# CLASSIFICATION OF WETLANDS AND DEEP-WATER HABITATS OF THE UNITED STATES

(An Operational Draft)



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FISH AND WILDLIFE SERVICE
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# CLASSIFICATION OF WETLANDS AND DEEP-WATER HABITATS OF THE UNITED STATES
## (An Operational Draft)

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## FOREWORD

The National Wetland Inventory Project of 1975-79 has sought (as did its predecessor of 1954, the first National Wetland Inventory Project), a wetland classification system that could be consistently and equally applied to the varying aspects of the wetland resources of the United States.

The result of that search, "The Classification of Wetlands and Deep-Water Habitats of the United States," has been under development for over two years, and has undergone peer review to an extent which is perhaps unprecedented in the history of documents published by the Fish and Wildlife Service. We want to acknowledge and thank those individuals and organizations who gave us assistance and guidance during the development of this system.

We have termed this document "An Operational Draft," and the selection of that phrase was made for two reasons. First, this classification system needs to be used in the field for a substantial period of time so that inconsistencies can be isolated and viable alternatives be examined. Secondly, similar to the Martin, et al (1953) system, this system will most assuredly need revising in the months and years ahead.

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# I. INTRODUCTION

In 1954, the U.S. Fish and Wildlife Service conducted an inventory of the wetlands of the United States (Shaw and Fredine 1956). Since then, wetlands in this country have undergone considerable change, both natural and man-related, and their characteristics and natural values have become better defined and more widely known. During this interval, state and federal legislation has been passed to protect wetlands, and some statewide wetland surveys have been conducted.

In 1974, the U.S. Fish and Wildlife Service directed its Office of Biological Services to design and conduct a new national inventory of wetlands. Whereas the single purpose of the 1954 inventory was to assess the amount and types of valuable waterfowl habitat, the scope of the new project is considerably broader (Montanari and Townsend, in press). It will provide basic data on the characteristics and extent of the nation's wetlands and deep-water habitats and facilitate the management of these areas on a sound, multiple-use basis.

Before the 1954 inventory was begun, Martin et al. (1953) had devised a wetland classification system to serve as a framework for the national inventory. The results of the inventory and an illustrated description of the 20 wetland types were published as Circular 39 (Shaw and Fredine 1956). This document has been one of the most common and most influential tools used in the continuous battle to preserve a rapidly vanishing and critically valuable national resource (Stegman 1976). However, the shortcomings of this work are well-known and have been documented (e.g., Leitch 1966, Stewart and Kantrud 1971).

In their attempt at simplification, Martin et al. ignored ecologically critical differences, such as the distinction between fresh and subsaline inland wetlands; also, dissimilar habitats, such as boreal black spruce forests and southern cypress-gum forests were often placed in the same category, with no provision in the system for distinguishing between them. Because of the central emphasis on waterfowl habitat, far greater attention was paid to vegetated areas than to nonvegetated areas. Probably the greatest single disadvantage of the Martin et al. system was the inadequate definition of types, which led to inconsistencies in application.

Numerous other classifications of wetlands and deep-water habitats have been developed, but most of these are regional systems and none would fully satisfy national needs (Stewart and Kantrud 1971, Golet and Larson 1974, Jeglum et al. 1974, Odum et al. 1974, Zoltai et al. 1975, Millar 1976). Because of the weaknesses inherent in Circular 39, and because our understanding of wetland ecology has grown significantly since 1954, the U.S. Fish and Wildlife Service elected to construct a new national classification system as the first step toward a new national inventory. The new classification has been designed to meet three long-range objectives: 1) to group ecologically similar habitats, so that value judgments can be made; 2) to furnish units for inventory and mapping; and 3) to provide uniformity in concepts and terminology throughout the United States.

# II. WETLANDS AND DEEP-WATER HABITATS

## CONCEPTS

For centuries we have spoken of marshes, swamps and bogs, but only relatively recently have we attempted to group these landscape units under the single term, "wetland." The need to do this has grown out of our desire to understand and describe the characteristics and values of all types of land, and to wisely and effectively manage wetland ecosystems. There is no single, correct, indisputable, ecologically sound definition for wetland, primarily because of the diversity of wetlands and because the gradation between dry and wet environments is continuous. The reasons or needs for defining wetland vary; as a result, a great proliferation of definitions has arisen. Our primary task here is to impose boundaries on natural ecosystems for the purposes of inventory, evaluation and management.

In general terms, wetland is land where water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. It spans a continuum of environments where terrestrial and aquatic systems intergrade. The concept of wetland embraces a number of characteristics including: 1) the elevation of the water table with respect to the ground surface; 2) the duration of surface water; 3) the soil types that form under permanently or temporarily saturated conditions; and 4) the various kinds of plants and animals that have become adapted to life in a "wet" environment. The single feature that most wetlands share is soil that, at least periodically, is saturated with water. This creates severe physiological problems for all plants except hydrophytes, which are adapted for life in water or in soil that is at least periodically saturated.

Deep-water habitats include environments where surface water is permanent and often quite deep so that water, rather than air, is the principal medium within which the dominant organisms live, whether they are attached to the substrate or not.

We define five major ecological systems: Marine, Estuarine, Riverine, Lacustrine and Palustrine. The first four of these include both wetland and deep-water habitats while the Palustrine includes only wetland habitat.

## DEFINITIONS

### Wetland

Instead of placing arbitrary limits on the position and fluctuation of the water table for the purpose of defining wetland, we have attempted to define wetland broadly and simply, and then to place limits on the concept. <u>For the purpose of this classification system, WETLAND is defined as land where the water table is at, near or above the land surface long enough to promote the formation of hydric soils[1] or to support the growth of hydrophytes.</u>[2] <u>In certain types of wetlands,</u>

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[1]The U.S. Soil Conservation Service is currently preparing a preliminary list of hydric soils for use in this classification system.

[2]The U.S. Fish and Wildlife Service is currently preparing a list of the hydrophytes of the United States.

vegetation is lacking and soils are poorly developed or absent as a result of frequent and drastic fluctuations of surface-water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the water or substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats.

Wetland as defined here includes land that is identified under other categories in some land-use classifications. For example, wetland and farmland are not necessarily exclusive. Many areas that we define as wetland are farmed during dry periods, but if they are not tilled or planted to crops, they will support hydrophytes.

## Deep-water Habitats

Permanently flooded lands lying below the deep-water boundary of wetland are defined as DEEP-WATER HABITATS in this classification. As in wetlands, the dominant plants are hydrophytes; however, the substrates are considered "not-soil" because the water is too deep to support emergent vegetation (U.S. Soil Conservation Service 1975).

## LIMITS

The upland limit of wetland is designated as: 1) the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover; 2) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or, in the case of wetlands without vegetation or soils; 3) the boundary between land that is flooded or saturated at some time during years of normal precipitation and land that is not. Areas with drained hydric soils that are no longer capable of supporting hydrophytes are not considered wetlands.

The boundary between wetland and deep-water habitat in the Marine and Estuarine Systems coincides with the elevation of the extreme low water of spring tide (ELWS); permanently flooded areas are considered deep-water habitats in these systems. The boundary between wetland and deep-water habitat in the Riverine, Lacustrine and Palustrine Systems lies at a depth of 2 m (6.7 ft) below low water; however, if emergents, shrubs or trees grow beyond this depth at any time, their deep-water edge is the boundary. Figures 1 and 2 illustrate the identifying features and limits of wetlands and deep-water habitats where tidal and nontidal forces predominate.

The 2 m lower limit for inland wetlands was selected because it represents the maximum depth to which emergent plants normally grow (Welch 1952, Zhadin and Gerd 1963, Sculthorpe 1967). As Daubenmire (1968:138) stated, emergents are not true aquatic plants, but are "amphibious," growing in both permanently flooded and wet, nonflooded soils. In their wetland classification for Canada, Zoltai et al. (1975) include only areas with water less than 2 m deep.

# III. THE CLASSIFICATION SYSTEM

The structure of this classification is hierarchical, progressing from systems and subsystems, at the most general levels, to classes, subclasses and dominance types. Modifiers for water regime, water chemistry and soils are applied to classes, subclasses and dominance types. Figures 3-7 illustrate the classification structure within each of the five ecological systems. Special modifiers are also included to describe wetlands and deep-water habitats either created or highly modified by man or beavers.

## HIERARCHICAL STRUCTURE

### Systems and Subsystems

The term SYSTEM refers here to a complex of wetland and deepwater habitats that share the influence of one or more dominant hydrologic, geomorphologic, chemical, or biological factors. We have chosen to subdivide systems into more specific categories called SUBSYSTEMS.

The characteristics of the five major systems have been discussed at length in the scientific literature and the concepts are well-recognized, but there is frequent disagreement as to which attributes should be used to bound the systems in space. For example, both the limit of tidal influence and the limit of ocean-derived salinity have been proposed for bounding the upstream end of the Estuarine System (Caspers 1967). As Bormann and Likens (1969) pointed out, boundaries of ecosystems are defined to meet pragmatic needs.

