines leading to the phrase "Freshwater Flat." After the process of first rejecting and then accepting leads, you finally have arrived at an identification of your wetland type.

Table 1 (Concluded)

After determining the wetland type of an area in question, the user should turn to the detailed description of that particular type in the guidebook. In our hypothetical case the user would turn to page 42, FRESHWATER FLAT, and carefully read the descriptive material.

The use of the key may not be as simple and easy as it may seem. After you have followed the key through until coming to an identification of the wetland type, it may appear that the wetland description does not seem to fit the site. In that case it always pays to go back to the key and make sure an error has not been made through haste or misunderstanding of terms used. Occasionally an area may be found that cannot be identified with the aid of the key; the entire guidebook is written from a regional perspective and does not cover all variations of each wetland type. If a site does not fit any of the wetland types as described but yet is suspected of being a wetland under Section 404, a professional ecologist or botanist may be required for a quantitative study of the vegetation at the site.

hydrologic and soil information will be required to determine whether or not a site is a wetland. The nine basic wetland types are defined as follows:

a. Saltwater aquatic. Wetlands that are dominated by free-floating, rooted, or otherwise attached herbaceous plants (including macroscopic marine algae) and that are permanently flooded by saline or brackish water (e.g., sea grass beds).

b. Saltwater coastal flat. Wetlands that have 25 percent or less vegetative cover and are occasionally (shallow flat) or regularly (deep flat) flooded by saline water of tidal origin (e.g., nonvegetated intertidal zone).

c. Saline inland flat. Wetlands that have 25 percent or less vegetative cover and are occasionally or regularly flooded by saline water of nontidal origin (e.g., inland salt flat).

d. Saltwater marsh. Wetlands that have more than 25 percent vegetative cover of herbaceous plants but 40 percent* or less cover by woody plants and that are occasionally (high marsh) or regularly (low marsh) flooded by brackish or saline water (e.g., Smooth cordgrass marshes).

e. Saltwater swamp. Wetlands that have more than 40 percent cover of woody plants and are occasionally or regularly flooded by brackish or saline water (e.g., mangrove swamps).

f. Freshwater aquatic. Wetlands that are usually dominated by free-floating or rooted aquatic herbs and are semipermanently or permanently flooded by fresh water (e.g., floating duckweed mats).

g. Freshwater flat. Wetlands that have 25 percent or less vegetative cover and are occasionally or regularly flooded by fresh water (e.g., mudflats).

h. Freshwater marsh. Wetlands that have more than 25 percent vegetative cover of herbaceous plants but 40 percent or less cover by woody plants that are occasionally or regularly flooded by fresh water (e.g., cattail marsh).

i. Freshwater swamp. Wetlands that have more than 40 percent cover by woody plants and are occasionally or regularly flooded by fresh water (e.g., cypress swamps).

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* The use of 40 percent as the division for woody plant cover is convenient for field work because when the tree cover is 40 percent, the distance between tree crowns equals the mean radius of a tree crown (UNESCO, 1973).

Organization of Guidebooks

15. Each guidebook is designed to be self-contained. Although this necessitates repetition of general information in the introductory part, the advantages in utility outweigh the duplication. The second part of each guidebook, entitled "Wetlands by Region," is the only one of the three parts unique with each guide. The third portion, containing appendixes and references to pertinent publications, is largely specific for each region, except for a glossary that is common to the entire group of regional guides.

16. Three major sections are found in Part II: Regional Environment, Regional Botanical References, and Wetland Types. The section on regional environment is brief and provides a broad context for the more detailed descriptions of wetland types in each region. Because of the synonymy of many scientific names, the standard used for the guide is given in the section on regional botanical references.

17. Description of each wetland type is based upon data in the literature and from discussions with scientists having familiarity with the area. The goal is to provide a sufficiently detailed description for use in the field but not to report every possible variation of each wetland type. Thus, the descriptions are a comparison between site-specific reports and extremely general discussions.

18. The description of vegetation in each wetland type is divided into the following four parts:

a. Growth form. Growth form, such as deciduous (e.g., Ash, Bald cypress) or evergreen (e.g., pine, Southern magnolia) trees, is a concise description based upon the physiognomy of the vegetation. This should be particularly helpful to those not familiar with the species in the area.

b. Species composition. Discussion of species composition in each case includes listings in alphabetical order (by scientific name) of the dominant plants and the most commonly associated species. Because of local variation within any wetland type, an alphabetical listing is preferred over an attempt at listing species by importance value. The choice of associated species listed sometimes is arbitrary but, in the absence of complete species lists for each type, is inescapable. The section on

transition zones outlines the plants or plant communities characteristically found between adjacent wetland types or between wetlands and uplands. Such transitions may be abrupt but more often they are gradual. The generalized structure of each wetland type and its relationship to transition zones is indicated.

c. Physical environments. The environmental conditions, the characteristic water regimes, and soils of each wetland type, are described where available. The discussions are limited to aspects of the physical environment most often affecting the vegetation and are not intended to fully describe the environment.

d. Field identification. The section on field identification gives the characteristics that distinguish the wetland type from other wetland types and from adjacent uplands.

19. In most cases some attempt to discuss successional relationships of wetland communities is made. In many cases, however, the successional relationships of wetlands vegetation are too poorly understood for meaningful generalizations.

20. The primary purpose of the guidebook series is to aid regulatory functions personnel in identifying wetland types. For that reason a well-organized but general approach has been attempted. The classification system in the guides is intended solely for implementation in the Section 404 permit program and is not considered a definitive classification system for other purposes.

Botanical Nomenclature

Common names

21. Common names, while admittedly convenient, often vary from place to place. One species may have several names in different geographic regions, or the same name may be applied to unrelated species in different areas. Yet other species lack a common name. In the guidebook series, the common name used for a plant is the one, in the opinion of the author, most often used locally within the region. A single common name is used even though several names may be in use within the region. Those species not known to have a common name are referred to by their scientific name. Specific common names are here capitalized.

22. To assist in utility of the guides, an attempt has been made to provide a common name at each point where a scientific name appears. In a few cases, however, this has not been practical or has been considered superfluous; for that reason, in cases where assurance of communication seemed evident, a single name was employed.

Scientific names

23. Botanists, ecologists, and other scientists use scientific names in their technical publications and discussions. The Latin form of scientific names is definitive and uniformly adhered to by botanists around the world under the International Code of Botanical Nomenclature. Thus, the Latin name of a plant species is understood by the scientific community throughout the world, regardless of the prevailing language in a country.

24. Scientific names used in this guidebook series consist of two words. The first word of the scientific name is that of the genus to which a plant belongs, and it is always capitalized. The second word of the scientific name is referred to as the specific epithet, and it is printed here in lower case even though it may be derived from a geographical name or the name of a person. Both words are italicized or underlined. Following the scientific name it is customary, at least in checklists, to give the name of the author or person who originally described the plant to science; the name of the author is referred to as the authority. The authority for plants in these guides is given in Appendix A and in most cases the authority is abbreviated.

25. The following example illustrates the function and meaning of a typical scientific name. The genus *Typha* was first described by the Swedish botanist Linnaeus, as was *Typha latifolia,* the Common cattail, which occurs over most of the United States. Its name, therefore, is written *Typha latifolia* L., indicating that this species was described by Linnaeus. The scientific name *latifolia* indicates that the plant has broad leaves, in this case an accurate description.

26. Occasionally, there is need to refer to an unidentified species of a particular genus; an unidentified species of *Potamogeton,* for example, would be referred to in the text as *Potamogeton* sp.

Similarly, it is sometimes convenient to refer to a group of species of a particular genus without giving the complete scientific name of each. A group of species of the genus *Potamogeton* would be given as *Potamogeton* spp.

27. Within the text of a paragraph or more of material, it is considered redundant to repeat the complete scientific name repetitively after its initial use. The species *Potamogeton amplifolius* would be given in full where first mentioned but at later times might be referred to in the text as *P. amplifolius*, the *P.* being an abbreviated form of *Potamogeton*. In situations where confusion with other species might result, however, the scientific name is given in full.

Synonymy of scientific names

28. Many plant species have been given more than one scientific name in the course of botanical history. A species may have been described and named independently by different botanists, or two species may have been considered one and the same following a period of study. In addition, there are differences of opinion among professional botanists as to whether a variation merits recognition as a variety or as a separate species or perhaps needs no additional name.

29. Because of differences of interpretation, one will often find a particular plant referred to by different scientific names in two or more separate publications. For this reason each of the guidebooks in this series has been compiled with the use of a particular publication as a standard for botanical nomenclature. In each case the standard for botanical nomenclature is a well-known regional manual of plant identification. The standard for each guidebook is identified in the section entitled Regional Botanical References.

PART II: WETLANDS OF PUERTO RICO

Regional Environment

30. Puerto Rico is a tropical island of a little more than 8900 km^2 (Hunt, 1967). Primarily of volcanic origin, the island apparently never has been connected with any continental land mass. Puerto Rico, along with other islands of the Greater Antilles, is one of the peaks of a partly submerged mountain range. Despite its small size the island supports a wide diversity of plant species. The variety of soil and rock types found on the island undoubtedly plays a significant role in that diversity. Erosion factors have created a complex physiography from the underlying unconsolidated sediments of Quaternary age, limestones of Tertiary age, and various other rocks of both igneous and metamorphic types dating from the Cretaceous.

31. The central mountain ranges rise to heights of over 1200 m. Trade winds move across the island from slightly north of east, depositing large amounts of rainfall on the northern slopes of the central mountains; annual precipitation averages of over 460 cm are reached in mountains of the Luquillo District of northeast Puerto Rico. Portions of the southwestern corner of the island, due to a rain shadow effect, are marked by very dry conditions because of an annual precipitation average of about 75 cm that is very unevenly distributed through the year. Temperatures are relatively uniform across the island except for minor differences between coastal localities and those high in the mountains. At San Juan the January average is 23.4°C and the July average is 26.6°C; temperatures may be lower and fluctuations slightly greater in the mountains, as at Cayey where the January average is 20.7°C and the July average is 24.2°C (Hunt, 1967). Official records indicate that temperatures of less than 3.9°C or more than 39.4°C have never been recorded on the island (Pico, 1950).

32. The wetlands of Puerto Rico share many plant species with the subtropical wetlands of peninsular Florida. The steep topography of the island, however, changes the nature of its wetlands. Water drains

from the mountainous interior by way of fast-moving streams and rivers except where it is impeded by man-made reservoirs. Ponds, lakes, marshes, and swamps are of greatest abundance on the flat alluvial plains near the coast but do occur locally in the interior as well. Even in the coastal regions, however, there generally is sufficient land relief to prevent the development of broad expanses of almost uniform wetland, such as those of the Florida Everglades. Instead, scattered ponds and lagoons surrounded by rather well-defined zones of deep and shallow marsh usually occur.

33. The influence of man and nature on the original vegetation has been extensive. The high population densities found over much of the island have contributed to the clearing of most of the original vegetation. Most of the more elevated wetland of the coastal region has been drained for sugar cane production. Many of the remaining freshwater wetlands are barely above sea level. Attempts to drain such areas to the sea in some cases have introduced tidal flushing into formerly freshwater areas. Other predominantly freshwater areas have natural outlets that permit intrusion of salt water. In either case the incursion of salt water during high tides and storms alternates with washing out of the salt water, which is particularly effective during rainy periods. The boundary between fresh and brackish water thus is difficult to define, and much of the area here treated as freshwater habitat is subject to occasional brackish influence.

34. Severe hurricane damage undoubtedly has also played an important role in altering the original vegetation. Puerto Rico is located in a hurricane belt; these hurricanes normally originate in the eastern part of the Caribbean, as well as in the ocean further east, and usually move westward across the island. The hurricane season extends mostly from early July to early November. Storms occurring early in the hurricane season rarely achieve sufficient intensity to cause major damage in Puerto Rico, but those occurring in August and September may reach major proportions by the time they pass over the island. Wadsworth and Eglerth (1959) cite evidence that about 50 hurricanes have passed directly over the island in its 450 years of recorded history.

Hurricanes inflict serious damage on forest communities, and Wadsworth (verbal communication, 1977) believes hurricanes have been significant factors in the destruction of many stands of *Pterocarpus* freshwater swamp forest.