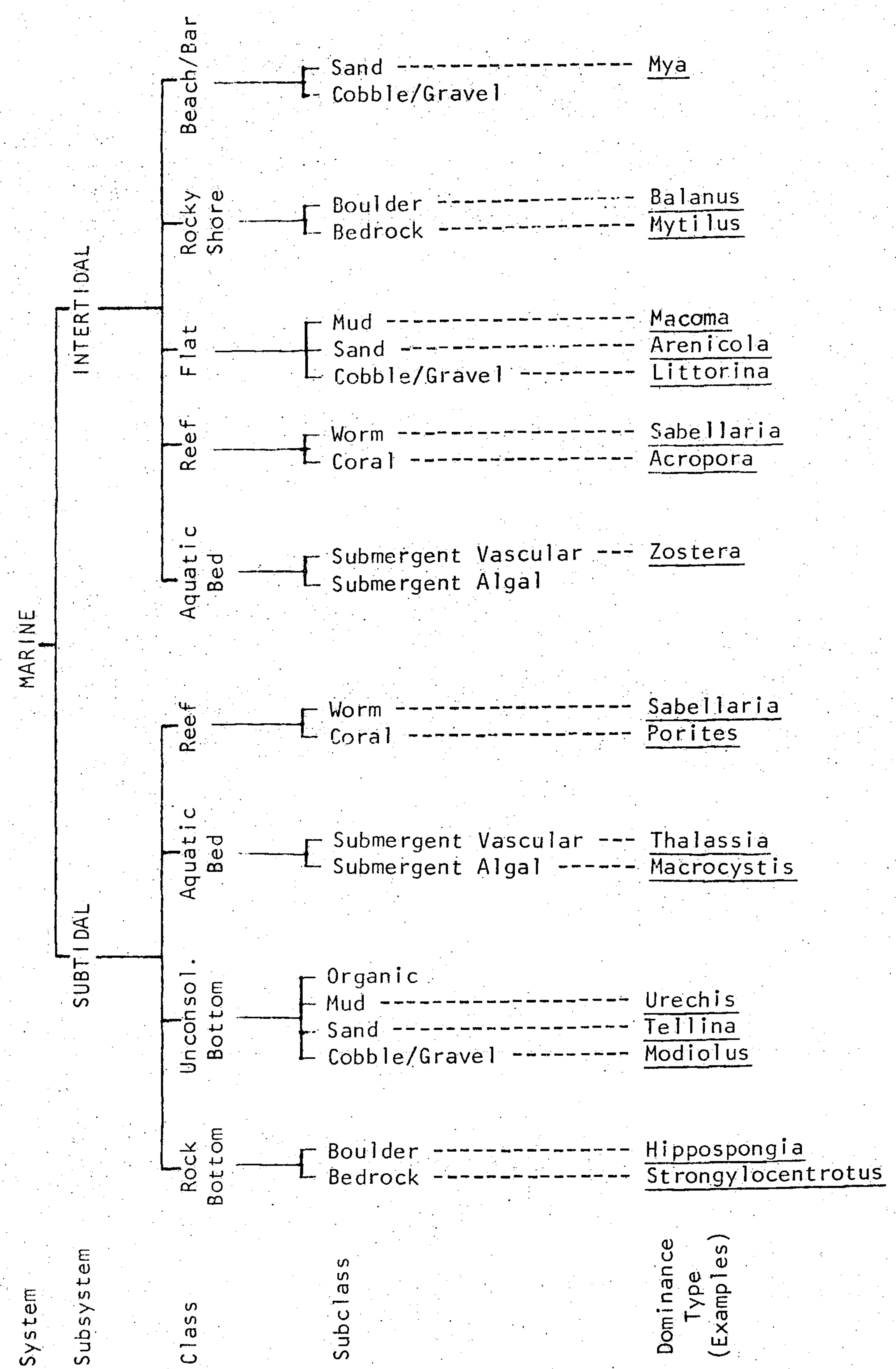


Figure 3. DIAGRAM OF THE CLASSIFICATION HIERARCHY FOR THE MARINE SYSTEM

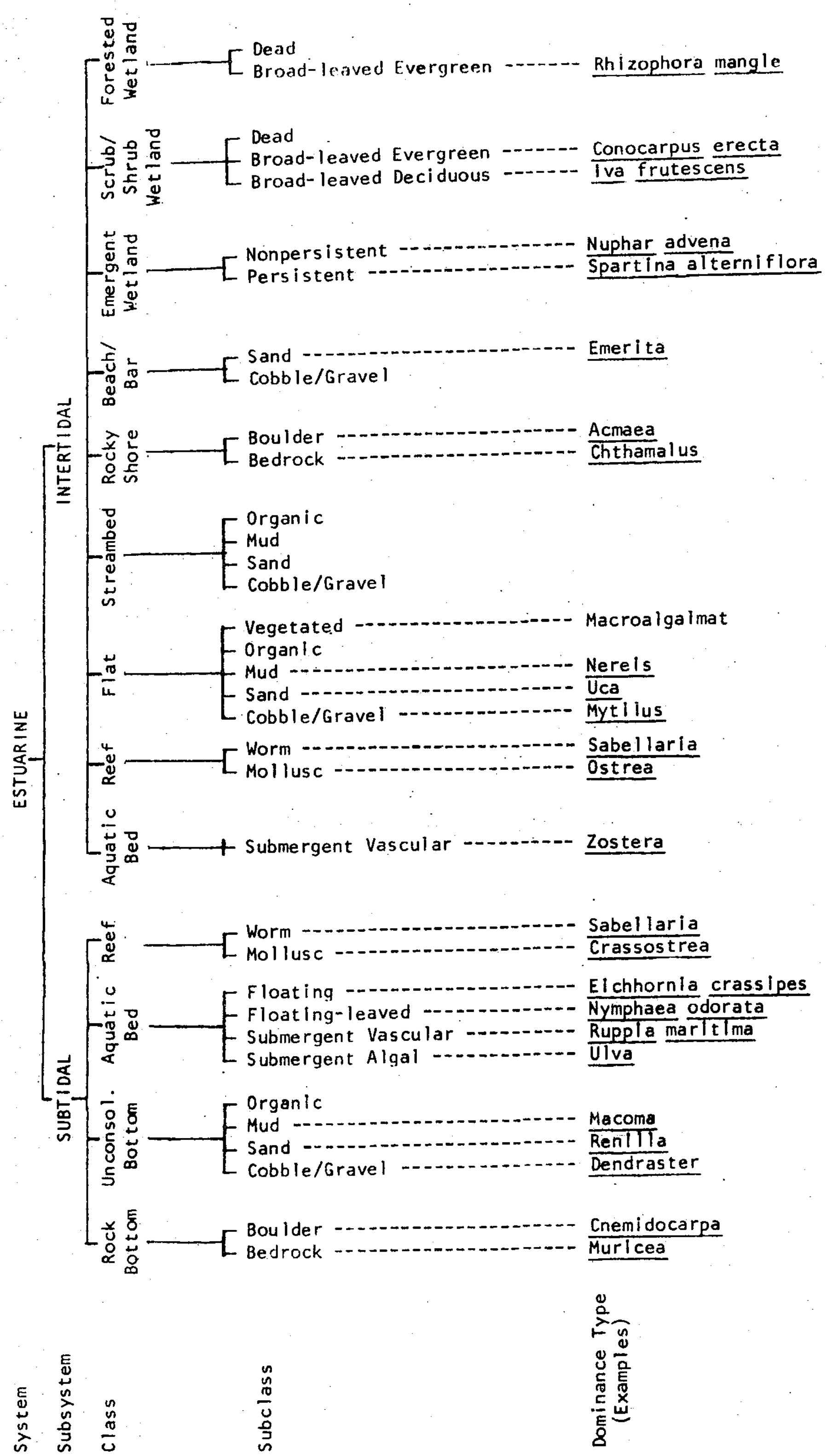


Figure 4. DIAGRAM OF THE CLASSIFICATION HIERARCHY FOR THE ESTUARINE SYSTEM.

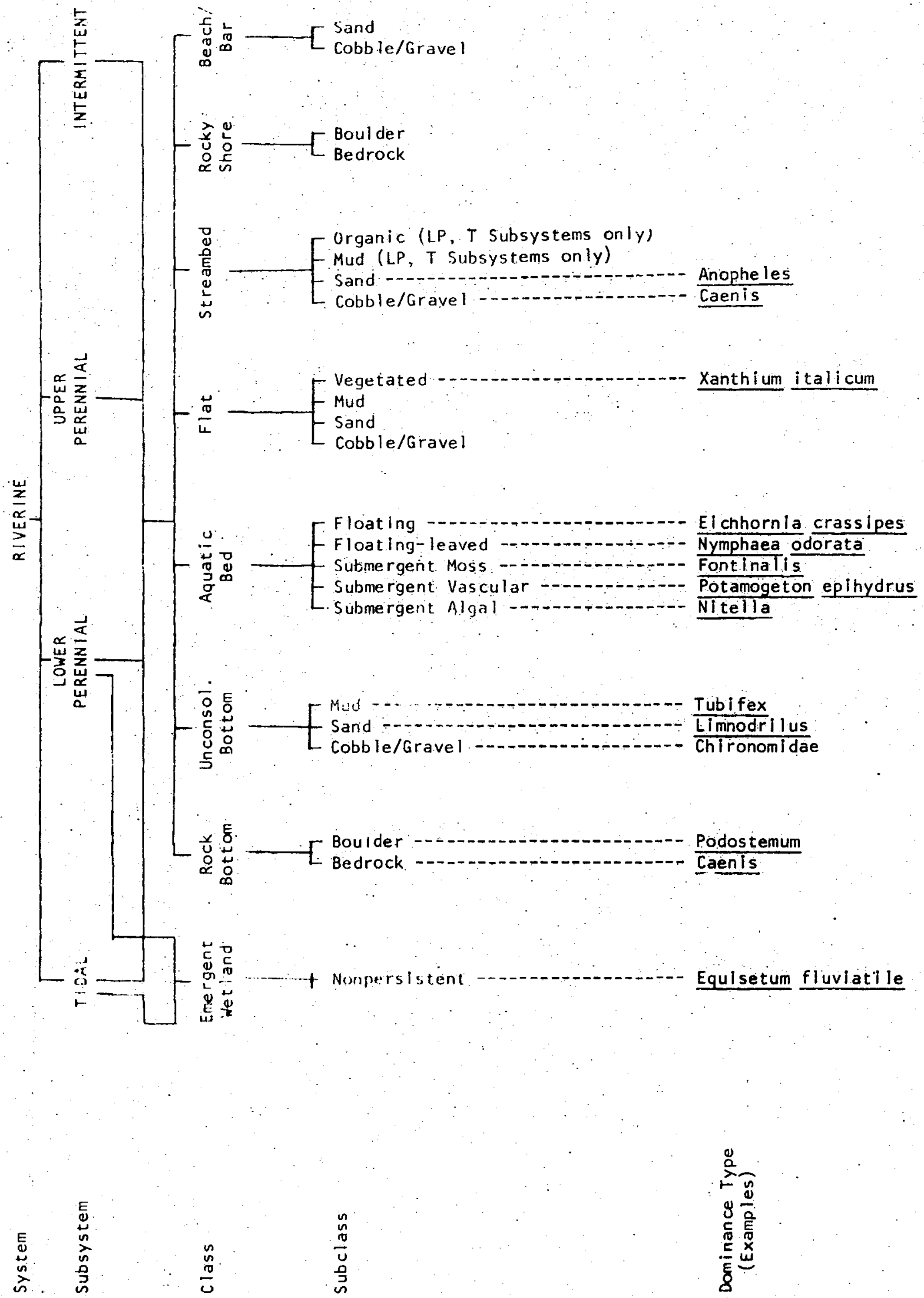


Figure 5. DIAGRAM OF THE CLASSIFICATION HIERARCHY FOR THE RIVERINE SYSTEM.

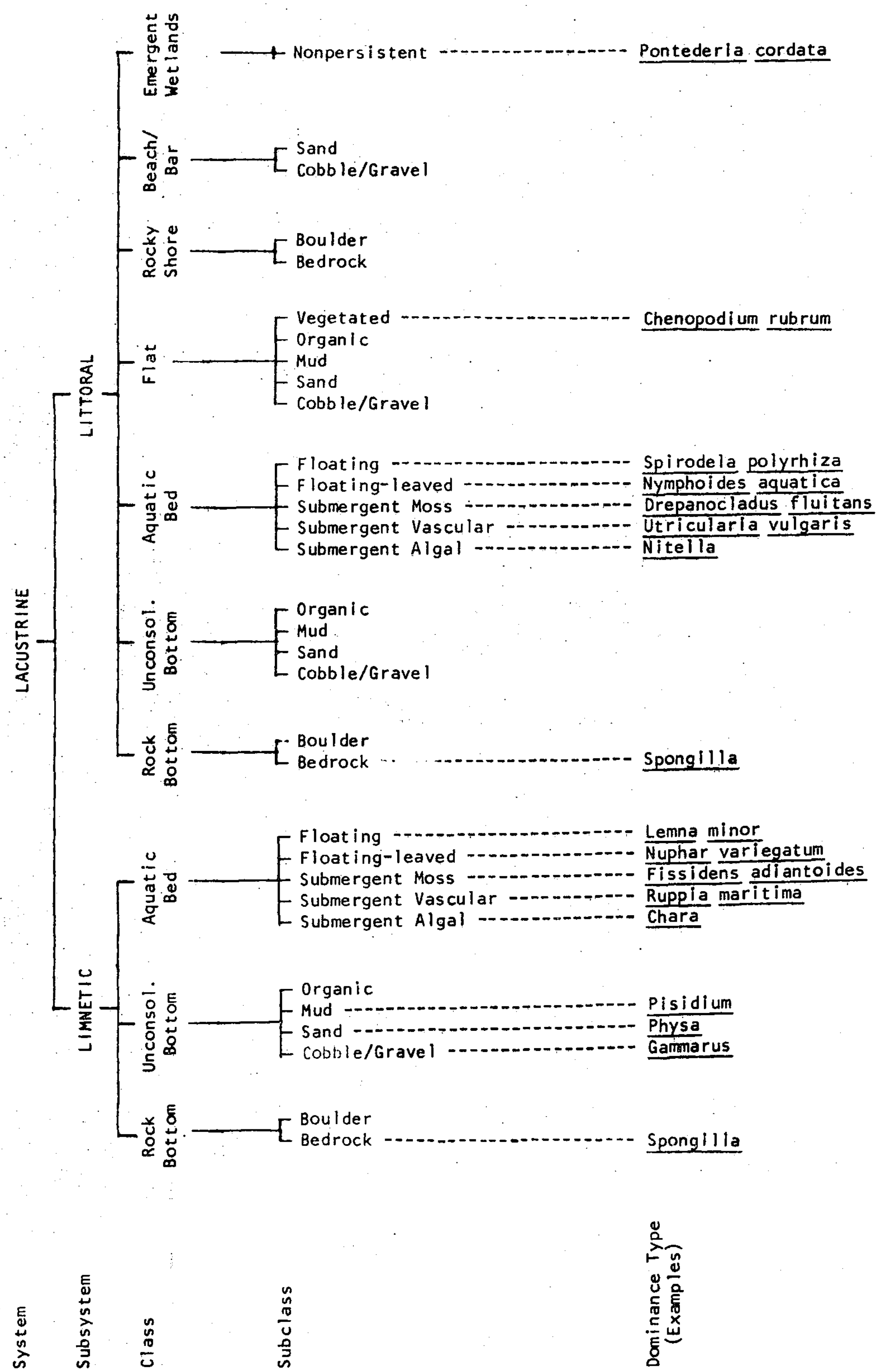


Figure 6. DIAGRAM OF THE CLASSIFICATION HIERARCHY OF THE LACUSTRINE SYSTEM.

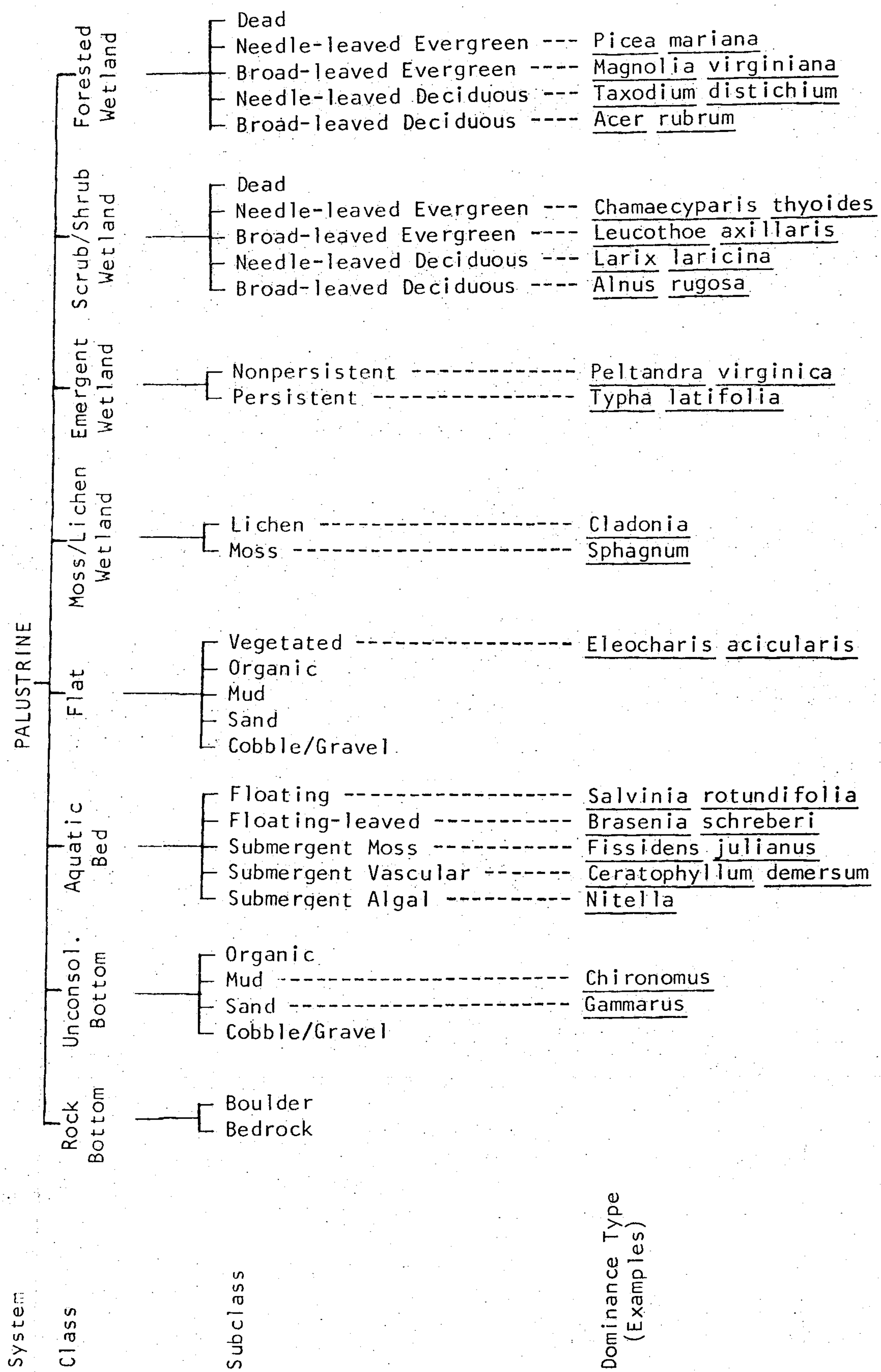


Figure 7. DIAGRAM OF THE CLASSIFICATION HIERARCHY OF THE PALUSTRINE SYSTEM.

## 1. MARINE

Definition.--The Marine System (Figure 3) consists of the open ocean overlying the continental shelf and its associated high-energy coastline. Marine habitats are exposed to the waves and currents of the open ocean and the water regimes are determined primarily by the ebb and flow of oceanic tides. Salinites exceed 30°/oo (parts per thousand), with little or no dilution except opposite mouths of estuaries. Shallow coastal indentations or bays without appreciable fresh-water inflow, and coasts with exposed rocky islands that provide the mainland with little or no shelter from wind and waves, are also considered part of the Marine System because they generally support typical marine biota.

Limits.--The Marine System extends from the outer edge of the continental shelf to: 1) the landward limit of tidal inundation (extreme high water of spring tides: EHWS) including the splash zone from breaking waves; 2) the seaward limit of wetland emergents, trees or shrubs where they extend into open ocean waters; or 3) the seaward limit of the Estuarine System where this limit is determined by factors other than vegetation. Deep-water habitats lying beyond the seaward limit of the Marine System are outside of the scope of this classification system.

Description.--The distribution of plants and animals in the Marine System primarily reflects differences in: 1) degree of exposure of the site to waves; 2) the texture and physico-chemical nature of the substrate; 3) the amplitude of the tides; and 4) latitude, which governs water temperature, the intensity and duration of solar radiation, and the presence or absence of ice.

Subsystems

(1) Subtidal. This includes that part of the Marine System in which the substrate is continuously submerged.

(2) Intertidal. This includes that part of the Marine System in which the substrate is exposed and flooded by tides. It also includes the associated splash zone.

Classes.--Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Reef, Flat, Rocky Shore and Beach/Bar.

2. ESTUARINE

Definition.--The Estuarine System (Figure 4) consists of deep-water tidal habitats and adjacent tidal wetlands which are usually semi-enclosed by land, but have open, partially obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by fresh water runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Along some low energy coastlines there is appreciable dilution of sea water. Those offshore areas with typical estuarine plants and animals, such as mangroves (*Rhizophora mangle*) and oysters (*Crassostrea virginica*), are also included in the Estuarine System even though they are not semi-enclosed by land.[1]

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[1] The Coastal Zone Management Act of 1972 defines an estuary as, "that part of a river or stream or other body of water having unimpaired connection with the open sea, where the sea water is measurably diluted with fresh water derived from land drainage." The Act further states that, "the term includes estuary-type areas of the Great Lakes." However, in this system we will not classify areas of the Great Lakes as estuarine.

Limits.--Estuaries extend upstream and landward to the place where ocean-derived salts measure less than 0.5°/₀₀ during the period of average annual low flow. The seaward limit of the Estuarine System is: 1) a line closing the mouth of a river, bay or sound; 2) a line enclosing an offshore area of diluted sea-water with typical estuarine flora and fauna; or 3) the seaward limit of wetland emergents, shrubs or trees where these plants grow seaward of the line closing the mouth of a river, bay, or sound.

Description.--The Estuarine System includes both estuaries and lagoons. It is more strongly influenced by its association with land than the Marine System. In terms of wave action, estuaries are generally considered to be low energy systems.

Estuarine water regimes and water chemistry are affected by one or more of the following forces: oceanic tides, precipitation, freshwater runoff from land areas, evaporation and wind. Estuarine salinities range from hyperhaline to oligohaline (Table 1). The salinity may be variable (poikilohaline), as in the case of hyperhaline lagoons (e.g., Laguna Madre, Texas) and most brackish estuaries (e.g., Chesapeake Bay, Virginia-Maryland); or it may be relatively stable (homoiohaline), as in the case of sheltered euhaline embayments (e.g., Chincoteague Bay, Maryland) or brackish embayments with partially obstructed access or small tidal range (e.g., Pamlico Sound, North Carolina). (For an extended discussion of estuaries and lagoons see Lauff [1967]).

Subsystems

(1) Subtidal. This includes that part of the Estuarine System in which the substrate is continuously submerged.