Regional Botanical References

35. Despite a tradition of nearly a hundred years of botanical studies on Puerto Rico, there is no modern flora covering the entire flora of the island. An incomplete flora by Stahl was published in the Spanish language in 1883-88, followed by the publications of Urban (1903-11, in Latin and German) and Britton and Wilson (1923-30, in English). The work by Britton and Wilson is considered to be the standard reference for the island's flora, but its nomenclature is significantly outdated. Recent work by Liogier (1965, 1967) has resulted in an updating of the nomenclature used in Britton and Wilson's publication. Yet another flora of considerable use in Puerto Rico is the Jamaican flora of Adams (1972); it too is a valuable source of nomenclature information.

36. Woody species of the island, many of which are found in wetlands and their transition zones, have been given superb treatments in the works of Little and Wadsworth (1964) and Little, Woodbury, and Wadsworth (1974); in addition, the first publication has been translated into a Spanish edition (Little, Wadsworth, and Marrero; 1967).

Wetland Types

List of wetland types in Puerto Rico

37. Of the nine possible wetland types, Puerto Rico possesses eight. A brief description of each type follows:

a. Saltwater aquatic. Wetlands that are dominated by free-floating, rooted, or otherwise attached herbaceous plants (including macroscopic marine algae) and are permanently flooded by saline or brackish water (e.g., seagrass beds).

b. Saltwater coastal flat. Wetlands that have 25 percent or less vegetative cover and are occasionally (shallow flat) or regularly (deep flat) flooded by saline water of tidal origin (e.g., *Batis* and *Sesuvium* flats).

c. Saltwater marsh. Wetlands that have more than 25 percent vegetative cover of herbaceous plants but 40 percent or less cover by woody plants and are occasionally or regularly flooded by brackish or saline water (e.g., leather fern marshes).

d. Saltwater swamp. Wetlands that have more than 40 percent cover of woody plants and are occasionally or regularly flooded by brackish or saline water (e.g., mangrove swamps).

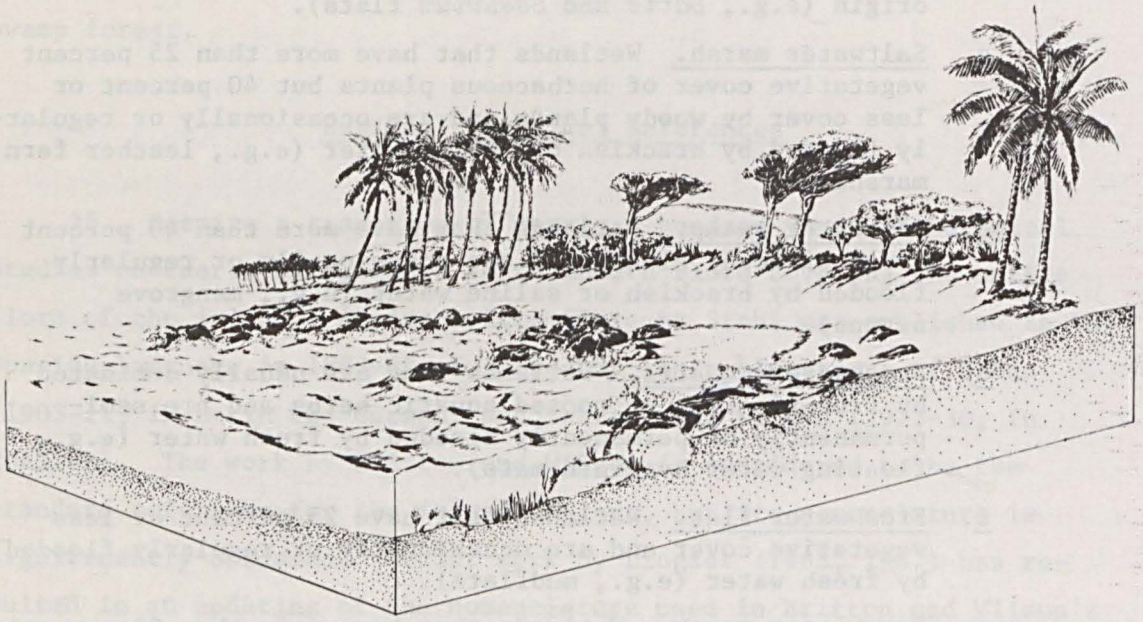
e. Freshwater aquatic. Wetlands that are usually dominated by free-floating or rooted aquatic herbs and are semi-permanently or permanently flooded by fresh water (e.g., floating water hyacinth mats).

f. Freshwater flat. Wetlands that have 25 percent or less vegetative cover and are occasionally or regularly flooded by fresh water (e.g., mudflats).

g. Freshwater marsh. Wetlands that have more than 25 percent vegetative cover of herbaceous plants but 40 percent or less cover by woody plants, which are occasionally or regularly flooded by fresh water (e.g., cattail marsh).

h. Freshwater swamp. Wetlands that have more than 40 percent cover by woody plants and are occasionally or regularly flooded by fresh water (e.g., Palo de pollo forest).

SALTWATER AQUATIC WETLANDS



Definition: Wetlands that are dominated by free-floating, rooted, or otherwise attached aquatic herbs and are permanently flooded by brackish or saline water

38. The saltwater aquatic wetland completely surrounds Puerto Rico. It consists of shallow marine areas and the intertidal zone, except where mangrove swamps are present. Vegetation of such sites consists of either marine algae on rocky sites or seagrasses. The shoreward limit of the saltwater aquatic wetland is apparently the elevation of the lower mean tide, and the seaward boundary is the limit of rooted plant growth (in the case of seagrasses) or to the limits of light penetration in the case of algal communities. Vegetation of the saltwater aquatic wetland is exposed above the water surface only during exceptionally low tides. These areas are highly productive and are important to many animal species by providing food and cover. The saltwater aquatic wetlands also are important in the detrital food chain and for nutrient cycling in the shallow coastal area.

VEGETATION

39. Growth forms and physiognomy: submerged narrow-leaved herbs, such as Turtle grass, and algae; frequently in dense, scattered, or extensive stands.

40. Species composition of the saltwater aquatic wetland:

Dominant species

Halodule wrightii (Shoal grass)
Halophila decipiens (Halophila)
Halophila engelmannii (Halophila)
Syringodium filiforme (Manatee grass)
Thalassia testudinum (Turtle grass or Palmas del mar)

Associated species

Acanthophora spp. (Red algae)
Acetabularia spp. (Green algae), Mermaid's wineglass
Avrainvillea spp. (Green algae)
Caulerpa spp. (Green algae)
Chaetomorpha spp. (Green algae)
Cladophora spp. (Green algae)
Dictyota spp. (Brown algae)
Ectocarpus spp. (Brown algae)
Enteromorpha spp. (Green algae)
Gracilaria spp. (Red algae)
Halimeda spp. (Green algae)
Laurencia spp. (Red algae)
Penicillus spp. (Green algae), Shaving brush alga
Polysiphonia spp. (Red algae)
Rhipocephalus spp. (Green algae)
Sargassum spp. (Brown algae), Gulfweed
Turbinaria spp. (Brown algae)
Udotea spp. (Green algae), Mermaid's fan
Ulva spp. (Green algae), Sea lettuce

Transitional species

Ruppia maritima (Widgeon grass)

Dominant and associated species. A wide variety of algal genera occur in association with rock and coral outcrops in the more exposed areas; important species belong to the genera *Dictyota, Turbinaria, Acanthophora, Avrainvillea,* and *Gracilaria.* In the rocky intertidal zone, the algae usually are small mosslike forms such as *Ectocarpus, Chaetomorpha, Polysiphonia, Cladophora,* and *Enteromorpha,* or the larger sheetlike *Ulva.* A dominant association of *Sargassum* spp. occurs on rocky high-energy coastal areas and exposed dead reefs on the north coast.

A narrow strip of sand or rock that is barren of macroscopic vegetation typically occurs just above the saltwater aquatic wetland along high-energy beaches. Just above the barren strip is an association of salt-tolerant species that is subject to heavy salt spray. Growing on the sand is a mixture of grasses and forbs, including *Paspalum vaginatum, Spartina patens, Sporobolus virginicus, Cakile lanceolata, Canavalia maritima,* and *Ipomoea pes-caprae.*

In the quiet shallow waters of bays and sheltered coasts, dense meadows of Turtle grass or Palmas del mar (*Thalassia testudinum*) often occur. *Halophila decipiens* and *H. engelmannii* also sometimes occur in these areas. On sites where the water is quite shallow and receives freshwater runoff, Turtle grass often is mixed with or replaced by Shoal grass (*Halodule wrightii*) or Manatee grass (*Syringodium filiforme*). In water of very low salinities, as in the mouths of rivers, estuaries, and brackish lagoons, Widgeon grass (*Ruppia maritima*) sometimes occurs. Often found with Turtle grass in quiet water are the following algae: *Acetabularia, Caulerpa, Halimeda, Laurencia, Penicillus, Rhipocephalus,* and *Udotea.*

Transitional species. Mudflats often form in protected waters between the seagrass beds and vegetation along the shore. Such areas typically support no vascular plants; there may be a heavy algal growth, however, and usually the mud contains high concentrations of purple sulphur bacteria and various invertebrates. The transition zone between salt water and fresh water at the mouths of rivers often supports a growth of Widgeon grass (*Ruppia maritima*).

A narrow strip of sand or rock that is barren of macroscopic vegetation typically occurs just above the saltwater aquatic wetland along high-energy beaches. Just above the barren strip is an association of salt-tolerant species that is subject to heavy salt spray. Growing on the sand is a mixture of grasses and forbs, including *Paspalum vaginatum, Spartina patens, Sporobolus virginicus, Cakile lanceolata, Canavalia maritima,* and *Ipomoea pes-caprae.* Small pockets of sand occurring in rock support a different group of species: Clavelon de playa (*Borrichia arborescens*), Spurge (*Euphorbia mesembrianthemifolia*), *Fimbristylis spadicea,* Sereno (*Gundlachia corymbosa*), and Temperara (*Suriana maritima*). Button mangrove (*Conocarpus erectus*) is an important woody species of the transitional zone. The species listed are adjacent to scrub vegetation on the upland side under most conditions.

ENVIRONMENTAL CONDITIONS

41. The shape of the ocean floor in combination with the direction and strength of prevailing winds determines whether a coast is exposed

to heavy wave action (high energy) or little wave action (low energy). The amount of wave action and the nature of the substrate strongly influence the nature of the vegetation present. Along many sandy stretches of the high-energy north coast, no macroscopic vegetation is found in the shallow water or intertidal areas. The factor preventing the growth of vascular plants may be the unstable nature of the sandy bottoms. Rock and coral outcrops along the northeastern coast typically support a variety of algae, particularly *Sargassum* spp. (Brown algae); such outcrops may play a significant role in breaking wave action, thereby making the areas more hospitable to algal growth, but another important factor is the low turbidity levels of the waters along the northeast coast.

FIELD IDENTIFICATION

42. The saltwater aquatic community can be identified by its landscape position below the intertidal zone and by the dominance of submerged, aquatic vascular plants and algae.

SALTWATER COASTAL FLAT

Definition: Wetlands that have 25 percent or less vegetative cover and are occasionally or regularly flooded by saline water of storm tidal origin (usually of storm tides)

43. Coastal flats primarily include nonvegetated or sparsely vegetated intertidal areas. They include hypersaline areas above the mean high tide that are inundated during storm tides and are sparsely vegetated. Some coastal flats around the island are in the form of slight depressions, flooded only at high tides, in which the water evaporates leaving the soils hypersaline; few plants can withstand these conditions. Coastal flats are found intermittently along the entire coast, but are particularly extensive along the coast of southwestern Puerto Rico where the lower precipitation levels are conducive to formation of extensive hypersaline soils.