(2) Intertidal. This includes that part of the Estuarine System in which the substrate is exposed and flooded by tides. It also includes the associated splash zone.

Classes.--Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Reef, Flat, Streambed, Rocky Shore, Beach/Bar, Emergent Wetland, Scrub/Shrub Wetland and Forested Wetland.

3. RIVERINE

Definition.--The Riverine System (Figure 5) includes all wetlands and deep-water habitats contained within a channel, except: 1) wetlands dominated by trees, shrubs, persistent emergents, nonaquatic mosses or lichens, and 2) habitats with waters containing ocean-derived salts in excess of 0.5°/oo. A channel is, "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iseri 1960:5).

Limits.--The Riverine System is bounded on the landward side by upland, by the channel bank (including natural or man-made levees), or by wetland dominated by trees, shrubs, persistent emergents, nonaquatic mosses or lichens. In braided streams, the system is bounded by the banks forming the outer limits of the depression within which the braiding occurs.

The Riverine System terminates at the downstream end where the concentration of ocean-derived salts in the water exceeds 0.5°/₀₀ during the period of annual average low flow, or where the channel enters a lake. It terminates at the upstream end where tributary streams originate, whether their flow is perennial or intermittent, or where the channel leaves a lake. Springs discharging into a channel are considered part of the Riverine System.

Description.--Water is usually, but not always, flowing (lotic) in the Riverine System. Upland islands or Palustrine wetlands may occur in the channel but they are not included in the Riverine System. Palustrine Forested Wetlands, Emergent Wetlands, Scrub/Shrub Wetlands, and Moss/Lichen Wetlands may occur adjacent to the Riverine System, often on a flood plain. Many biologists have suggested that all the wetlands occurring on the river flood plain should be a part of the Riverine System because they consider their presence to be the result of river flooding. However, we concur with Reid and Wood (1976:72,84) who state, "The floodplain is a flat expanse of land bordering an old river. . . . Often the floodplain takes the form of a very level plain occupied by the present stream channel, and it may never, or only occasionally, be flooded. . . . It is this subsurface water [the ground water] that controls to a great extent the level of lake surfaces, the flow of streams, and the extent of swamps and marshes."

Subsystems.--The Riverine System is divided into four subsystems: the Tidal, the Lower Perennial, the Upper Perennial, and the

Intermittent. Each is defined in terms of water permanence, gradient, water velocity, streambed composition and the extend of flood plain development. The subsystems have characteristic water temperatures, flora, and fauna (see Reid 1961, Illies and Botosaneau 1963, Hynes 1970). All four subsystems are not necessarily present in all rivers, and the order of occurrence may be other than that given below.

(1) Tidal. In this subsystem, the gradient is low and water velocity fluctuates under tidal influence. The streambed is mainly mud with occasional patches of sand. Oxygen deficits may occur at times and the fauna is similar to that in the Lower Perennial Subsystem. The flood plain is typically well-developed and water temperatures approximate those of the Lower Perennial Subsystem.

(2) Lower Perennial. This includes those channels that contain nontidal flowing water throughout the year. The flow is slow and the substrate consists mainly of sand and mud. Oxygen deficits may occur at times, the fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is low compared to that of the Upper Perennial Subsystem and the flood plain is well-developed. Generally, the average of mean monthly water temperatures is more than 20°C, and in tropical latitudes, the average of the monthly means during the summer may reach 25°C (Illies and Botosaneau 1963).

(3) Upper Perennial. This includes channels that contain flowing water throughout the year. The flow is fast and the substrate consists of rock, cobbles, or gravel with occasional patches of sand.

The natural dissolved oxygen concentration is normally near saturation; the fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared to the Lower Perrenial Subsystem, and there is very little flood plain development. Generally, the average of mean monthly water temperatures is about 20 C (Illes and Botosaneau 1963).

(4) Intermittent. This includes those channels that contain flowing water only part of the time. During those periods when the water is not flowing, it may remain in isolated pools or surface water may be absent.

Classes.--Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Flat, Streambed, Rocky Shore, Beach/Bar, and Emergent Wetland (nonpersistent).

4. LACUSTRINE

Definition.--The Lacustrine System (Figure 6) includes wetlands and deep-water habitats with all of the following characteristics: 1) situated in a topographic depression or a dammed river channel; 2) lacking trees, shrubs, persistent emergents, nonaquatic mosses or lichens with greater than 30 percent areal coverage; and 3) greater than 8 hectares (20 acres) in size. Similar wetlands and deep-water habitats smaller than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature forms all or part of the boundary, or if the water depth in the deepest part of the basin is greater than 2 m at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5°/oo.

Limits.--The Lacustrine System is bounded by upland or by wetland dominated by trees, shrubs, persistent emergents, nonaquatic mosses or lichens. Lacustrine systems formed by damming a river channel are bounded by the contour approximating the normal spillway elevation or normal pool elevation except where Palustrine wetlands extend lakeward of that boundary. Where a river enters a lake, the extension of the lacustrine shoreline forms the Riverine/Lacustrine boundary.

Description.--The Lacustrine System includes permanently flooded lakes and reservoirs (e.g., Lake Superior), intermittent lakes (e.g., playa lakes) and tidal lakes with ocean-derived salinities below 0.5°/oo (e.g., Lake Maurapas, Louisiana). Typically, this system contains extensive areas of deep water and exhibits considerable wave action. Islands of Palustrine wetland may lie within the boundaries of the Lacustrine System.

Subsystems

(1) Limnetic. This subsystem includes all deep-water habitats within the Lacustrine System. Many small Lacustrine Systems have no Limnetic Subsystem.

(2) Littoral. This subsystem includes all wetland habitats that fall within the Lacustrine System. It extends from the

shoreward boundary of the system to a depth of 2 m below low water or to the maximum extent of nonpersistent emergents if these grow beyond the 2 m depth.

Classes.--Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Flat, Rocky Shore, Beach/Bar, and Emergent Wetland (nonpersistent).

5. PALUSTRINE

Definition.--The Palustrine System (Figure 7) includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, nonaquatic mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below $0.5^{\circ}/_{\circ\circ}$. It also includes wetlands lacking such vegetation, but with all the following characteristics: 1) size less than 8 hectares; 2) absence of an active wave-formed or bedrock shoreline feature; 3) water depth in the deepest part of basin less than 2 m at low water; and 4) salinity due to ocean-derived salts less than $0.5^{\circ}/_{\circ\circ}$.

Limits.--The Palustrine System is bounded by upland or by any of the other four systems.

Description.--The Palustrine System was developed to group the extensive vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie which are found throughout the country. It also includes small, shallow permanent or intermittent water bodies, often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels or estuaries; on river flood plains; in isolated catchments; or on slopes. They may also occur as islands in lakes or rivers. The erosive forces of wind and water are of minor importance except in times of severe flood.

The emergent vegetation adjacent to rivers and lakes is often referred to as "the shore zone" or the "zone of emergent vegetation" (Reid and Wood 1976), and is generally considered a separate community from that of the river itself. As an example, Hynes (1970:85) says in reference to riverine habitats, "We will not here consider the long list of emergent plants which may occur along the banks out of the current, as they do not belong, strictly speaking, to the running water habitat." There are often great similarities between wetlands lying adjacent to lakes or rivers and isolated wetlands of the same class in basins without open water.

Subsystems.--No subsystems are recognized for the Palustrine System.

Classes.--Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Flat, Moss/Lichen Wetland, Emergent Wetland, Scrub/Shrub Wetland and Forested Wetland.

## Classes, Subclasses and Dominance Types

The CLASS is the highest taxonomic unit below the subsystem level. It describes the general appearance of the habitat in terms of either plant life form or physiography and composition of the substrate, features which can be recognized without the aid of detailed environmental measurements.[1]

Use of life forms at the class level has two major advantages: 1) it does not require a high level of biological expertise to distinguish between various life forms, and 2) it has been established that various life forms are easily recognizable on a great variety of remote sensing products (e.g., Radforth 1962, Anderson et al. 1976). If plants cover more than 30 percent of the substrate, we distinguish classes on the basis of the life form of the plants which constitute the uppermost layer of vegetation and possess an areal coverage greater than 30 percent. For example, an area with 50 percent areal coverage of trees over a shrub layer with a 60 percent areal coverage would be classified as a Forested Wetland; an area with 20 percent areal coverage of trees over the same (60 percent) shrub layer would be classified a Scrub/Shrub Wetland. Finer differences in life forms are recognized at the SUBCLASS level. For example, Forested Wetland is divided into Broad-leaved Deciduous, Needle-leaved Deciduous, Broad-leaved Evergreen, Needle-leaved

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[1] Our attempts to use familiar terms such as marsh, swamp, bog, and meadow at the class level were unsuccessful primarily because of wide discrepancies in the use of these terms in various regions of the United States. In an effort to resolve that difficulty, we decided to base the classes upon the fundamental components (life form, water regime, substrate type, water chemistry) which give rise to such terms. We believe that this approach will greatly reduce the misunderstandings and confusion that result from the use of the common terms.

Evergreen, and Dead Subclasses. Subclasses are named on the basis of the predominant life form.

If plants cover less than 30 percent of the substrate, the physiography and composition of the substrate are the principal characteristics used to distinguish classes. The nature of the substrate reflects regional and local variations in geology and the influence of wind, waves, and currents upon erosion and deposition of substrate materials. Rocky Shores have been recognized as a separate class, also based on substrate, even though these habitats may support more than 30 percent cover of macrophytic algae. Similarly, we decided to characterize beaches and flats on the basis of substrate, although, in some cases, macrophytic algae or "pioneer" vegetation may cover more than 30 percent of the substrate. Reefs are a unique class in which the substrate itself is composed primarily of living and dead animals.

Most classes based on substrate have been divided into subclasses according to the texture or composition of the substrate; for example, four subclasses of unconsolidated bottoms are recognized: Cobble/Gravel, Sand, Mud and Organic. In the special case of coral reefs, subclasses are designated on the basis of the type of organism that has formed the reef.

The DOMINANCE TYPE forms the taxonomic category subordinate to subclass. Dominance types are determined on the basis of dominant plant species (e.g., Jeglum et al. 1974), dominant sedentary or sessile animal species (e.g., Thorson 1957) or dominant plant and animal species (e.g., Stephenson and Stephenson 1972). A dominant plant species has traditionally meant one that has control over the community (Weaver and

Clements 1938:91), and this plant is also usually the predominant species (Cain and Castro 1959:29). When the subclass is based on life form we name the dominance type for the dominant species or combination of species (codominants) in the same layer of vegetation used to determine the subclass.[1] For example, a Needle-leaved Evergreen Forested Wetland with 70 percent areal coverage of Picea mariana and 30 percent areal coverage of Larix laricina would be designated as a Picea mariana Dominance Type. When the relative abundance of codominant species is approximately equal, the Dominance Type consists of a combination of species names. For example, an Emergent Wetland with approximately equal areal coverage of broad-leaved cattail (Typha latifolia) and hardstem bulrush (Scirpus acutus) would be designated as Typha latifolia/Scirpus acutus Dominance Type.

When the subclass is based on substrate material, the Dominance Type is named for the predominant plant or sedentary or sessile macroinvertebrate species without regard for life form. In the Marine and Estuarine Systems, sponges, alcyonarians, molluscs, crustaceans, worms, ascidians and echinoderms may all be part of the community represented by the Macoma Dominance Type. Sometimes it is necessary to designate two or more codominant species as a Dominance Type. Thorson (1957) has recommended guidelines and suggested definitions for establishing community types and dominants on level bottoms.

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[1]Percent areal cover will seldom be measured in the application of this system, but the term must be related to a frame of reference. We suggest $2m^2$ for herbaceous and moss layers, $16m^2$ for shrub layers and $100m^2$ for tree layers (Meuller-Dombois and Ellenberg 1974:74). When percent areal cover is the key for establishing boundaries between units of the classification, it may be necessary to make cover measurements occasionally on plots in order to maintain uniformity of ocular estimates made in the field, or interpretations made from aerial photographs.

## 1. ROCK BOTTOM

Definition.--In the Marine and Estuarine Systems the class Rock Bottom includes all deep-water (subtidal) habitats with rock substrates. In the Lacustrine, Palustrine and Riverine Systems, Rock Bottom includes all wetlands and deep-water habitats with rock substrates and permanently flooded, intermittently exposed, and semipermanently flooded water regimes. This class does not include those habitats classified as Aquatic Beds.

Description.--The solid rock substrate of the rocky benthic or bottom zone is one of the most important factors in determining the abundance, variety and distribution of organisms. The stability of the bottom allows a rich assemblage of plants and animals to develop. Rock bottoms are usually high energy habitats with well-aerated waters. Temperature, salinity, current and light penetration are also important factors in determining the composition of the benthic community. Animals that live on the rocky surface are generally firmly attached by hooking or sucking devices although they may move about over the substrate in search of food. Some may be permanently attached by cement. A few animals hide in rocky crevices and under rocks, some move rapidly enough to avoid being swept away, and others burrow into finer substrates between boulders. Plants are also firmly attached (e.g., by holdfasts) and, in the Riverine System, they are commonly streamlined or flattened in response to high water velocities.

Subclasses and Dominance Types.--Rock Bottom has been divided into two subclasses, Bedrock and Boulder. The Dominance Types for both subclasses are similar.

(1) Bedrock. These bottoms consist of stable bedrock surfaces. Grooves and crevices, when present, provide shelter and microhabitats.

(2) Boulder. These bottoms consist predominantly of relatively stable, rock fragments larger than 256 mm (10 in) in diameter (Wentworth 1922). Often, finer material is mixed with these boulders.

Examples of Dominance Types for the Marine and Estuarine Systems are *Hippospongia* encrusting sponges and *Cnemidocarpa*, *Strongylocentrotus*, *Pisaster*, *Muricea*, and *Laminaria*. Examples of Lacustrine and Riverine Dominance Types are *Spongilla*, *Lymnaea*, *Caenis*, Chironomidae, and *Hydrosyche*.

2. UNCONSOLIDATED BOTTOM

Definition.--In the Marine and Estuarine Systems, Unconsolidated Bottom includes all deep-water (subtidal) habitats with unconsolidated substrates. In Lacustrine, Palustrine and Riverine Systems, the class includes all unconsolidated substrates with permanently flooded, intermittently exposed and semipermanently flooded water regimes. This class does not include habitats classified as Aquatic Beds.

Description.--Unconsolidated Bottoms are characterized by the lack of large stable surfaces for plant and animal attachment. They are usually found in lower energy areas than Rock Bottoms, and may be very unstable. Exposure to wave and current action, temperature, salinity and light penetration determine the composition and distribution of organisms.

Most macroalgae attach to the substrate by means of basal holdfast cells or discs; however, in sand and mud, algae penetrate the substrate and higher plants can successfully root if wave action and currents are not too strong. The majority of animals in unconsolidated sediments live within the substrate, e.g., Macoma and Mellita. Some, such as Chaetopterus, maintain permanent burrows, and others may live on the surface, especially in coarse-grained sediments.

In the Marine and Estuarine Systems, Unconsolidated Bottom communities are relatively stable. They vary from the Arctic to the tropics, depending largely on temperature, and from the open ocean to the upper end of the estuary depending upon salinity. Thorson (1957) has summarized and described characteristic types of level bottom communities in detail.

In the Riverine System, the substrate type is, to a great extent, determined by current velocity, and plants and animals exhibit a high degree of morphologic and behavioral adaptation to flowing water. Some species are confined to specific substrates and others are at least more abundant in one type of substrate than they are in others. According to Hynes (1970:208), "The larger the stones, and hence the more complex the substratum, the more diverse is the invertebrate fauna." In Lacustrine and Palustrine Systems, there is usually a high correlation, within a given water body, between the nature of the substrate and the number of species and individuals. For example, in the profundal bottom of eutrophic lakes where light is absent, oxygen content is low and carbon dioxide concentration is high, the sediments are ooze-like organic materials and species diversity is low. Each substrate type typically supports a relatively distinct community of organisms (Reid 1961:307).

Subclasses and Dominance Types.--The class Unconsolidated Bottom has been divided into four subclasses: Cobble/Gravel, Sand, Mud, and Organic. Differences in grain size and interstitial space in unconsolidated substrates greatly affect the species composition of the benthic flora and fauna.

(1) Cobble/Gravel. The substrate is predominantly cobble and gravel although finer sediments may be intermixed. An example of a Dominance Type for the Marine System is *Modiolus* and for the Estuarine System, *Dendraster*. Examples for the Lacustrine, Palustrine and Riverine Systems are *Diamesa*, *Nemoura*/*Eukiefferiella* (Slack et al. 1977). *Chironomus*/*Hydrosyche*/*Physa* (Krecker and Lancaster 1933), *Limnea*, *Baetis*, *Spongilla*, *Lumbriculus*, and *Gammarus*.

(2) Sand. The substrate is predominantly sand, although finer or coarser sediments may be intermixed. The Sand Bottom has a more limited fauna and flora than either Mud or Cobble/Gravel Bottom. Examples of Dominance Types in the Marine System are *Pecten*, *Tellina*, *Penaeus*, and *Spatangus* and for the Estuarine System, *Tellina*, *Arenicola*, *Dendraster*, and *Renilla*. Examples for the Lacustrine, Palustrine and Riverine Systems are *Physa*, *Gammarus*, Chironomidae, *Limnodrilus*, and *Ephemera*.

(3) Mud. The substrate is predominantly silt and clay although coarser sediments or organic material may be intermixed. Organisms living in mud must often be able to adapt to rather low oxygen concentrations. Examples of Dominance Types for the Marine and Estuarine Systems include Amphiura, Macoma, Echinocardium, and Urechis. Examples of Dominance Types for the Lacustrine, Palustrine and Riverine Systems are Tubifex, Anodonta, Pisiduim, Chaoborus, and Chironomus.

(4) Organic. The substrate is predominantly composed of organic material. These habitats have a limited number of species and are very low in faunal productivity (Welch 1952).

3. AQUATIC BED

Definition.--The class Aquatic Bed represents wetlands and deepwater habitats that the majority of the time are dominated by submergent plants, floating-leaved plants or floating plants for the majority of the growing season in most years. Water regimes are restricted to subtidal, irregularly exposed, permanently flooded, intermittently exposed, and semipermanently flooded.

Description.--Aquatic Beds represent a diverse group of plant communities that require surface water for optimum growth and reproduction. They are best developed in relatively permanent water.

Subclasses and Dominance Types

(1) Submergent Algal. These habitats occur in both tidal and nontidal locations, but they are far more diverse and widespread in the Marine and Estuarine Systems. In these coastal areas, algal beds

occupy rock substrates and unconsolidated substeates characterized by a wide range of sediment depths and textures. They may extend to water depths of 30 m (98 ft). Coastal algal beds are most luxuriant along the rocky shores of the northeast and the west. Macrocystis beds are especially well-developed on the Pacific Coast. Along both coasts, Fucus and Laminaria may dominate dense Submergent Algal Beds. In tropical regions, this subclass is characterized by green algae, including forms containing calcareous particles; Halimeda and Penicillus are common examples. Caulerpa and Laurencia also may form large Submergent Algal Beds. Other plants, such as Enteromorpha and Ulva, are tolerant of fresh water and flourish in some estuaries.

Inland Submergent Algal Beds are represented by plants such as the Chara and Nitella which look much like vascular plants and may grow in similar situations. However, Chara meadows may be found in Lacustrine waters as deep as 40 m (131 ft) (Zhadin and Gerd 1963), where hydrostatic pressure limits the survival of vascular submergents (Welch 1952).

(2) Submergent Vascular. In the Marine and Estuarine Systems this subclass has been referred to by others as temperate grass flats (Phillips 1974); tropical marine meadows (Odum 1974); eelgrass beds, turtlegrass beds and seagrass beds (Akins and Jefferson 1973, Eleuterius 1973, Phillips 1974). Submergent Vascular Beds extend to depths greater than 10 m (33 ft) in clear marine waters. The greatest numbers of plant species occur in shallow, clear, tropical or subtropical waters of moderate current strength in the Caribbean and along the Florida and Gulf Coasts. Principal Dominance Types in these areas include Thalassia testudinum, Halodule beaudettei, Syringodium filiformis, Ruppia maritima,

Halophila and Vallisneria americana.

Five major species dominate the Submergent Vascular Beds along the temperate coasts of North America: Halodule beaudettei, Phyllospadix scouleri, P. torreyi, Ruppia maritima and Zostera marina. Zostera beds have the most extensive distribution, but they are limited primarily to the more sheltered estuarine environment. In the lower salinity zones of estuaries, stands of Ruppia, Potamogeton and Vallisneria often occur, along with Najas and Myriophyllum.

Submergent Vascular Beds in the Riverine, Lacustrine and Palustrine Systems occur at all depths within the photic zone. Typical inland genera include Potamogeton, Ceratophyllum, Myriophyllum, Najas, Ruppia, Utricularia and Vallisneria.

(3) Submergent Moss. These Aquatic Beds are far less abundant than Algal or Vascular Beds. They occur primarily in the Riverine System and in permanently flooded and intermittently exposed parts of some Lacustrine Systems. The most important Dominance Types include genera such as Fissidens, Drepanocladus and Fontinalis. The latter may grow to depths as great as 120 m (392 ft) (Hutchinson 1975). For simplicity, aquatic liverworts of the genus Marsupella are included in this subclass.

(4) Floating-leaved. These Aquatic Beds are characterized by floating-leaved plants. They are found in all systems except the Marine. These beds typically occur in sheltered areas where there is little water movement (Wetzel 1975). Typical dominants include Nymphaea, Nuphar, Potamogeton natans and Brasenia schreberi. Plants such as

Nuphar advena and Polygonum amphibium, which may stand erect above the water surface or substrate, may be considered emergents or floating-leaved plants, depending upon the life form adopted at a particular site.