VEGETATION

44. Growth forms and physiognomy: nonvegetated or scattered succulent forbs; usually less than 0.6 m tall.

45. Species composition of the saltwater coastal flat wetland:

Dominant species

Batis maritima (Saltwort, Barrilla)
Sesuvium portulacastrum (Sea purslane)

Associated species

Heliotropium curassavicum (Cotorrera de la playa)

Dominant and associated species. Coastal flats in the intertidal zone commonly have few or no plants present. The occasionally flooded flats on higher ground, however, often support mats of herbaceous plants on the hypersaline soils. *Batis maritima* and *Sesuvium portulacastrum* are common species on such sites, and *Heliotropium curassavicum* is a common associate.

Avicennia germinans (Mangle prieto) sometimes invades the succulent mats of saltwater coastal flats.

Transitional species. Coastal flats may be found adjacent to the ocean, the saltwater aquatic community, the saltwater swamp wetland, or saltwater marsh. In any case, the border usually is distinct.

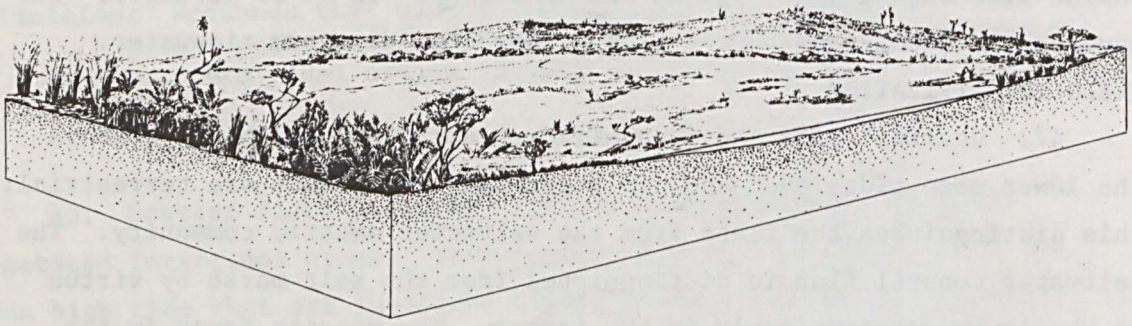
ENVIRONMENTAL CONDITIONS

46. Soils of saltwater coastal flats usually are saline or hypersaline with salinity as high as 120 to 130 ppt (12 to 13 percent). The hypersaline conditions result from evaporation of storm tidewater.

FIELD IDENTIFICATION

47. Coastal flats are recognized readily because they are above the lower mean tide level and, if vegetated, the plants are terrestrial; this distinguishes the flats from the saltwater aquatic community. The saltwater coastal flat is distinguished from the salt marsh by virtue of the low vegetative cover in the former. The species found in the coastal flat usually also are found in the salt marsh, although they may be uncommon in the salt marsh.

SALTWATER MARSH



Definition: Wetlands that have more than 25 percent vegetative cover of herbaceous plants but 40 percent or less cover by woody plants and that are occasionally or regularly flooded by brackish or saline water

48. Extensive salt marshes, such as those of the eastern coast of the United States, have not developed in Puerto Rico. The position of the regularly inundated marsh is occupied largely by mangrove forests. Marshes that are flooded irregularly occur upland of the mangrove forests for the most part and are of two types: fern-dominated marsh and succulent-dominated marsh.

VEGETATION

49. Growth forms and physiognomy: fairly dense stands of succulents, no more than 0.6 m in height and usually much less, or dense stands of waist-high ferns.

50. Species composition of the satlwater marsh:

Dominant species

Acrostichum spp. (Leather ferns)
Batis maritima (Barrilla)
Sesuvium portulacastrum (Sea purslane)
Sporobolus virginicus (Seaside rush-grass)

Associated species

Heliotropium curassavicum (Cotorrera de la playa)
Portulaca oleracea (Purslane)

Dominant and associated species. Solid stands of Leather fern often develop in areas where mangroves have been cut or otherwise destroyed. Leather ferns also tend to appear when formerly freshwater marshes are invaded by salt water. The Leather ferns grow in dense stands of a metre high or more and seldom are intermixed with other species.

Areas of high salinity and poor soils often support a salt marsh that is dominated by succulents. Species composition of such marshes is similar to that found on saltwater coastal flats, the two wetland types differing primarily in cover value. Barrilla (*Batis maritima*) and Sea purslane (*Sesuvium portulacastrum*) are the dominant species. Associated species include Cotorrera de la playa (*Heliotropium curassavicum*) and Seaside rush-grass (*Sporobolus virginicus*). Purslane (*Portulaca oleracea*) often appears shortly after periods of heavy rainfall, usually in areas adjacent to White mangrove (*Laguncularia racemosa*). This kind of salt marsh is a common feature in the zone between mangrove forests and upland vegetation, particularly in arid areas. The succulent marsh also grows around the edges of natural salinas (areas of high salinity behind the mangrove swamps). The salinas form in shallow depressions that effectively trap occasional tide waters; evaporation of the salt water results in hypersaline soils in which few plants are capable growth. Areas of lower salinity and marl soils support a graminoid-dominated vegetation; such sites usually are dominated by Seaside rush (*Sporobolus virginicus*) and less so by *Fimbristylis* (*F. cymosa*, *F. spathacea*, and other species).

Leather fern marshes adjacent to mangrove probably revert to mangrove swamp eventually. The fern stands are extremely dense, though, and regrowth of mangroves undoubtedly is a slow process. The high stress environment of the salina no doubt plays a major role in the prevention of succession in the normal sense. Eventual deposition of sediments in a salina depression conceivably would lead to establishment of either succulents or mangroves.

Transitional species. The saltwater marsh usually is adjacent to either mangrove forest or upland vegetation. The Leather fern marsh often starts abruptly at the edge of a clearing in the mangrove swamp, and a transition zone as such is not present. The Leather fern marsh also may be adjacent to a freshwater marsh, but here too the boundary is often sharp with little indication of a transition zone. Cattail (*Typha domingensis*) and Common reed (*Phragmites australis*) sometimes dominate the zone of low salinity between saltwater marsh and freshwater marsh, but neither species is restricted to the brackish situation. The succulent marsh often is adjacent to mangroves; stunted individuals of Black mangrove or Mangle prieto (*Avicennia germinans*), White mangrove or Mangle blanco

(*Laguncularia racemosa*), and Buttonwood or Mangle boton (*Conocarpus erectus*) characterize the transition zone between salt marsh and mangrove swamp.

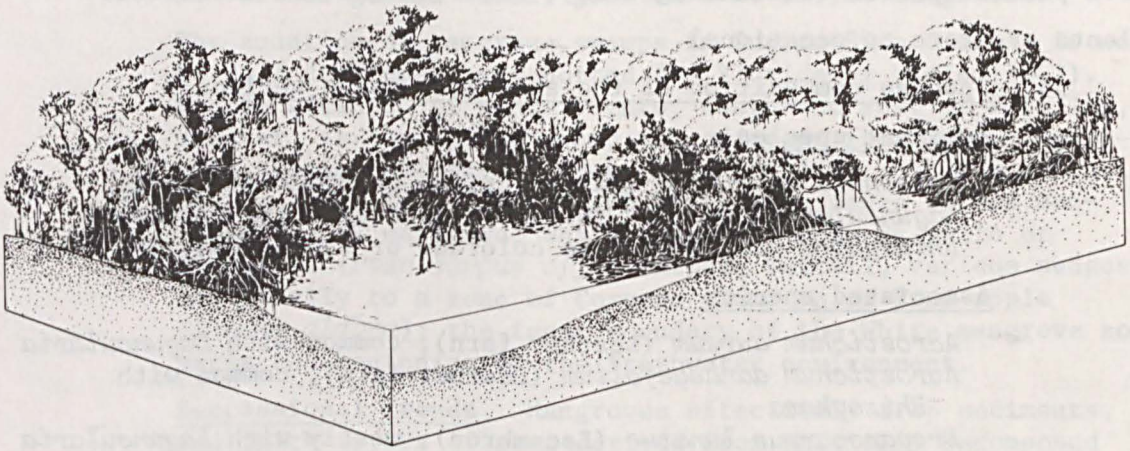
ENVIRONMENTAL CONDITIONS

51. Leather fern marshes generally occur on sites of relatively low salinity and having black muck soils. The succulent marshes, on the other hand, are found on sites having hypersaline soils and very little organic matter.

FIELD IDENTIFICATION

52. The dominance of either Leather ferns or succulents usually is sufficient to separate the saltwater marsh from most other wetland types. The succulent marsh is distinguished from the saltwater coastal flat on the basis of total vegetative cover--the saltwater marsh must have over 25 percent total cover while the flat has 25 percent or less cover.

SALTWATER SWAMP



Definition: Wetlands that have more than 40 percent cover by woody plants and are occasionally or regularly flooded by brackish or saline water

53. The saltwater swamp wetland in Puerto Rico is represented by mangroves. Mangroves have been destroyed in Puerto Rico through a variety of activities; clearing, dredging, and filling operations have played major roles in reducing the original mangrove forests of an estimated 24,300 hectares to less than 4,000 hectares today (Lugo and Cintron, 1975). Mangrove forests have been classified according to topography by Lugo and Snedaker (1974); by that system the mangrove swamps of Puerto Rico may be classified as either fringe, riverine, basin, or overwash types. Mangroves occur on all coasts of the island but are most extensive on the northern and southern coastlines. Mangrove forests of the northern coast are largely of the basin type, while those on the southern coast are mostly fringe in nature. Mangrove swamps are extremely productive biologically. The larvae and immature forms of shrimp, various other marine crustaceans, fish, and other marine animals live in the swamps until sufficiently mature to go beyond the mangroves into the open ocean waters.

VEGETATION

54. Growth forms and physiognomy: moderate to very dense growth

of low to medium-tall, broadleaf evergreen shrubs and trees (Mangroves), which often have aerial prop roots (Red mangroves) and sometimes extensive pneumatophores (Black mangroves); dwarf shrubs and herbaceous plants are rare to occasional.

55. Species composition of the saltwater swamp wetland:

Dominant species

Avicennia germinans (Mangle prieto or Black mangrove)
Laguncularia racemosa (Mangle blanco or White mangrove)
Rhizophora mangle (Mangle colorado or Red mangrove)

Associated species

Acrostichum aureum (Leather fern), common with *Laguncularia*
Acrostichum danaeaefolium (Leather fern), common with *Rhizophora*
Drepanocarpus lunatus (Escambron), mostly with *Laguncularia*
Hibiscus tiliaceus (Mahoe), mostly with *Laguncularia*
Hippocratea volubilis (Bejuco prieto), mostly with *Laguncularia*
Rhabdadenia biflora (Rubber vine), mostly with *Laguncularia*

Transitional species

Batis maritima (Barrilla)
Conocarpus erectus (Mangle boton)
Colubrina arborescens (Abeyuelo)
Pithecellobium unguis-cati (Una de gato)
Pluchea carolinensis (Pluchea)
Pluchea odorata (Pluchea)
Thespesia populnea (Emajaguillo)
Typha domingensis (Enea)

Dominant and associated species. Three unrelated woody species, all referred to as mangroves and tolerant of salt water, are dominants in the Puerto Rico saltwater swamp forest: Mangle colorado or Red mangrove (*Rhizophora mangle*), Mangle blanco or White mangrove (*Laguncularia racemosa*), and the Mangle prieto or Black mangrove (*Avicennia germinans*). Red mangrove typically is the dominant species in riverine and fringe forests, while the Black and White mangroves are dominant in basin forests.

Although mangrove swamps are communities with relatively low species diversity, several kinds of plants besides mangroves do occur there, particularly in the upland portions of the swamps. Swamp bush (*Pavonia spicata*), Mahoe (*Hibiscus tiliaceus*), and Escambron (*Drepanocarpus lunatus*) occur in occasional openings in the mangrove swamps dominated by White mangrove (*Laguncularia racemosa*). Leather ferns (*Acrostichum* spp.) also may be found in openings of mangrove swamps. The

vines Bejuco prieto (*Hippocratea volubilis*) and Rubber vine (*Rhabdadenia biflora*) often climb among the mangroves (particularly White mangroves). Epiphytic air-plants (bromeliads) of various genera rarely grow on some of the mangroves.