(5) Floating. This subclass is characterized by genera which float freely on the water surface, such as: Lemna, Spirodela, Pistia, Eichhornia, Trapa, Salvinia and Azolla. These plants are found primarily in protected portions of slow-flowing rivers and in the Lacustrine and Palustrine Systems. Floating Beds are dynamic habitats; they are easily moved about by wind or water currents. They cover a large area of water in some parts of the country, particularly the southeast.

4. REEF

Definition.--The class Reef includes ridge- or mound-like structures formed by the colonization and growth of sedentary invertebrates.

Description.--Reefs are characterized by their elevation above the surrounding substrate and their interference with normal wave flow; they are primarily subtidal, but parts of some Reefs may be intertidal as well. Although corals, oysters and tubeworms are the most visible organisms and are mainly responsible for Reef formation, other molluscs, foraminifera, corralline algae and other forms of life also contribute substantially to Reef growth. Frequently, Reefs contain an abundance of dead skeletal material and shell fragments, in comparison to the amount of living matter.

Subclasses and Dominance Types

(1) Coral. Coral Reefs are widely distributed in shallow waters of warm seas. They are found in Hawaii, Puerto Rico, the Virgin Islands, and southern Florida. They are characterized by Odum (1971) as stable, well-adapted, highly diverse and highly productive ecosystems with a great degree of internal symbiosis. Coral Reefs lie almost entirely within the Marine Subtidal Subsystem, although the upper part of some reefs is sometimes exposed. Examples of Dominance Types are *Porites*, *Acropora* and *Montipora*; the distribution of these types primarily reflects elevation, wave exposure, and the age of the Reef.

(2) Mollusc. This subclass occurs in both the Estuarine Intertidal and Subtidal Subsystems. These Reefs are found on the Pacific, Atlantic, and Gulf Coasts and in Hawaii and the Carribbean. Mollusc Reefs may become extensive, affording a substrate for sedentary and boring organisms and a shelter for many others. Reef molluscs are adapted to great variations in water level, salinity and temperature, and these same factors control their distribution. Examples of Dominance Types for this subclass are the oysters (*Ostrea*, *Crassostrea*).

(3) Worm. Worm Reefs are constructed by large colonies of sabellariid worms living in individual tubes constructed from cemented sand grains. Although they do not support as diverse a biota as do Coral and Mollusc Reefs, they provide a distinct habitat which may cover large areas. Worm Reefs are generally confined to tropical waters, and are most common along the coasts of Florida, Puerto Rico, and the Virgin Islands. They occur in both the Marine and Estuarine Systems

where the salinity approximates that of sea water. The Dominance Type for this subclass is Sabellaria.

5. FLATS

Definition.--The class Flat refers to level landforms composed of unconsolidated sediments. Normally, Flats occur only in areas sheltered from strong currents and wave action. They may be irregularly shaped or elongate and continuous with the shore, whereas Bars generally are elongate, parallel to the shoreline, and separated from the shore by water. Water regimes are restricted to irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded and intermittently flooded.

Description.--Estuarine and Marine Flats occur in the intertidal zone. The distribution of fauna is dependent on substrate texture, current and wave action, and salinity; temperature and salinity may be extremely variable. Regularly flooded Flats support diverse populations of tube-dwelling and burrowing invertebrates including worms, clams and crustaceans (Gray 1974). These invertebrates are mostly detritus feeders. Irregularly flooded Flats have been called salt flats, pans or pannes. They are typically high in salinity and are usually surrounded by, or lie on the landward side of, Emergent Wetland (Martin et al. 1953, Type 15). Flats are also commonly colonized by algae and diatoms and there may be an algal crust or mat.

The distribution of organisms in Riverine and Lacustrine Flats is dependent upon substrate material, current and wave action, and the frequency of inundation. Lacustrine Flats may include the entire basin of a lake. Palustrine Flats are generally the result of high salinity, removal of vegetation by man, animals, or fire, or the discharge of thermal waters or pollutants. In many arid areas, Palustrine and Lacustrine Flats are crusted or saturated with salt. Martin et al. (1953) called these habitats inland saline flats (Type 9); they are also called alkali flats, salt flats, and salt pans. Faunal diversity and abundance caries with salinity, duration of inundation and temperature.

Subclasses and Dominance Types

(1) Cobble/Gravel. The Flats are composed predominantly of cobbles or gravel, often with shell fragments or finer sediments intermixed. Unlike Rocky Shores, Cobble/Gravel Flats are not stable and communities are more transitory. Examples of Dominance Types in the Marine and Estuarine Systems are: *Balanus*, *Patella*, *Littorina*, *Thais*, and *Mytilus*.

(2) Sand. Sand Flats are composed predominantly of sand, often with particles of other sizes intermixed. Although population density may be very high, species diversity is usually comparatively low. In the Marine and Estuarine Systems, some examples of Dominance Types are *Mya*, *Macoma*, *Tellina*, *Arenicola*, *Uca*, *Leptosynapta*, and *Paractis*.

(3) Mud. Mud Flats are composed predominantly of silt and clay, and tend to be anaerobic below the surface. They usually have a higher organic content than Cobble/Gravel and Sand Flats. In the Marine and Estuarine Systems some examples of Dominance Types are: *Uca*, *Callianassa*, *Nassarius*, *Macoma*, *Nereis*, *Amphitrite*, *Cerianthiopsis* and *Thyone*.

(4) Organic. These Flats consist of exposed organic soils of formerly vegetated wetlands. In the Estuarine System, Organic Flats are often dominated by microinvertebrates such as foraminifera or smaller snails (*Cerithium*).

(5) Vegetated Flats. Some Flats are exposed for a sufficient period to be colonized by herbaceous annuals or seedling herbaceous perennials (pioneer plants). When these plants cover more than 30 percent of the substrate, the area is classified as a Vegetated Flat. This vegetation is usually killed by rising water levels and may be removed before the beginning of the next growing season. Examples of Dominance Types are *Xanthium italicum*, *Chenopodium rubrum*, *Echinochloa crusgalli*, and *Eleocharis acicularis*.

6. STREAMBED

Definition.--The class Streambed is restricted to the Riverine and Estuarine Systems. It includes all parts of channels that are not included in any of the other classes. Streambed may have the classes Beach/Bar and Flat included within it, but in the Intermittent Subsystem of the Riverine System the entire channel frequently contains only the class Streambed.

Description.--Streambeds vary greatly in substrate and form depending on the gradient of the channel and the velocity of the water. In the Riverine System, material on the bed is continually being moved downstream; in Estuarine streambeds, material may be moved upstream or downstream according to the direction of tidal flow. Frequently Bars occur on the convex side of single channels or they may be included as islands within the bed of braided streams (Crickmay 1974). Flats and Beaches are particularly common adjacent to Streambed, particularly in the Lower Perennial and Tidal Subsystems of larger rivers and in estuarine streams where wave action is especially strong. In estuarine areas, Streambed is the proper class for the entire channel of tidal creeks that are dewatered at low tide. In most cases, Streambeds are not vegetated because of the scouring effect of the moving water, but, like Flats, they may be colonized by "pioneering" annuals during periods of low flow or they may have perennial emergents and shrubs that are too scattered to classify as Emergent Wetland or Scrub/Shrub Wetland.

Subclasses and Dominance Types

(1) Cobble/Gravel. This subclass is characteristic of Upper Perennial and Intermittent Subsystems of the Riverine System. When water flows over this material, the surface is frequently broken in areas called riffles. Cobble/Gravel Streambeds are particularly common in streams with braided channels. Examples of Dominance Types in Intermittent Cobble/Gravel Streambeds are *Limnodrilus*, *Caenis*, *Chironomus*, *Anopheles* (Stehr and Branson 1938). An example for the Upper Perennial is *Agrenia/Hypogastrura* (Slack et al. 1977).

(2) Sand. This subclass is also characteristic of the Upper Perennial and Intermittent Subsystems of the Riverine System. Frequently, Sand Streambeds are interspersed with Cobble/Gravel Streambeds. Examples of Dominance Types in Intermittent Sand Streambeds are *Gammarus*, *Physa*, *Chironomus* (Stehr and Branson 1938).

(3) Mud. This subclass is characteristic of the Lower Perennial and Tidal Subsystems of the Riverine. Mud Streambeds are frequently associated with large Mud Flats.

(4) Organic. This is not a common subclass in the Riverine System but it occurs along the edge of streams flowing over deep peat deposits, usually in the Lower Perennial Subsystem. Organic Streambeds are common in creeks draining Estuarine Emergent Wetlands with organic soils.

## 7. ROCKY SHORE

Definition.--The class Rocky Shore includes wetland environments characterized by stable bedrock surfaces or relatively stable, large rock fragments. Water regimes are restricted to irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded and intermittently flooded.

Description.--In Marine and Estuarine Systems, Rocky Shores are generally high energy habitats which lie exposed as a result of continuous erosion by wind-driven waves or strong currents. The substrate is stable enough to permit the attachment and growth of sessile or sedentary invertebrates and attached algae or lichens. Rocky Shores usually display a vertical zonation which is a function of tidal range, wave action and degree of exposure to the sun. In the Lacustrine and Riverine Systems, Rocky Shores support sparse plant and animal communities.

Subclasses and Dominance Types.--The class Rocky Shore is divided into two subclasses, Bedrock and Boulder. The Dominance Types are similar for both subclasses.

(1) Bedrock. These wetlands consist of stable bedrock surfaces.

(2) Boulder. These wetlands consist of relatively stable rock fragments larger than 256 mm in diameter.

Communities or zones of Marine and Estuarine Rocky Shores have been studied in detail (Lewis 1964, Ricketts and Calvin 1968, Stephenson and Stephenson 1972). Each zone supports a rich assemblage of invertebrates and algae. Dominance Types of the Rocky Shore often can be characterized by one or two dominant genera from these zones.

The uppermost zone (termed the Littorine/Lichen Zone) is dominated by periwinkles (*Littorina* and *Nerita*) and lichens. This zone frequently takes on a dark, or even black appearance, although abundant lichens may lend a colorful tone. These organisms are rarely submerged, but are kept moist by sea spray. Frequently, this habitat is invaded from the landward side by semi-marine genera such as *Lygia*.

The next lower zone (the Balanoid Zone) is commonly dominated by molluscs, green algae and barnacles of the balanoid group. From a distance, the zone appears white. Dominance Types such as *Balanus*, *Chthamalus* and *Tetraclita* may form an almost pure sheet of barnacles, or these animals may be interspersed with molluscs, tubeworms and algae such as *Pelvetia*.

The transition between the littorine/lichen and balanoid zones is frequently marked by the replacement of the periwinkles with both true and false limpets such as *Acmaea* and *Siphonaria*. The limpet band approximates the upper limit of the regularly flooded intertidal zone.

In the middle and lower intertidal areas, which are flooded and exposed by tides at least once daily, lie a number of other communities which can be characterized by dominant genera. Mussels (*Mytilus*) and gooseneck barnacles (*Mitella*) form communities exposed to strong wave action. The *Fucus* and *Laminaria* Dominance Types lie slightly lower, just above the coralline algae (*Lithothamnion*) Dominance Type. The *Laminaria* Dominance Type approximates the lower end of the Intertidal Subsystem; it is generally exposed at least once daily. The *Lithothamnion* Dominance Type forms the transition to the Subtidal Subsystem and is exposed only irregularly.

We have not identified Dominance Types for the Lacustrine and Riverine Systems.

## 8. BEACH/BAR

*Definition*.--The class Beach/Bar consists of sloping landforms generated by waves and currents and composed predominantly of unconsolidated sand, gravel or cobbles. They have less than 30 percent vegetative cover. Beaches are generally continuous with the shore, extending landward to a distinct break in landform or substrate type (e.g., a foredune, cliff or bank) or to the point where vegetation covers 30 percent or more of the substrate. Bars are elongate ridges, banks or mounds which are bordered by water on at least two sides. Water regimes are restricted to irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded and intermittently flooded.

*Description*.--Beaches and Bars are characterized by a shifting, unstable substrate with high permeability, variable surface moisture, and relatively low organic matter content. The surface layer has a high oxygen content and there is a deeper anaerobic layer (Hedgpeth 1957, Ranwell 1972). They may be sparsely vegetated and populated by a diversity of specialized burrowing invertebrates such as molluscs, crustaceans and polychaetes. Faunal distribution is controlled by waves, currents, interstitial moisture, salinity and sediment grain size. In Marine and Estuarine Beaches and Bars the fauna is usually more diverse than in Lacustrine or Riverine Beaches and Bars (Hedgpeth 1957, Riedl and McMahan 1974).

Subclasses and Dominance Types

(1) Cobble/Gravel. Cobble/Gravel Beaches and Bars typically form where wave action is especially strong so that sand and silt particles are largely eroded and transported from the Beach or Bar and deposited in deeper waters. While cobbles and gravel predominate, sand is usually mixed with these larger particles. Some of the larger cobbles and occasional boulders found on these Beaches may support sedentary organisms such as *Balanus*.

(2) Sand. Sand Beaches and Bars are composed predominantly of calcareous or terrigenous sand. Examples of Dominance Types in the Marine and Estuarine Systems are *Donax*, *Mya*, *Tivela*, *Oliva*, *Thoracophelia*, *Haustorius*, *Orchestia*, *Chiredotea*, *Emerita*, *Ocypode* (Hedgpeth 1957, Riedl and McMahan 1974). Examples of Dominance Types in the Riverine, Lacustrine, and Palustrine Systems are *Parastenocaris*, *Phyllognathus*, and *Pristina* (Neel 1948).

## 9. MOSS/LICHEN WETLAND

Definition.--The Moss/Lichen Wetland class includes areas where mosses or lichens cover the substrate and where other plants such as emergents, shrubs or trees comprise less than 30 percent of the areal cover.

Description.--Mosses and lichens are important components of the flora in many wetlands, especially in the north, but these plants usually form a ground cover under a dominant layer of trees, shrubs or emergents. In some instances higher plants are uncommon and mosses or lichens dominate the flora. Such Moss/Lichen wetlands are not common, even in the northern United States where they occur most frequently.

Subclasses and Dominance Types

(1) Moss. These wetlands are most abundant in the far north. Areas covered with *Sphagnum* spp. are usually called bogs (Golet and Larson 1974, Jeglum et al. 1974, Zoltai et al. 1975), whether *Sphagnum* or higher plants are dominant. In Alaska, mosses such as *Drepanocladus* and the liverwort *Chiloscyphus fragilis* may dominate shallow pools with impermanent water; *Sphagnum*, *Campylium stellatum*, *Desmatodon heimii*, *Aulacomnium palustre* and *Oncophorus wahlenbergii* are typical of wet soil in this region (Britton 1957, Drury 1962).

(2) Lichen. These wetlands are also a northern subclass. *Cladonia* forms the most important Dominance Type. Pollett and Bridgewater (1973) described areas with mosses and lichens as bogs or fens, the distinction being based on the availability of nutrients and the

particular plant species present. Sjörs (1959) and Jeglum et al. (1974) mentioned the presence of Lichen Wetlands in the Hudson Bay Lowlands and in Ontario, respectively.

## 10. EMERGENT WETLAND

Definition.--The Emergent Wetland class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

Description.--In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central United States, violent climatic fluctuations cause Emergent Wetlands to revert to an open water phase in some years (Stewart and Kantrud 1972). They are found throughout the United States and occur in all systems except the Marine. Emergent Wetlands are known by many names including marsh, meadow, fen, prairie pot hole, and slough. Areas that are dominated by pioneer plants that become established during periods of low water are not Emergent Wetlands and should be classified as Vegetated Flats.

### Subclasses and Dominance Types

(1) Persistent. Wetlands in this subclass are dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the Estuarine and Palustrine Systems.

Persistent Emergent Wetlands dominated by *Spartina alterniflora*, *S. patens*, *S. cynosuroides*, *Juncus roemerianus*, *Typha angustifolia*, and *Zizaniopsis miliacea* are major components of the Estuarine Systems of the Atlantic and Gulf Coasts of the United States. On the Pacific Coast, *Salicornia pacifica*, *Suaeda californica*, *Triglochin maritima* and *Spartina foliosa* are common dominants.

Palustrine Persistent Emergent Wetlands contain a vast array of grass-like plants such as *Typha* spp., *Scirpus* spp., *Cladium jamaicens* *Carex* spp., and true grasses such as *Phragmites communis*, *Glyceria* spp., *Beckmania syzigachne* and *Scolochloa festucacea*. There is also a variety of broad-leaved persistent emergents such as *Lythrum salicaria*, *Rumex mexicanus*, *Decodon verticillatus*, and many species of *Polygonum*.

(2) *Nonpersistent*. Wetlands in this subclass are dominated by plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious trace of emergent vegetation. For example, *Zizania aquatica* in the north central states does not become apparent until mid-summer and fall when it forms dense emergent stands. Nonpersistent emergents also include species such as *Peltandra virginica*, *Pontederia cordata* and *Sagittaria* spp. Movement of ice in Riverine and Lacustrine Systems often removes all traces of emergent vegetation during the winter. Where this occurs, the area should be classified as Nonpersistent Emergent Wetland.

## 11. SCRUB/SHRUB WETLAND

Definition.--The class Scrub/Shrub Wetland includes areas dominated by woody vegetation less than 6 mm (20 ft) in height. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

Description.--Scrub/Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities. They occur only in the Estuarine and Palustrine Systems, but are one of the most widespread classes in the country (Shaw and Fredine 1956). Scrub/Shrub Wetlands are known by many names such as shrub swamp (Shaw and Fredine 1956), shrub carr (Curtis 1959), bog (Heinselman 1970), and pocosin (Kologiski 1977). For practical reasons we have also included forests composed of young trees less than 6 m tall in this class.

### Subclasses and Dominance Types

(1) Broad-leaved Deciduous. These are wetlands where deciduous trees or shrubs less than 6 m high represent more than 50 percent of the total areal cover. In the Estuarine System they are dominated by such plants as *Baccharis halmifolia*, and *Iva frutescens*. *Alnus* spp., *Salix* spp., *Cephalanthus occidentalis*, *Zenobia pulverulenta*, *Betula pumila* and young trees such as *Acer rubrum* are typical Dominance Types in the Palustrine System.

(2) Needle-leaved Deciduous. This subclass is found only in the Palustrine System where it is represented by young or stunted trees

such as *Larix laricina* or *Taxodium distichium*.

(3) Broad-leaved Evergreen. These wetlands are found in both the Estuarine and Palustrine Systems. In the Estuarine System, vast acreages are dominated by mangroves (*Rhizophora mangle*, *Languncularia racemose*, *Conocarpus erecta*, *Avicennia germinans*) that are less than 6 m in height. In the Palustrine System, the broad-leaved evergreen species are typically found on organic soils. In the north, typical representatives are *Ledum groenlandicum*, *Andromeda glaucophylla*, *Kalmia polifolia*, and the semi-evergreen *Chamaedaphne calyculata*. In the south, *Lyonia lucida* and *Leucothoe axillaris* are characteristic broad-leaved evergreen species.

(4) Needle-leaved Evergreen. These wetlands are found only in the Palustrine System. The dominant species are young or stunted trees such as *Picea mariana* or *Pinus serotina*.

(5) Dead. These wetlands are dominated by dead woody vegetation less than 6 m in height. They are usually produced by a prolonged rise in the water table, which often results from the activities of man or beavers, but they may result from other natural causes such as fire, salt spray which often accompanies severe coastal storms, and insect infestations; and from air pollution or man's use of herbicides.

## 12. FORESTED WETLAND

Definition.--The class Forested Wetland is characterized by woody vegetation that is 6 m or more in height.

Description.--Forested Wetlands are most common in the eastern United States and in those sections of the west where moisture is relatively abundant, particularly along rivers and in the mountains. They occur only in the Palustrine and Estuarine Systems. Palustrine Forested Wetlands normally possess an overstory of trees, an understory of young trees or shrubs and an herbaceous layer. Forested Wetlands in the Estuarine System are restricted to the mangrove forests of Florida, Puerto Rico and the Virgin Islands.

Subclasses and Dominance Types

(1) Broad-leaved Deciduous. These wetlands are found throughout the country, but reach their greatest abundance in the south and east. Dominant trees typical of this subclass include: *Acer rubrum*, *Ulmus americana*, *Fraxinus pennsylvanica*, *F. nigra*, *Nyssa sylvatica*, *N. aquatica*, *Quercus bicolor*, *Q. lyrata*, and *Q. michauxii*. Wetlands in this subclass generally occur on mineral soils or highly decomposed organic soils.

(2) Needle-leaved Deciduous. These wetlands are represented by a limited group of species. *Larix laricina* is characteristic of the Boreal Forest Region where it occurs as a dominant on organic soils. The southern representatives of this subclass include *Taxodium distichum* and *T. ascendens* which are noted for their ability to tolerate long periods of surface inundation.

(3) Broad-leaved Evergreen. These wetlands reach their greatest development in the southeast where *Persea borbonia*, *Gordonia lasianthus* and *Magnolia virginiana* are prevalent, especially on organic soils. This subclass also includes *Rhizophora mangle*, *Avicennia nitida* and *Laguncularia racemosa* which are adapted to varying levels of salinity.

(4) Needle-leaved Evergreen. These wetlands are widespread in the north where *Picea mariana*, growing on organic soils, represents a major dominant. Whereas *P. mariana* is common on nutrient-poor soils, *Thuja occidentalis* dominates northern wetlands on more nutrient-rich sites. Along the Atlantic Coast, *Chamaecyparis thyoides* is one of the most common dominants on organic soils. *Pinus serotina* is a common needle-leaved evergreen found in the southeast in association with dense stands of broad-leaved evergreen and deciduous shrubs.