The zonation of mangrove swamps in Puerto Rico usually is not so well developed as reported for Florida by Davis (1943). In the vicinity of Punta Viento, south and east of Patillas, however, is a mangrove swamp and adjacent freshwater vegetation showing beautifully developed zonation. At that location one can move inwardly through succeeding zones of Red mangrove, Black mangrove, White mangrove, Palo de pollo or Bloodwood (*Pterocarpus officinalis*), Cattail, various sedges, and finally to a zone of Corazon cimmaron or Pond-apple (*Annona glabra*); the inner boundary of the White mangrove zone marks the beginning of the freshwater environment.

Successional trends. Mangroves effectively trap sediments, and thick layers of peat derived from partially decomposed leaves and roots may accumulate rapidly, particularly in a deep-water swamp, resulting in a decrease in the water level. In a shallow-water swamp where the surface layer of peat is exposed to the air, however, peat accumulation tends to be balanced by its removal through the processes of oxidation. Succession from mangrove swamp to upland vegetation types as a result of sedimentation and accumulation of peat surely must be an extremely slow process and is not well documented.

Man has had a significant effect on the mangrove forests of Puerto Rico (Lugo and Cintron, 1975). Draining, cutting and clearing, and filling operations have decreased the extent of mangrove forests dramatically and species composition of remaining stands has been altered significantly. Red mangrove, which has been cut in great quantities for its wood, does not regenerate from its roots and has decreased in relative abundance. The invasive and fast-growing White mangrove has become more prevalent, at least locally.

Transitional species. Along much of the southern coast, mangroves give way to either xeric upland vegetation or salinas that are barren of vegetation. A band of salt marsh dominated by Barrilla (*Batis maritima*) and Sea purslane (*Sesuvium portulacastrum*) often occurs between the mangroves and upland vegetation. The zone of xeric upland vegetation nearest the mangroves includes a gorup of salt-tolerant species, such as Mangle boton (*Conocarpus erectus*), Abeyuelo (*Colubrina arborescens*), Emajaguillo (*Thepesia populnea*), and Una de gato (*Pithecellobium unguis-cati*). Mangle boton or Buttonwood is a relative of the White mangrove and sometimes is considered a mangrove. Mangle boton commonly grows on elevated sites adjacent to mangrove swamps, however, and is not an important species in saturated soils.

Along any of the island's coasts, but particularly on the north coast, the vegetation behind the mangrove swamp may be either swamp or marsh. Enea (*Typha domingensis*) or Leather fern (*Acrostichum* spp.) is a typical component of the transition zone between freshwater swamp (dominated by *Pterocarpus officinalis*) and mangrove forests; in many cases Leather fern and Enea will be important components of the adjacent marsh itself.

ENVIRONMENTAL CONDITIONS

56. Red mangroves are particularly well adapted to deep water because the arching prop roots provide support for the plants; also, the Red mangrove's large propagules are adapted for lodging and growth in deep waters. In the more inland regions where tidal flushing is infrequent and soil salinities are higher, the Red mangrove usually is of smaller size than in deeper seaward situations; bands of taller Red mangrove plants are found, however, along the edges of tidal channels marked by better flushing. Abundant evidence indicates that the Red mangrove is either stunted or killed by hypersaline conditions. The Red mangrove tolerates reduced salinities very well, however, and can be found upstream in estuaries where freshwater conditions prevail during at least a part of the year.

57. The Black mangrove is more tolerant of high salinities than either Red mangrove or White mangrove and is a dominant along the arid southern and western coasts where hypersaline conditions tend to develop along the upland margins of the mangrove swamps. Unlike the Red and White mangroves, the Black mangrove does not invade regions of greatly reduced salinity. A particularly fine stand of young Black mangrove is found west of Luquillo in the Punta Picua area.

58. The White mangrove often dominates the upland portion of the mangrove swamp in those areas where hypersalinity is not a factor. White mangrove is a fast-growing species and increases in abundance dramatically after the cutting of mangrove swamps. Probably the best tract of White mangrove on the island is situated around the mouth of a stream about halfway between Luquillo and Laguna Aguas Prietas.*

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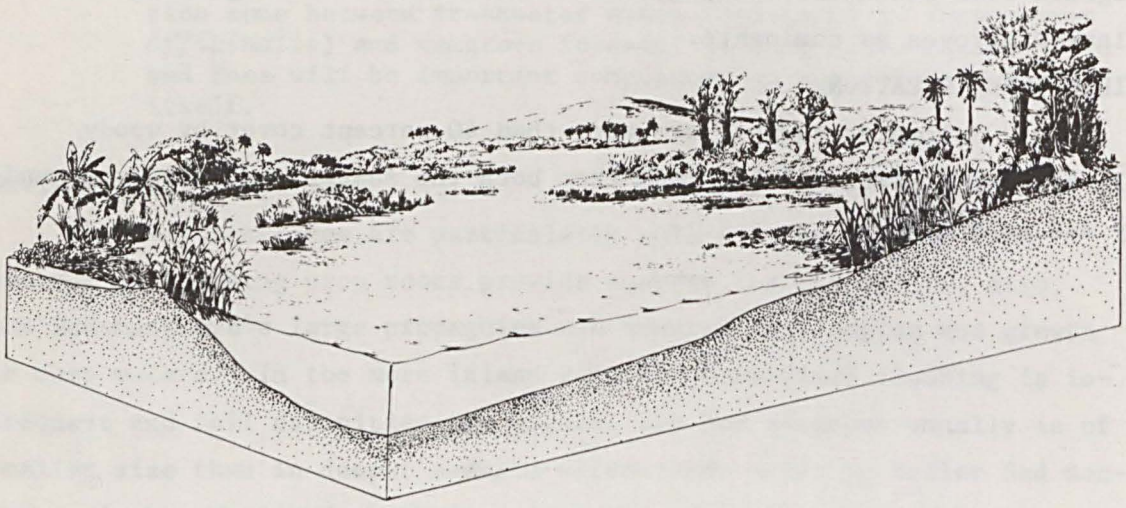
* Personal communication, Roy Woodbury, University of Puerto Rico at Rio Piedras, 1977).

59. Lugo and Cintron (1975) found that soil salinities are high in all mangrove forests of Puerto Rico regardless of specific location. The highest soil salinities were found in basin forests having White and Black mangroves as dominants.

FIELD IDENTIFICATION

60. Saltwater swamps have more than 40 percent cover by woody plants, which distinguishes them from both the saltwater aquatic community and salt marsh.

FRESHWATER AQUATIC WETLAND



Definition: Wetlands that are dominated usually by free-floating or rooted aquatic herbs and are semipermanently or permanently flooded by fresh water

61. Freshwater aquatic habitats are associated with streams and rivers, ponds and lakes, canals, and reservoirs. The water of such sites may be either still or moving. Large, quiet bodies of water originally were restricted largely to the flat coastal lowlands, but a series of impounded reservoirs now exist in the mountainous interior.

WARNING

62. The freshwaters of Puerto Rico, and possibly also the brackish waters, often harbor snails that serve as the intermediate host for a blood fluke that causes a serious disease in humans called schistosomiasis or bilharziasis. The microscopic intermediate forms of the parasite (cercariae of *Schistosoma mansoni*) swim in water and infect humans by boring into the skin. The study of freshwater plants in Puerto Rico is potentially dangerous and should be carried out with great caution. Wearing rubber boots and rubber gloves when working with freshwater habitats is a worthwhile precautionary measure.

63. Growth forms and physiognomy: free-floating herbs, such as Water hyacinth, and rooted aquatic herbs, such as Water lily, occurring in dense, sometimes scattered, stands; often with abundant masses of filamentous algae attached to vegetation or in detached floating clumps.

64. Species composition of the freshwater aquatic wetland:

Dominant species

Alternanthera philoxeroides (Alligator weed)
Cabomba piauhyensis (Fanwort)
Ceratophyllum demersum (Hornwort)
Eichhornia crassipes (Flor de agua)
Eriochloa polystachya (Malojilla)
Lemna perpusilla (Duckweed)
Najas guadalupensis (Naiad)
Nymphaea spp. (Water lily or Yerba de hicotea)
Nymphoides indica (Snowflake)
Panicum purpurascens (Para grass)
Pistia stratiotes (Lechuguilla del rio)
Potamogeton fluitans (Pondweed)
Potamogeton foliosa (Pondweed)
Spirodela polyrhiza (Duckweed)
Utricularia gibba (Bladderwort)

Transitional species

Cladium jamaicense (Sawgrass or cortedero)
Colocasia esculenta (Taro)
Cyperus giganteus (Giant sedge)
Eleocharis spp. (Spike rush)
Gynerium sagittatum (Cana brava)
Hymenachne amplexicaulis (Hymenachne)
Ludwigia octovalvis (Yerba de clavo)
Phragmites australis (Common reed)
Rhynchospora spp. (Beaked sedge)
Typha domingensis (Cattail or Enea)

Dominant and associated species. In many rapidly flowing streams, there are no vascular plants, although algal layers generally are present on the bottom and phytoplankton may occur in the surface layers. Vascular plants, when present, may be anchored to the bottom and with submerged or emergent leaves or they may be free floating. The bottoms of moving bodies of water often support the following anchored submerged plants: Naiad (*Najas guadalupensis*), Fanwort (*Cabomba piauhyensis*), Hornwort (*Ceratophyllum demersum*), and the pondweeds (*Potamogeton fluitans* and *P. foliosa*).

Bodies of quiet water often support an abundance of floating species including Flor de agua (*Eichhornia crassipes*), Lechuguilla del rio (*Pistia stratiotes*), and the duckweeds (*Lemna perpusilla* and *Spirodela polyrhiza*). The Flor de agua thrives in either quiet or slowly flowing rivers, often forming tremendous floating mats near the shore and in backwaters; it often overtakes and out-competes the smaller Lechuguilla del rio. The Flor de agua, or Water hyacinth as it is commonly called, is one of the most agressive of all aquatic weeds and chokes many of the slowly flowing freshwater streams. The bottom of quiet water that is not covered with a thick mat of Flor de agua and other floaters may support a growth of submerged plants; Fanwort (*Cabomba paiauhyensis*), Bladderwort (*Utricularia gibba*), and Hornwort (*Ceratophyllum demersum*) may be found under such conditions. Among other common species of quiet-water habitats are several species of Yerba de hicotea (*Nymphaea* spp.), Alligator weed (*Alternanthera philoxeroides*), and sometimes Cattails or Enea (*Typha domingensis*), although Cattail is perhaps more common in wet areas at the bases of slopes. Floating mats of the rhizomatous grasses Para (*Panicum purpurascens*) and Malojilla (*Eriochloa polystachya*) sometimes grow outward from riverbanks, as in the Dorado area.

Transitional species. A marsh generally develops where the freshwater aquatic community is bordered by quiet shallows. The transition zone from open water to freshwater marsh is characterized by an assemblage of plants that are more typical of the marsh itself; species of such transition zones must be tolerant of deep water and are discussed in the freshwater marsh wetland type.

The banks of rivers, lakes, and canals support a distinctive vegetation type. Tall stands of Cana brava (*Gynerium sagittatum*) are conspicuous features of these banks, but an assemblage of various sedges, particularly species of the genera *Eleocharis* and *Rhynchospora*, is of greater importance. Stands of Common reed (*Phragmites australis*) sometimes occur on banks but the species is of importance only locally. Taro (*Colocasia esculenta*), an escape from cultivation, thrives on the banks of larger waterways and actually invades the channels of minor streams. The grasses *Panicum aquaticum* and *P. condensum* and Yerba de clavo (*Ludwigia octovalvis*), a member of the Evening Primrose family, are other common components of the transition zone between freshwater aquatic wetland and the banks adjacent to them.

ENVIRONMENTAL CONDITIONS

65. There is a substantial seasonal fluctuation in rainfall over much of Puerto Rico with most of the precipitation occurring between

May and November. This seasonal fluctuation tends to be reflected in changes of water level in bodies of fresh water. Local conditions vary greatly, however, in large part because of Puerto Rico's topography and drainage patterns. Mountain streams are subject to flash floods whereas lowland freshwater lagoons show only moderate and gradual changes in water level.

FIELD IDENTIFICATION

66. The freshwater community is dominated by herbaceous species, thereby distinguishing it from the freshwater swamp. The freshwater aquatic community is dominated by rooted and usually free-floating aquatic plants, which separate it from freshwater marshes having more "terrestrial" species such as Sawgrass, Cordgrass, and Cattail. Boundaries of this wetland type may change rapidly as sediment accumulates, in which case the species composition changes, usually to a freshwater marsh.

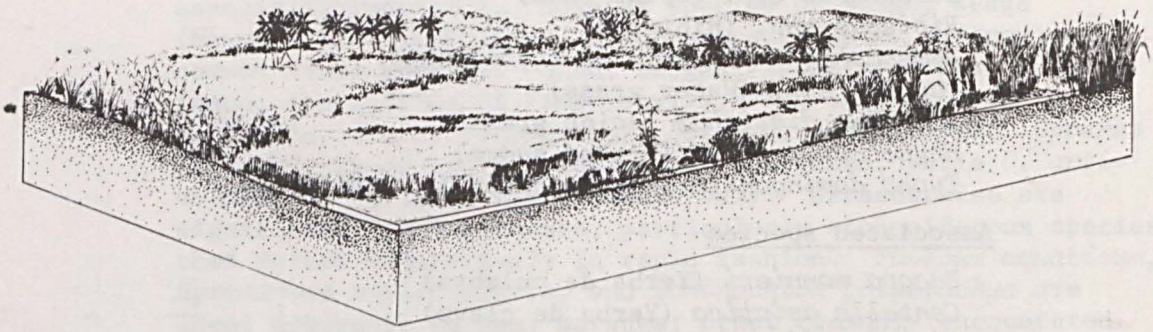
FRESHWATER FLAT

Definition: Wetlands that have 25 percent or less vegetative cover and are occasionally or regularly flooded by fresh water

67. Freshwater flats are apparently of both minimal extent and significance to Section 404 regulations in Puerto Rico. Freshwater flats are most common surrounding areas of fluctuating water levels, such as around reservoirs or adjacent to streams and rivers. While such flats do occur in Puerto Rico, they are not extensive, apparently because freshwater aquatic habitats generally are not subject to major water level fluctuations.

68. As the water level recedes, a community of *Centella asiatica* and *Lippia* spp. often develops, along with scattered plants of *Bacopa monnieri*, *Hyptis* spp. (*H. capitata*, *H. pectinata*, and *H. suaveolens*), and *Cleome spinosa*. In overflow areas where the water is shallow and soils usually remain moist, *Polygonum* spp. (Smartweed) takes over, along with *Jussiaea* spp. and *Aeschynomene americana*. In areas that are pastured, the grass *Panicum purpurascens*, usually known as Para grass, takes over with a few of the above mentioned weedy species invading it.

FRESHWATER MARSH



Definition: Wetlands that have more than 25 percent vegetative cover of herbaceous plants but 40 percent or less cover by woody plants and that are occasionally or regularly flooded by fresh water

69. Freshwater marshes of Puerto Rico occur primarily in the lowland coastal areas. Freshwater marshes often are adjacent to freshwater aquatic habitats; such marshes often are inundated for long periods and invaded readily by aquatic species. Other marshes are flooded on an infrequent basis but yet are characterized by soils that are more or less saturated. Such marshes often border occasionally flooded fields. The distinction between marshes and occasionally flooded fields often is difficult to make; in many instances, study by a botanist familiar with Puerto Rican wetlands may be essential for their demarcation.

VEGETATION

70. Growth forms and physiognomy: typically consists of dense stands of graminoids, both grasses and sedges being species of importance; forbs, either scattered or in small dense stands, often occur, particularly at the edge of marshes.

71. Species composition of the freshwater marsh:

Dominant species

Blechnum serrulatum (Swamp fern)
Cladium jamaicense (Sawgrass)

Cyperus giganteus (Giant sedge), in deep marsh
Cyperus spp. (Sedge)
Echinochloa polystachya (Water grass)
Eleocharis spp. (Spike rush)
Hibiscus spp. (Hibiscus)
Hymenachne amplexicaulis (Hymenachne)
Panicum spp. (Water grass)
Paspalum distichum (Joint grass)
Rhynchospora spp. (Beaked sedge)
Typha domingensis (Enea), often in deep marsh

Associated species

Bacopa monnieri (Yerba de culebra)
Centella asiatica (Yerba de clavo)
Fimbristylis spp. (Fimbristylis)
Hydrocotyle spp. (Pennywort)
Leersia hexandra (Cutgrass)
Nymphaea spp. (Yerba de hicotea), in deep marsh
Nymphoides indica (Snowflake)
Sacchiolepis striata (Sacchiolepis)
Sagittaria lancifolia (Arrowhead)
Thalia geniculata (Pampano)
Thelypteris spp. (Swamp fern)

Transitional species

Cyperus ligularis (Sedge)
Guettarda scabra (Cucubano)
Myrsine guianensis (Badula)
Paspalum vaginatum (Paspalum grass)
Randia aculeata (Tintillo)
Rhynchospora cyperoides (Beaked sedge)
Tabebuia heterophylla (Roble)
Various woody invader species from mesophytic forest

Dominant and associated species. Freshwater marshes generally are of two distinct types, separated rather subjectively on the basis of duration of flooding and depth of standing water. The two types of marshes intergrade freely but are discussed here as separate entities: shallow marsh and deep marsh.

Shallow marshes generally are dominated by grasses and sedges, although forbs are also significant components of many shallow marshes. The species diversity of shallow marsh communities is high, and the structure is complex. A small area that appears uniform physiographically may support many individual stands occupied by different plant species. The individual components of the mosaic are determined largely by slight differences in elevation, underlying rock and soil types, and past land utilization, as well as such factors as fire and agricultural practices. The tendency for many marsh species to reproduce vegetatively also contributes to the patchwork nature of the freshwater marsh.

Grasses and sedges are important components of the shallow marsh (as they are also in the deep marsh). Spike rushes (*Eleocharis* spp., especially *E. cellulosa*) often are dominant species; small-growing species such as *E. caribaea* often are especially important. Several species of Beaked sedge (*Rhynchospora cyperoides, R. corymbosa,* and *R. setacea*) are common marsh species. Other sedges, usually of less importance, are species of Fimbristylis (*Fimbristylis complanata, F. cymosa,* and *F. ferruginea*), *Scleria,* and *Cyperus. Cyperus ligularis* is of rather widespread occurrence, while *C. articulatus* is of local significance only. Grasses also are significant marsh elements, particularly stoloniferous species that spread vegetatively in rapid fashion. *Panicum aquaticum, Hymenachne amplexicaulis,* and *Echinochloa polystachya* are local dominants in many marshes; other commonly encountered species are *Leersia hexandra, Panicum geminatum, Paspalum distichum,* and *Sacchiolepis striata.*

Grasses and sedges usually dominate marshes, but species of other plant groups frequently are present and may dominate certain areas locally, as near the borders of marshes. The tiny *Bacopa monnieri* often forms solid mats in and around muddy areas, particularly along the upper edges of marshes. Other common plants of shallow marshes are Pennywort (*Hydrocotyle* spp.), Arrowhead (*Sagittaria lancifolia*), Pampano (*Thalia geniculata*), and Yerba de clavo (*Centella asiatica*). Smartweeds (*Polygonum* spp.) and *Caconapia stricta* may be of significance locally in disturbed shallow marshes.

Enea or Cattail (*Typha domingensis*) is the most common species of the deep marsh. *Typha* often grows at the edge of open water, especially in areas where water stands for two to three months at a time; it also occurs on floodplain marshes. Giant sedge (*Cyperus giganteus*) is another species of the deep marsh that may border open water, especially in disturbed areas, or it may occur on floodplains. Stands of *Cyperus giganteus* approaching 20 to 24 hectares in size have been observed on floodplain sites northeast of San Juan. Sawgrass (*Cladium jamaicense*) is not an abundant species on the island but often is found growing in deep water just upland of *Typha,* although Enea or Cattail may extend all the way from deep marsh into very shallow marsh, to the total exclusion of *Cladium.* Sawgrass plants sometimes have the lowest leaves 1.8 m above the base of the plant, an indication of former deep water levels at the growing site. Water lilies (*Nymphaea* spp.) often grow in the deepest areas of the deep marsh, often in the area between open water and graminoid-dominated marsh. A variety of submerged aquatic species (*Najas, Potamogeton, Ceratophyllum,* etc.) may invade deep marsh from the open water areas in which they are usually more abundant.

A good-sized Sawgrass marsh of exceptional quality occurs at the edge of Laguna Tortuguero; the Tortuguero marsh is floristically and physiognomically similar to the sawgrass marshes in the Florida Everglades, and many of the plant species found are common to the two areas. Sawgrass or Cortedero (*Cladium jamaicense*) reaches its best development on soils that consist of basic to low acidic peat covering marl; *Rhynchospora* sp. is dominant on sites having peat over silica sand. The two genera grow side by side at Laguna Tortuguero due to the fact that soils of both types are present.

Ferns sometimes are conspicuous elements of the freshwater marsh. Several species of the fern genus *Thelypteris* often are found on the burned stumps of Sawgrass. The Swamp fern (*Blechnum serrulatum*) frequently grows in slightly elevated areas of the marsh, especially on soils of an acidic nature.

Successional patterns. Deep marsh is filled in with organic matter, precipitated marl, and silt carried from higher ground until it becomes shallow marsh. Initial sediment accumulations may be too loose to support the root systems of shallow water species. Eventually, however, the material becomes sufficiently consolidated to promote succession. Shallow marsh tends to fill in also, resulting in replacement of the hydrophytic plant community by a mesophytic one. In the absence of disturbing factors, the shallow marsh would be expected to change to a climax lowland mesophytic forest over a period of many years. Disturbance by man's activities in Puerto Rico is so widespread, however, and has gone on so long that none of the original lowland mesophytic forest (rain forest?) remains; its nature, therefore, remains largely conjectural.

Certain short-term successional changes can be observed in marsh habitats. Generally speaking the shorter grasses and sedges, as well as other herbaceous species, tend to be replaced by larger plants of both herbaceous and woody affinities. Fire during the dry season, where allowed to take its course, plays an important role in maintaining the smaller marsh plants. Dense mats of the tiny, creeping *Bacopa monnieri* quickly establish on ground made bare by fire. The *Bacopa* mats soon are overtaken by grasses and sedges, however, followed eventually by other species of larger size.

Several woody species readily invade shallow marsh. The most common invaders probably are Hicaco (*Chrysobalanus icaco*), Cerero (*Myrica cerifera*), and Corazon cimarron (*Annona glabra*). If nature were left to take its course, these woody plants would convert many shallow marshes into a kind of shrub-dominated freshwater swamp. Burning, cutting, and other factors of disturbance are extensive, though, and shrub-dominated wetlands apparently are of minimal extent in Puerto Rico.

Transitional species. The transition zone between marsh and upland vegetation often is highly disturbed; typically, however, the transition zone includes certain species from the marsh and others from the adjacent upland communities, many of which are woody species. The following small trees occur at the edge of the marsh or as small islands in the marsh: Badula (*Myrsine guianensis*), Cucubano (*Guettarda scabra*), Tintillo (*Randia aculeata*), and Roble (*Tabebuia heterophylla*). *Rhynchospora cyperoides* is a sedge that is common along the edge of the marsh as well as on elevated islands within the marsh. Another sedge species, *Cyperus ligularis*, is of some significance locally as a transition zone indicator; it grows in damp fields as well as in the transition zones, though, so its utility is not so great in wetland delineation. A tall grass, *Paspalum vaginatum*, is of widespread occurrence and tends to grow on the elevated ground adjacent to marshes. The transition zone between deep marsh and open water may be occupied by Enea or Cattail (*Typha domingensis*), Giant sedge (*Cyperus giganteus*), or Water lily (*Nymphaea* spp.); where *Nymphaea* is present it usually borders directly onto the open water. Snowflake (*Nymphoides indica*) is commonly associated with *Nymphaea*.

ENVIRONMENTAL CONDITIONS

72. Deep marsh develops on the margins of ponds, lagoons, lakes, and other bodies of water marked by little or no flow. Seasonal fluctuation in water level may be minimal or substantial, depending on local physiographic factors, but rarely does the water level recede below ground level. Water depths in deep marshes range from 0.1 to 2.5 m but usually are within the range of 0.5 to 1.5 m.

73. The presence of Water lily (*Nymphaea* spp.) in freshwater marshes usually is indicative of permanent flooding, because *Nymphaea* is an aquatic group that does not tolerate prolonged drying. Emergent species are much more tolerant of drying and many may grow in either shallow water or on moist soils.

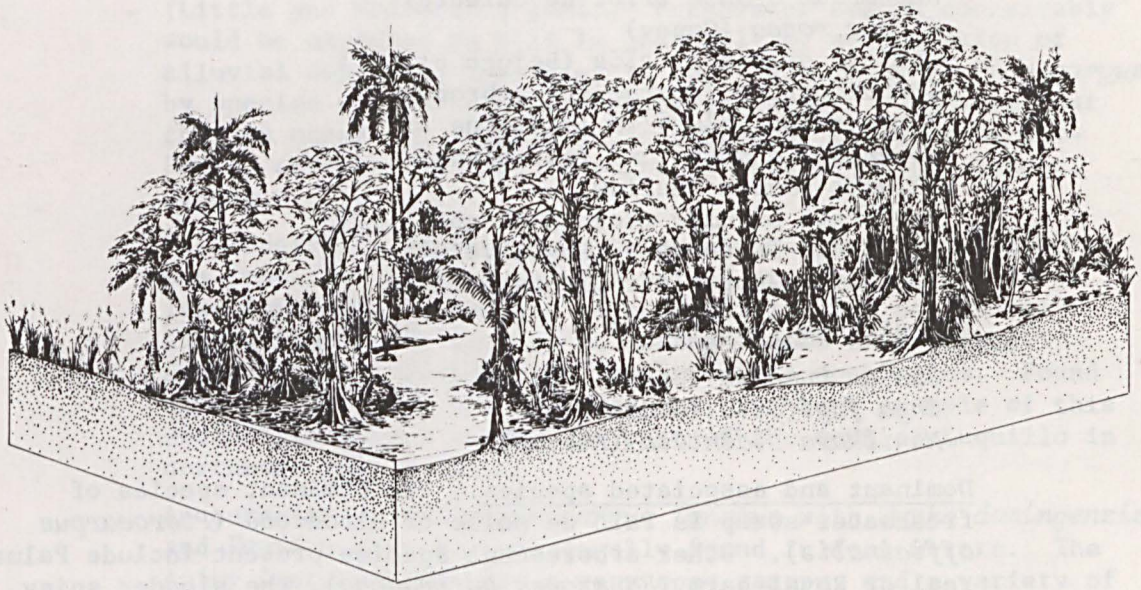
74. The shallow marsh commonly is subject to seasonal flooding. This type of marsh may be flooded to depths of from a few centimetres to nearly a metre. During the dry season there is no standing water, but the soil remains wet.

FIELD IDENTIFICATION

75. The freshwater marsh is separated from almost all other wetland types with little difficulty. It is distinguished from the

adjacent freshwater aquatic community by the change from a dominance of rooted and free-floating aquatic plants (such as *Nymphaea* and a variety of submerged genera, including *Najas*) to a predominance of nonaquatic species (such as a variety of grass and sedge genera). Many of the aquatic species invade adjacent marshes, however, so that quantitative studies of species composition may be essential to the accurate distinction of these two wetland types. Similarly, some freshwater marsh species tolerate brackish water, and the distinction of freshwater marsh from saltwater marsh may be difficult.

FRESHWATER SWAMP



Definition: Wetlands that have more than 40 percent cover by woody plants and are occasionally or regularly flooded by fresh water

76. Freshwater swamp communities are found in relatively few areas of Puerto Rico at the present time. The low-lying, flat coastal areas undoubtedly once supported much more extensive freshwater swamps, but only remnant tracts have escaped burning, clearing for agriculture, cutting for wood, or damage by hurricanes.

VEGETATION

77. Growth froms and physiognomy: stands of evergreen trees to 15 m or more in height with compound leaves and buttressed bases; vines and epiphytes abundant.

78. Species composition of the freshwater swamp wetland:

Dominant species

Pterocarpus officinalis (Palo de pollo)

Associated species

Acrostichum spp. (Leather fern)
Annona glabra (Corazon cimarron)
Anthurium acaule (Flor de culebra)
Clusia rosea (Cupey)
Cydista aequinoctialis (Bejuco blanco)
Drepanocarpus lunatus (Escambron)
Hippocratea volubilis (Medicine vine)
Hohenbergia antillana (Air plant)
Malache scabra (Mallow)
Paullinia pinnata (Bejuco de costilla)
Roystonea borinquena (Royal palm)
Tillandsia spp. (Air plants)

Transitional species

Bucida bucerus (Ucar)
Inga fagifolia (Guama)
Manilkara bidentata (Ausubo)

Dominant and associated species. The dominant species of freshwater swamp is Palo de pollo or Bloodwood (*Pterocarpus officinalis*). Other arborescent species present include Palma real or Royal palm (*Roystonea borinquena*), the slender spiny Escambron (*Drepanocarpus lunatus*), and Cupey or Pitch apple (*Clusia rosea*). The Cupey starts as an epiphyte but soon sends roots to the ground and eventually becomes an independent tree. The shrub *Malache scabra* sometimes is common in the swamp. Leather ferns (*Acrostichum* spp.) grow in openings that allow sufficient light to support their growth. Scattered plants of a variety of water-tolerant grasses, sedges, and other herbaceous plants grow in open areas of the forest during the dry season but are absent at other times.

Vines and air-plants (epiphytes) are abundant and conspicuous in the freshwater swamp. *Paullinia pinnata* and *Hippocratea volubilis* are among the most common vines found. Large plants of Flor de culebra (*Anthurium acaule*) cling to the trunks and buttresses of *Pterocarpus*. The most conspicuous of the air-plants in the crowns of the trees are the common *Tillandsia* spp. and *Hohenbergia antillana*, a species having very broad leaves. The beautiful flowering vine Bejuco blanco (*Cydista aequinoctialis*) is particularly prominent due to its rose-pink to white flowers.

At its best development the freshwater swamp is a beautiful wetland. The *Pterocarpus* trees reach heights of 15 m or more and are marked by very prominent buttresses. The buttress system often consists of four large buttresses to a tree with numerous smaller ones in between, none of which are much more than 2.5 cm thick but rising to heights of 3.5 to 4.5 m and flaring to 0.6 to 1.5 m wide at the base.

Remnant freshwater swamps are found mostly on the landward side of mangrove forests but also occur inland in swamps and along streams and rivers. In the lower Luquillo forest region, *Pterocarpus* ascends to an elevation of about 450 m (Little and Wadsworth, 1964). Freshwater swamps conceivably would be expected to fill in gradually by accumulation of alluvial deposits, resulting in the replacement of *Pterocarpus* by species of the lowland mesophytic forest. Evidence that this is occurring locally is suggested by the *Pterocarpus-Bucida* association that is found in several of the remnant stands.

An association dominated by Corazon cimarron (*Annona glabra*) was important on parts of the island at one time but is of less importance today due to the exploitation of its very lightweight roots for use in making floats on fishnets. Usually only a single tree is present at most sites. Found on both the north and south coasts, the best example of this swamp type occurs about 3 km east of the town of Luquillo in northeast Puerto Rico.

An association of *Drepanocarpus lunatus* with *Typha domingensis* and *Panicum* spp. is occasionally found in deep waters. The spiny *Drepanocarpus* has a very open canopy, and a variety of smaller plants that are water tolerant are associated with it. It may be associated with White mangrove (*Laguncularia*) on sites having relatively high salinities, while *Annona glabra* is a common associate on freshwater sites.

Transitional species. The remaining freshwater swamps typically border mangroves in the direction of the coast. In some cases *Pterocarpus* borders directly against White mangrove (*Laguncularia*) or Red mangrove (*Rhizophora*), but at other sites the more upland species of mangrove are present as well. Along the upland margin *Pterocarpus* swamps usually border disturbed areas from which the original mature mesophytic forest largely has been removed. *Bucida bucerus*, *Inga fagifolia*, and *Manilkara bidentata* are common transition zone species along the interface between freshwater swamp and upland mesophytic forest.

ENVIRONMENTAL CONDITIONS

79. The remaining freshwater swamps are relatively dry, with the ground being wet but only occasionally flooded. Soils are consistently salt free.

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APPENDIX A: SCIENTIFIC AND COMMON NAMES OF PLANTS OF PUERTO RICO

Scientific/Common Names

Acanthophora spp.
Red alga
Acetabularia spp.
Green alga
Acrostichum aureum L.
Leather fern
Acrostichum danaeaefolium Langsd. & Fisch.
Leather fern
Aeschynomene americana L.
Shy leaves
Alternanthera philoxeroides (Mart.) Griseb.
Alligator weed
Annona glabra L.
Corazon cimarron
Anthurium acaule (Jacq.) Schott.
Flor de culebra
Avicennia germinans (L.) L.
Mangle prieto
Avrainvillea spp.
Green alga
Bacopa monnieri (L.) Pennell
Yerba de culebra
Batis maritima L.
Barrilla
Blechnum serrulatum L. C. Rich
Swamp fern
Borrichia arborescens (L.) DC.
Clavelon de playa
Bucida bucerus L.
Ucar
Cabomba piauhyensis Gardn.
Fanwort
Caconapia stricta (Schrad.) Britton
Caconapia
Cakile lanceolata (Willd.) Schulz
Mostacilla del mar
Canavalia maritima (Aubl.) Thou
Mato de la playa
Casuarina equisetifolia L.
Casuarina
Caulerpa spp.
Green alga

Centella asiatica (L.) Urban
Yerba de clavo
Ceratophyllum demersum L.
Hornwort
Chaetomorpha spp.
Green alga
Chrysobalanus icaco L.
Hicaco
Cladium jamaicense Crantz
Sawgrass
Cladophora spp.
Green alga
Clusia rosea Jacq.
Cupey
Colocasia esculenta (L.) Schott
Taro
Colubrina arborescens (Mill.) Sarg.
Abeyuelo
Conocarpus erectus L.
Mangle boton
Cydista aequinoctialis (L.) Miers.
Bejuco blanco
Cyperus articulatus L.
Sedge
Cyperus giganteus Vahl
Giant sedge
Cyperus haspan L.
Sedge
Cyperus ligularis L.
Sedge
Dictyota spp.
Brown alga
Drepanocarpus lunatus (L.f.) G. F. W. Meyer
Escambron
Echinochloa polystachya (HBK.) Hitchc.
Water grass
Ectocarpus spp.
Brown alga
Eichornia crassipes (Mart.) Solms.
Flor de aqua
Eleocharis caribaea (Rottb.) Blake
Spike rush
Eleocharis cellulosa Torr.
Spike rush
Eleocharis interstincta (Vahl) Roem. & Schult.
Spike rush
Eleocharis mutata (L.) Roem. & Schult.
Spike rush
Enteromorpha spp.
Green alga

Eriochloa polystachya HBK.
Malojillo
Euphorbia mesembrianthemifolia Jacq.
Spurge
Fimbristylis complanatum (Ritz.) Link
Fimbristylis
Fimbristylis cymosa R. Br.
Fimbristylis
Fimbristylis ferruginea (L.) Vahl
Fimbristylis
Fimbristylis spadicea (L.) Vahl
Fimbristylis
Gracilaria spp.
Red alga
Guettarda scabra (L.) Vent.
Cucubano
Gundlachia corymbosa (Urban) Britton
Sereno
Gynerium sagittatum (Aubl.) Beauv.
Cana brava
Halimeda spp.
Green alga
Halodule wrightii Aschers.
Shoal grass
Halophila decipiens Ostenf.
Halophila
Halophila engelmannii Aschers.
Halophila
Heliotropium curassavicum L.
Cotorrera de la playa
Hibiscus tiliaceus L.
Mahoe
Hippocratea volubilis L.
Bejuco prieto
Hohenbergia antillana Mez.
Air plant
Hydrocotyle spp.
Pennywort
Hymenachne amplexicaulis (Rudge) Nees
Hymenachne
Hyptis spp.
Marrubio
Inga fagifolia (L.) Willd.
Guama
Ipomoea pes-caprae (L.) Roth
Bejuco de playa
Laguncularia racemosa (L.) Gaertn.
Mangle blanco
Laurencia spp.
Red alga

Leersia hexandra Sw.
Cutgrass
Lemna perpusilla Torr.
Duckweed
Lippia spp.
Capeweed
Ludwigia octovalvis (Jacq.) Raven
Yerba de clavo
Malache scabra B. Vogel
Mallow
Manilkara bidentata (A. DC.) Chev.
Ausubo
Mimosa ceratonia L.
Zarga
Myrica cerifera L.
Cerero
Myrsine guianensis (Aubl.) Kuntze
Beidula
Najas guadalupensis (Spreng.) Magnus
Naiad
Nymphaea spp.
Yerba de hicotea
Nymphoides indica (L.) Kuntze
Snowflake
Panicum aquaticum Poir.
Water grass
Panicum condensum Nash
Panic-grass
Panicum geminatum Forsk.
Water grass
Panicum purpurascens Raddi
Para grass
Paspalum distichum L.
Joint grass
Paspalum vaginatum Sw.
Paspalum grass
Paullinia pinnata L.
Bejuco de palma
Pavonia spicata Cav.
Swamp bush
Penicillus spp.
Red alga
Phragmites australis (Cav.) Trin.
Common reed
Pictetia aculeata (Vahl) Urban
Tachuelo
Pistia stratiotes L.
Lechuguilla del rio
Pithecellobium unguis-cati (L.) Benth.
Una de gato

Pluchea spp.
Marsh fleabane
Polygonum spp.
Yerba de hicotea
Polysiphonia spp.
Red alga
Portulaca oleracea L.
Purslane
Potamogeton fluitans Roth
Pondweed
Potamogeton foliosa Raf.
Pondweed
Pterocarpus officinalis Jacq.
Palo de pollo
Randia aculeata L.
Tintillo
Rhabdadenia biflora Jacq.
Rubber vine
Rhipocephalus spp.
Green alga
Rhizophora mangle L.
Mangle colorado
Rhynchospora corymbosa (L.) Britton
Beaked sedge
Rhynchospora cyperoides (Sw.) Mart.
Beaked sedge
Rhynchospora setacea (Berg.) Boeckl.
Beaked sedge
Roystonea borinquena Cook
Palma real
Ruppia maritima L.
Widgeon grass
Sacciolepis striata (L.) Nash
Sacchiolepis
Sagittaria lancifolia L.
Arrowhead
Sargassum spp.
Brown algae
Scleria spp.
Stone-rush
Sesuvium portulacastrum (L.) L.
Sea purslane
Spartina patens (Ait.) Muhl.
Salt grass
Spirodela polyrhiza (L.) Schleid.
Duckweed
Sporobolus virginicus (L.) Kunth
Seaside rush-grass
Suriana maritima L.
Temporana

Syringodium filiforme Kunzing
Manatee grass
Tabebuia heterophylla (DC.) Britton
Roble blanco
Thalassia testudinum Konig
Palmas del mar
Thalia geniculata L.
Pampano
Thelypteris spp.
Marsh fern
Thespesia populnea (L.) Solander
Emajaguillo
Tillandsia spp.
Pinones
Turbinaria spp.
Brown alga
Typha domingensis Pers.
Enea
Udotea spp.
Green alga
Ulva spp.
Sea-lettuce
Utricularia gibba L.
Bladderwort

Abeyuelo
Colubrina arborescens (Mill.) Sarg.
Air plant
Hohenbergia antillana Mez.
Alligator weed
Alternanthera philoxeroides (Mart.) Griseb.
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Sagittaria lancifolia L.
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Paullinia pinnata L.
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Ipomoea pes-caprae (L.) Roth
Bejuco prieto
Hippocratea volubilis L.
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Caconapia stricta (Schrad.) Britton
Cana brava
Gynerium sagittatum (Aubl.) Beauv.
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Lippia spp.
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Casuarina equisetifolia L.

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Fimbristylis cymosa R. Br
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Ulva spp.
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Cyperus articulatus L.
Sedge
Cyperus haspan L.
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Cyperus ligularis L.
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Halodule wrightii Aschers.
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Scleria spp.
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Pavonia spicata Cav.
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Temporana
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Tintillo
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Bucida bucerus L.
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Ruppia maritima L.
Yerba de clavo
Centella asiatica (L.) Urban
Yerba de clavo
Ludwigia octovalvis (Jacq.) Raven
Yerba de culebra
Bacopa monnieri (L.) Pennell
Yerba de hicotea
Nymphaea spp.
Yerba de hicotea
Polygonum spp.
Zarga
Mimosa ceratonia L.

APPENDIX B: GLOSSARY

ABUNDANCE: a term used in quantitative vegetation sampling, referring to density of a given species per unit area; usually expressed as the total number of individual organisms in a unit area.

ACIDIC: having a pH value of less than 7, nonalkaline.

ALGAE: a nonvascular chlorophyll-bearing organism, common to various types of wetlands and very important in productivity.

ALKALINE: having a pH value greater than 7, nonacidic.

ANGIOSPERM: a plant characterized by flowers and seeds enclosed in fruits; e.g., orchids, palms, oaks, etc.

ANNUAL: a plant in which the entire life cycle is completed in a single growing season.

AQUATIC VEGETATION: a plant characteristically growing wholly or partly submerged in water.

AUTHORITY: the name of the person or persons who first described a particular plant to science, appearing in conjunction with a scientific name; e.g., *Typha latifolia* L. (the L. representing the botanist Linnaeus).

BACKWATER: an accumulation of usually quiet water, held back by a natural dike, high tides, or unusually high water levels in creeks, rivers, or lakes.

BANANA HOLE: type of freshwater swamp occurring in small sinkholes in Florida.

BARRIER ISLAND: an offshore island, similar to a bar, except with ridges, vegetation, and swampy tracts.

BAY: a body of water, smaller than a gulf, located in a recess in the shoreline.

BAYHEAD: a regional name applied to a type of freshwater swamp in Florida, dominated by a mixture of hardwood species.

BAYOU: a small, sluggish secondary stream or lake, often existing as an area of backwater in an abandoned channel.

BIENNIAL: a plant normally requiring two growing seasons to complete its life cycle; vegetative growth appears the first year and flowering and fruiting follow in the second year.

BOG: a vegetation type usually denoting an area of wet, acid peat.

BRACKISH: referring to water or soils having salinity contents of 0.5 to 30 ppt (o/oo).

BROADLEAF: having broad, flat leaves; usually referring to angiosperms (flowering plants) as contrasted with the needle-leaves of many gymnosperms.

CARR: a poorly defined regional wetland term, used primarily in parts of the Midwest; refers to a successional community (dominated by shrubs) that appears between marsh and swamp formation.

CLIMAX: the terminal community of a particular plant succession sequence, maintaining itself relatively unchanged unless the environment changes.

COASTAL FLAT: wetland type having 25 percent or less vegetative cover and that is occasionally or regularly flooded by saline water of tidal origin.

COLONY: a group of organisms of the same species growing in a localized area, often used to refer to a group of plants becoming established in a new situation.

COMMUNITY: a distinctive combination of two or more ecologically related species, living together and interacting with each other in a characteristic natural habitat.

CONIFER: a common term for any gymnosperm of the order Coniferales (the group containing those gymnosperms producing definite cones, as pine, spruce, etc.).

COVER: a term used in quantitative vegetation sampling, referring to the amount (percent) of ground with vegetation above it; estimated by vertically projecting the outline of the crown onto the ground.

dbh: diameter (of a tree) at breast height.

DECIDUOUS: shedding of leaves at end of growing season (or sometimes, in the Southwest, under periods of environmental stress before the end of the growing season); usually referring to broad-leaved woody angiosperms (flowering plants) but sometimes referring to gymnosperms (e.g., Bald cypress).

DEFLATION PLAIN BASIN: a basin formed in arid areas by removal of loose material from an area by wind.

DETRITAL: referring to dead organic tissues, decomposed material, and organisms in an ecosystem; usually including the live microorganisms involved in the decomposition of the material.

DISCLIMAX: a potentially long-persisting and self-reproducing vegetation type, maintaining its composition and structure only as a consequence of continuing disturbance (as by fire, grazing, etc.).

DOMINANT: a prevailing species of an area; a species that to a considerable extent controls the conditions for existence of its associates within an ecosystem.

DWARF SHRUB: woody plants characterized by numerous stems and rarely exceeding 50 cm in height.

ECOTONE: the transition zone between two or more adjacent plant communities, usually containing species from each of the adjacent vegetation types.

EMERSED: standing out above the water, as the leaves of certain hydrophytes.

EMERGENT: same as EMERSED.

EPIPHYTE: a plant that grows on another plant for support but is not parasitic on it.

ESTUARY: a basin in which river water mixes with and dilutes sea water.

EVERGREEN: a perennially green plant, never losing all its leaves at one time.

FEN: a poorly defined regional term for a type of marsh; usually said to be formed on peat that is circumneutral or alkaline in pH; vegetation marked by high species diversity; equivalent to the sedge-meadow of many authors.

FLOATING-LEAVED COMMUNITY: an aquatic assemblage dominated by species having leaves that float on the water surface, often floating by virtue of long flexuous petioles (such as most water lilies).

FLORA: the vegetation of an area; also used to denote a book for identification of plant species in an area.

FORBS: associated herbaceous species other than grasses; term used in ecological description of nonwoody vegetation.

FREQUENCY: a term used in quantitative vegetation sampling, relating to the number of times a species occurs in a given number of sample plots; expressed as a fraction of the total, usually in percent.

FRESH WATER: water containing less than 0.5 ppt (o/oo) salinity.

FRESHWATER AQUATIC COMMUNITY: a wetland dominated by free-floating or rooted aquatic herbs and that is semipermanently or permanently flooded by fresh water (e.g., a patch of water lilies).

FRESHWATER INLAND FLAT: a wetland having less than 25 percent vegetative cover and that is occasionally or regularly flooded by fresh water (e.g., mudflats).

FRESHWATER MARSH: a wetland having more than 25 percent vegetative cover by terrestrial herbs but 40 percent or less cover by woody plants, occasionally or regularly flooded by fresh water (e.g., sawgrass prairie).

FRESHWATER SWAMP: a wetland having more than 40 percent cover by woody plants and that is occasionally or regularly flooded by fresh water (e.g., cypress swamp).

GENUS (plural GENERA): a taxonomic category that represents a group of closely related species (e.g., all kinds of cattail are placed in the single genus *Typha*).

GRAMINOID: a term referring to grasses or grasslike plants (including the grasses, sedges, rushes, etc.).

GRASS-SEDGE BOG: a wet peatland dominated by grasses and sedges.

GROUNDWATER: water contained in rocks below the water table.

GROWTH FORM: a descriptive concept of vegetation based on some particular characteristic, such as deciduous versus evergreen and broad-leaf versus needle-leaf.

GUT: a narrow inlet of water along a coastline.

GYMNOSPERM: any of a number of different kinds of woody seed-plants in which the seeds are not enclosed in a fruit (e.g., pine, cedar, etc.).

HALOPHYTE: any plant species capable of tolerating salinity levels of more than 0.5 ppt (o/oo).

HAMMOCK: a dense growth of broad-leaved trees on a slight elevation; not considered wet enough to be a swamp.

HARDPAN: a hard, impervious subsurface layer of clay soil, usually impervious to both water and root penetration.

HARDWOOD: a broad-leaved angiosperm (flowering plant) tree having wood characterized by the presence of specialized cells called vessels.

HERB: a nonwoody plant--annual, biennial, or perennial--whose aboveground parts are short lived (in temperate regions, only one growing season).

HERBACEOUS: the adjective used to describe plants that are herbs.

HYDRIC: aquatic.

HYDROPHYTE: a plant growing in water or in characteristically wet soil.

HYPERSALINE: soil or water with a high salt content.

IMPOUNDMENT: standing body of open water created by artifically blocking or restricting the flow of a river, stream, or tidal area.

INTERMITTENT STREAM: a stream receiving its water primarily from surface runoff.

INTERTIDAL ZONE: in coastal areas, the region between levels of high tide and low tide.

KARST TOPOGRAPHY: a topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.

KELP: any of the various large, coarse brown seaweeds (brown algae) of marine waters.

LACUSTRINE: pertaining to a lake.

LAGOON: a shallow coastal body of water, partly separated from the sea by beaches or islands; usually a lagoon is elongate and parallel to the shoreline and characterized by higher salinity than found in an estuary.

LAKE: a natural depression fed by one or more streams and from which a stream may flow; occurs due to widening or natural blockage of a river or stream or occurs in an isolated natural depression that is not part of a surface river or stream; usually too deep to permit the growth of rooted plants from shore to shore.

LIANA: a woody or herbaceous climbing plant--a vine--with its roots in the soil.

LITTORAL: that portion of a body of water extending from shoreline toward the middle of the water to the limit of occupancy by rooted plants.

MANUAL: a handbook used in the taxonomic identification of plant species.

MARL: a deposit of crumbly, earthy material, usually composed of clay mixed with limestone or other carbonate.

MARSH: a wetland dominated by nonwoody vegetation; if woody plants are present, they account for less than 40 percent vegetative cover.

MESIC: pertaining to a habitat characterized by a medium amount of water, neither very wet nor very dry (much vegetation adjacent to wetlands is MESOPHYTIC in nature).

MUCK: a type of surface deposit in a poorly drained area, consisting of much dark, partially decomposed organic matter intermixed with mineral matter.

MUDFLATS: an area usually supporting only sparse vegetation or no vegetation at all, although algae may be numerous on such sites; mudflats may be intertidal in coastal areas or associated with areas of widely fluctuating water levels inland.

MUSKEG: a term used in several different ways but usually referring to bog (in itself a poorly defined term) habitats of the far north.

NEEDLE-LEAF: a descriptive term used in referring to the usually slender, often evergreen, leaves of many gymnosperms (e.g., pine).

NONVASCULAR PLANT: referring to the simple (and usually small and inconspicuous) plants characterized by a lack of specialized conducting and supporting tissues (e.g., algae).

NONWOODY: referring to a plant that does not form long-lived above ground structures; plants other than trees and shrubs.

OPEN WATER: areas that support very little vegetative cover (25 percent or less); such areas comprise the permanent or semipermanent interior portions of many ponds and lakes.

OXBOW: a shallow, crescent-shaped lake that results when loops of a meandering stream are cut off; oxbows are very common in deltaic regions.

PEAT: a dark-brown or black substrate produced by the partial decomposition and disintegration of mosses, sedges, trees, and other

plants growing in areas of its deposition; peat characteristically is deposited in certain wetland types.

PERCHED WETLANDS: wetlands located away from significant stream influence; perched wetlands include potholes and many so-called bogs, swamps, and similar areas vegetated by marsh or swamp plants.

PERENNIAL: a woody or herbaceous plant living from year to year, normally not dying after once flowering.

PERIPHYTON: algae growing attached to rocks and vegetation.

PERMANENT: used in reference to bodies of water that are long persistent and not subject to the normal processes of drying out by evaporative forces.

PHREATOPHYTE: a plant that has roots extending into the water table, thereby attaining a permanent water supply; of major concern in arid areas.

PHYSIOGNOMY: a descriptive concept based on the external appearance of vegetation (e.g., forest, prairie, marsh, etc.).

PHYTOPLANKTON: small, free-floating or weakly swimming algae, restricted to the very upper levels of bodies of water.

PLAYA LAKE: a slight depression in the plains of the Interior region, containing water after heavy rains but dry at other times, often supporting distinctive vegetation.

PNEUMATOPHORE: slender conical roots that grow vertically out of the mud, found in certain types of mangroves; used in conduction of oxygen to underground root systems.

POCOSIN: a regional term applied in the Carolinas to upland bogs found in undrained, shallow depressions in pine savannahs; pocosins are dominated by evergreen shrub species.

POND: a small, quiet body of standing water, usually sufficiently shallow to permit the potential growth of rooted plants from shore to shore.

POTHOLES: wetlands occupying basins formed by melting of isolated chunks of buried ice left behind by receding glaciers.

PRODUCTIVITY: the rate at which energy is stored in the form of organic substances, which can be used as food materials.

RESERVOIR: a pond or lake build for storage of water, usually by construction of a dam across a stream or river.

RHIZOME: an underground stem, growing horizontally, often thickened and containing accumulations of reserve food material; important structure for vegetative reproduction in many wetland plant species.

RIPARIAN: pertaining to vegetation of a riverbank or streamside.

SALINA: the term used for coastal flat (salt flat) in Puerto Rico.

SALINE: referring to water having too much salinity to be considered fresh water (in common usage the term is applied to water of high salinity, i.e., in excess of 30 ppt).

SALINE FLAT: wetlands having 25 percent or less vegetative cover that are occasionally or regularly flooded by saline water or nontidal origin (e.g., salt flats in interior of U. S.).

SALINE WATER: water containing greater than 30 ppt (o/oo) salinity.

SALINITY: pertaining to the percentage of salt found in saline water.

SALT FLAT: any area having high concentrations of soil salinity and supporting little or no vegetation, may be either coastal or inland.

SALT WATER: water containing high concentrations of salinity; normally the term is used to refer to sea water.

SALTWATER AQUATIC WETLAND: a wetland that is dominated by free-floating rooted, or otherwise attached herbaceous plants (including macroscopic marine algae) and that are permanently flooded by saline or brackish water (e.g., seagrass beds).

SALTWATER MARSH: a wetland having saline (including brackish) soils with 40 percent or less cover by woody plants and 25 percent or more cover by terrestrial herbs that is occasionally or regularly flooded by brackish or saline water (e.g., smooth cordgrass marshes).

SALTWATER SWAMP: a wetland having saline (including brackish) soils with 40 percent or more cover by woody plants and occasionally or regularly flooded by brackish or saline water (e.g., mangrove swamps).

SANDBAR: a bar or low ridge of sand bordering the shore or near the surface of the water, built up by currents or wave action.

SEAGRASS BEDS: usually areas of shallow water located along the coastline that support the underwater growth of seagrasses; of great value in providing cover for spawning fish and for their great productivity.

SEAWEED: any of the various macroscopic forms of marine algae (either Red algae, Brown algae, or Green algae).

SEDGE: any member of the plant family Cyperaceae; often used to refer to the specific genus *Carex* of the Cyperaceae.

SEMIPERMANENT: referring to a body of water that under normal circumstances is long persisting but under certain conditions may dry up in response to the normal processes of evaporation.

SHALLOWS: wetlands that are not usually considered marsh; represented by shallow pools, salt pans that hold water, and shallow lakes in estuarine systems; they may be nonvegetated or vegetated with emergent or submergent vascular plants or algae.

SHRUB: a perennial woody plant of relatively low stature (usually considered less than 20 ft) with several to many stems from at or near the ground.

SHRUB BOG: any permanently waterlogged peatland dominated by shrubs.

SINKHOLE: a characteristic feature of karst topography in limestone areas; a depression or "sink" occurs when the underlying limestone is eroded through solution processes; the sinkhole may or may not hold water.

SLOUGH: a channel of slow-moving water in a region having little topographic relief.

SOUND: a wide channel or strait connecting two large bodies of water or separating an island from the mainland.

SPECIES: a taxonomic category below the rank of genus representing a group of closely-related individuals that actually or potentially interbreed (e.g., the genus *Typha* contains several species of Cattail: *T. latifolia*, *T. angustifolia*, and *T. domingensis*; the species are considered to be closely related and hybridization is common in Cattails).

SPECIFIC EPITHET: the term referring to the scientific name applied to each species within a genus (e.g., *latifolia* is the specific epithet of the species *Typha latifolia*).

STAND: a group of plants on a given sample area.

STRAND VEGETATION: a term defined in several different ways, usually referring to the vegetation at the very edge of the shore (exclusive of any adjacent areas, such as dunes).

STREAM: any mass of water with a unidirectional flow.

SUBMERGED: referring to a hydrophytic plant that grows characteristically completely under water.

SUBMERGENT: same as SUBMERGED.

SUBMERSED: same as SUBMERGED.

SUCCESSION: the gradual, usually orderly and sometimes predictable sequence of plant communities occupying a given area with the passage of time.

SUCCULENT: a plant having juicy and fleshy stems and leaves that are adapted for water storage.

SWAMP: a wetland in which the dominant vegetation consists of trees (greater than 40 percent cover), tidal or nontidal, saltwater or freshwater.

TIDAL: referring to the alternate rise and fall of waters along the coast or of those having coastal influence.

TIDAL CREEK: a wetland situated along channels where water flows in both directions due to tidal influence.

TRANSITION ZONE: also referred to as ECOTONE; the intermediate zone between two or more adjacent plant communities, usually containing species from each of the adjacent vegetation types.

TREE: a perennial woody plant usually having a single trunk or stem and usually more than 6 m in height.

TUNDRA: a treeless plain, either wetland or "dry," found between the northern limits of trees and the region of perpetual ice and snow in the far north, or above treeline in the high mountains.

UPLANDS: areas that are not flooded on a regular basis and that do not support vegetation dominated by hydrophytes.

VASCULAR PLANT: referring to any of the many kinds of plants having specialized conducting and supporting tissue as well as differentiation into the structures known as roots, stems, and leaves (e.g., trees and shrubs of all kinds, grasses, etc.).

VEGETATIVE COVER: a term used in quantitative vegetation sampling, referring to the amount (percent) of ground with vegetation above it; estimated by vertically projecting the outline of leaves onto the ground.

VEGETATIVE REPRODUCTION: in seed plants, referring to reproduction by any of several means other than by seeds (e.g., underground rhizome systems, formation of roots on detached stems and leaves, etc.).

VERNAL POOL: a regional term applied to depressions in the grassland area of California; these pools, supporting a distinctive assemblage of plant species, fill with water in winter but dry up by summer.

WATER TABLE: the surface of the water-saturated zone of permeable rocks.

WETLANDS: those areas that are inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

WET MEADOWS: graminoid-dominated marshes, often with a wide variety of associated species, often found along floodplains where freshwater swamps have been cleared.

WILLOW HEAD: willow-dominated freshwater swamp occurring in southern Florida.

XERIC: pertaining to an area or habitat having a very low or inadequate moisture supply; plants of such habitats are XEROPHYTIC.

APPENDIX C: INTERPRETATION OF WETLAND DEFINITION

1. An area of some concern with respect to policy in the interpretation of the wetland definition is inclusion of the littoral zone as a wetland. In bodies of fresh water, the littoral zone is that area extending from the shoreline into the water to the limits of occupancy by rooted plants. The littoral zone has been defined in several ways by various marine science disciplines but usually is used as more-or-less synonymous with the intertidal zone (that region between high and low tides). Most intertidal littoral habitats (such as marine seagrass beds, macrophytic algal beds, rocky shores, and flats; as well as freshwater habitats such as mud flats and submerged aquatic plant beds) were regulated prior to the Federal Water Pollution Control Act Amendments of 1972, in large part by Sections 9 and 10 of the River and Harbor Act of 1899.

2. The emphasis in this report is on plant communities and their transition zones, and, from a technical standpoint, it is unrealistic to exclude the littoral zone plant communities from technical consideration. The reason for this is that plant communities are dynamic entities that are subject to considerable variation with respect to their position along various environmental gradients, and thus cannot be delineated precisely by policy statements that fail to take field realities into account. Seagrass beds, for example, usually are considered permanently inundated habitats; den Hartog,* however, reports that of the 12 genera of seagrasses, only three (none of which occur in American waters) occur exclusively in permanently flooded habitats.

3. For technical purposes, therefore, a broad definition of wetland has been followed in this guidebook series; although for purposes of practical delineation of wetlands from a standpoint of policy regulatory functions, personnel may find it necessary to follow a narrower definition.

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* C. den Hartog. 1977. Structure, function, and classification in seagrass communities. in C. McRoy and C. Helfferich, eds. Seagrass ecosystems. Marcel Dekker, Inc., New York.