(5) Dead. These wetlands are dominated by dead woody vegetation greater than 6 m in height. Like Dead Scrub/Shrub Wetlands, they are most common in, or around the edges of, man-made impoundments and in beaver ponds. The same factors that produce Dead Scrub/Shrub Wetlands also produce Dead Forested Wetlands.

## MODIFIERS

In order to fully describe wetlands and deep-water habitats, certain modifiers must be applied at the class level and at lower levels in the classification hierarchy. The modifiers described below were adapted from existing classifications or were developed specifically for this system. Modifiers for water regime, water chemistry, soil, and special modifiers for disturbed wetlands are defined in this section.

### Water Regime Modifiers

Precise description of hydrologic parameters requires detailed knowledge of the duration and timing of surface inundation on both a yearly and long-term basis, as well as an understanding of ground-water fluctuations. Because such information is seldom available, the water regimes that, in part, determine characteristic wetland and deep-water plant and animal communities are described here in only general terms. Water regimes are defined under two major headings, Tidal and Nontidal. These terms are not intended as modifiers.

Tidal water regime modifiers should be used for wetlands and deep-water habitats in the Estuarine and Marine Systems and nontidal modifiers should be used for all nontidal parts of the Palustrine, Lacustrine and Riverine Systems. The Tidal Subsystem of the Riverine System and tidally-influenced parts of the Palustrine and Lacustrine Ecological Systems require careful selection of water regime modifiers. Subtidal and irregularly exposed wetlands and deep-water habitats in the Palustrine, Riverine, and Lacustrine Systems should be called permanently flooded-tidal rather than subtidal. Palustrine, Riverine, and Lacustrine wetlands regularly flooded by the tide should be designated regularly flooded. Palustrine, Riverine and Lacustrine wetlands which are only irregularly flooded by tides should be designated by the appropriate nontidal water regime modifier with the word tidal added, as in seasonally flooded-tidal.

1. TIDAL

The water regimes are largely determined by oceanic tides.

Subtidal.--The substrate is permanently flooded with tidal water.

Irregularly Exposed.--The land surface is exposed by tides less often than daily.

Regularly Flooded.--Tidal water alternately floods and exposes the land surface at least once daily.

Irregularly Flooded.--Tidal water floods the land surface less often than daily.

The periodicity and amplitude of tides vary in different parts of the United States, mainly because of differences in latitude and geomorphology. On the Atlantic Coast, two approximately equal high tides are the rule (semidiurnal). On the Gulf Coast, there is frequently only one high tide and one low tide each day (diurnal). The usual pattern on the Pacific Coast is two unequal high tides and two unequal low tides (mixed semidiurnal).

Individual tides range in height from approximately 9.5 m (31 ft) at St. John, New Brunswick (U. S. National Oceanic and Atmospheric Administration 1973) to less than 1 m (3.3 ft) along the Louisiana coast (Chabreck 1972). Tides of only 10 cm (25 in) are not uncommon in Louisiana. Therefore, while there can be no hard and fast rules, the division between regularly flooded and irregularly flooded water regimes would probably occur approximately at: mean high water on the Atlantic Coast, lowest higher high tide on the Pacific Coast, and just above mean tide level of the Gulf Coast. The width of the intertidal zone is determined by the tidal range, the slope of the shoreline, and the degree of exposure of the site to wind and wave.

2. NONTIDAL

These water regimes are not influenced by oceanic tides, although they may be affected by wind or seiches in lakes. Water regimes are defined in terms of the growing season which we equate to the frost-free period (see the U. S. Department of Interior National Atlas 1970:11 for generalized regional delineation). The remainder of the year is defined as the dormant season, a time when even extended periods of flooding may have little influence on the development of plant communities.

Permanently Flooded.--Water covers the land surface at all times of the year in all years. Vegetation is composed of obligate hydrophytes.

Intermittently Exposed.--Surface water is present throughout the year except in years of extreme drought.

Semipermanently Flooded.--Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at, or very near, the land surface except during severe drought.

Seasonally Flooded.--Surface water is present for extended periods early in the growing season, but is absent by the end of the season in most years. When surface water is absent, the water table is usually near the land surface.

Saturated.--The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present.

Temporarily Flooded.--Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.

Intermittently Flooded.--The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this regime may change as soil moisture conditions change. Some areas exhibiting this regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes.

Artificially Flooded.--The amount and duration of flooding is under the direct and purposeful control of man; it does not depend just on normal variation in precipitation or riverflow. The vegetation growing in these areas cannot be considered a reliable predictor of water regimes. Agricultural lands managed under a rice-soybean rotation and wildlife management areas where crops or forests may be flooded or dewatered to attract wildlife are typical of this regime.

## Water Chemistry Modifiers

The accurate characterization of water chemistry in wetlands and deep-water habitats is a very difficult task, both because of problems in measurement and because values tend to vary with changes in the season, weather, time of day and other factors. Yet, very subtle changes in water chemistry, which occur over short distances, may have a dramatic influence on the types of plants or animals that inhabit an area. We feel that a description of water chemistry must be an essential part of this classification system.

The two key parameters employed in this system are salinity and hydrogen ion concentration (pH). All habitats are classified according to salinity, and fresh-water habitats are further subdivided by pH levels.

1. SALINITY MODIFIERS

Differences in salinity are reflected in the species composition of plants and animals. Many authors have suggested using biological changes as the basis for subdividing the salinity range between sea water and fresh water (Remane and Schlieper 1971). Others have suggested a similar subdivision for the inland salinity spectrum (Moyle 1946, Bayly 1967, Stewart and Kantrud 1971). Since the gradation between fresh and hypersaline or hyperhaline waters is continuous, any boundary will be artificial, and few classification systems agree completely. In inland environments, salinity is usually expressed in specific conductance, milligrams per liter (mg/l), milliequivalents per liter (meq/l), percent salt or total dissolved solids.

Estuarine and marine waters are a complex solution of salts; these are dominated by sodium chloride (NaCl). The term haline is used to indicate the dominance of ocean salt. The relative proportions of the various major ions are usually similar to those found in sea water, even if the water is diluted below sea strength. Dilution of sea water with fresh water and concentration of sea water by evaporation result in a wide range of recorded salinities in both surface water and interstitial (soil) water.

We have modified the Venice System, suggested at a "Symposium on the Classification of Brackish Waters" in 1958, for use in the Marine and

Estuarine Systems (Table 1). The system has been widely used during recent years (Macan 1961, 1963, Burbank 1967, Carriker 1967, Reid and Wood 1976), although there has been some criticism of its applicability (den Hartog 1960, Price and Gunter 1964).

The salinity of inland waters is dominated by four major cations: calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K), and the major anions: carbonate ($CO_3$), sulfate ($SO_4$) and chloride (Cl) (Wetzel 1975). Salinity is governed by the interactions between precipitation, surface runoff, ground-water flow, evaporation, and, in some cases, evapotranspiration by plants. The ionic ratios of inland waters usually differ appreciably from those found in the sea, although there are some exceptions (Bayly 1967). The great chemical diversity of these waters, the wide variation in physical conditions such as temperature, and the relative impermanence of surface water in many cases, make it extremely difficult to subdivide the inland salinity range in a meaningful way. Bayly (1967) has attempted a subdivision on the basis of animal life; Stewart and Kantrud (1971) and Moyle (1945) have suggested two very different divisions on the basis of plant life. We have decided to employ a subdivision which is identical to that used in the Estuarine and Marine Systems (Table 1).

The term saline is used to indicate that any of a number of ions may be dominant or co-dominant. The term brackish has been applied to inland waters of intermediate salinity (Remane and Schlieper 1971, Stewart and Kantrud 1971), but is not universally accepted (see Bayly 1967:84); therefore, mixosaline will be used here. In some inland wetlands high soil salinities control the invasion or establishment of many

Table 1. Salinity Modifiers Used in This Classification System.

| Coastal Modifiers[1] | Inland Modifiers[2] | Salinity (°/oo) | Approximate Specific Conductance (μMhos at 25°C) |
|---|---|---|---|
| Hyperhaline | Hypersaline | >40 | >60,000 |
| Euhaline | Eusaline | 30 -40 | 45,000-60,000 |
| Mixohaline (Brackish) | Mixosaline[3] | 0.5-30 | 800-45,000 |
| Polyhaline | Polysaline | 18 -30 | 30,000-45,000 |
| Mesohaline | Mesosaline | 5 -18 | 8,000-30,000 |
| Oligohaline | Oligosaline | 0.5-5 | 800- 8,000 |
| Fresh | Fresh | < 0.5 | < 800 |

[1]Coastal modifiers are employed in the Marine and Estuarine Systems.

[2]Inland modifiers are employed in the Riverine, Lacustrine and Palustrine Systems.

[3]The term Brackish should not be used for inland wetlands or deep-water habitats.

plants. These salinities are expressed in units of specific conductance as well as percent salt (Ungar 1974), and they are also covered by the salinity classes in Table 1.

2. pH MODIFIERS

Acid waters are, almost by definition, poor in calcium and often generally low in other ions, but some very soft waters may have a neutral pH (Hynes 1970). It is difficult to separate the effects of high concentrations of hydrogen ions from low base content, and many studies suggest that acidity may never be the major factor controlling the presence or absence of particular plants and animals. Nevertheless, some researchers have demonstrated a good correlation between pH levels and plant distribution (Sjörs 1950, Jeglum 1971). Jeglum (1971) showed that plants can be used to predict the hydrogen ion concentration of moist peat.

There seems to be little doubt that, where a peat layer isolates plant roots from the underlying mineral substrate, the availability of minerals in the root zone strongly influences the types of plants that occupy the site. For this reason, many authors subdivide freshwater, organic wetlands into mineral-rich and mineral-poor categories (Sjörs 1950, Heinselman 1970, Jeglum 1971, Moore and Bellamy 1974). We have instituted pH modifiers for freshwater wetlands (Table 2) because pH has been widely used to indicate the difference between mineral-rich and mineral-poor sites, and because it is relatively easy to determine. The ranges presented here are similar to those of Jeglum (1971), except that the upper limit of the circumneutral level (Jeglum's mesotrophic) was raised to bring it into line with usage of the term in the United States. The ranges given apply to the pH of water. They were converted from Jeglum's moist-peat equivalents by adding 0.5 pH units.

Table 2

pH Modifiers Used in This Classification System

| Modifier | pH of Water |
|---|---|
| Acid | <5.5 |
| Circumneutral | 5.5-7.4 |
| Alkaline | >7.4 |

## Soil Modifiers

Soil is one of the most important physical components of wetlands. Through its depth, mineral composition, organic matter content, moisture regime, temperature regime and chemistry, it exercises a strong influence over the types of plants that live on its surface and the kinds of organisms that dwell within it. In addition, the nature of soil in a wetland, particularly the thickness of organic soil, is of critical importance to engineers planning construction of highways or buildings. For these and other reasons, it is essential that soil be considered in the classification of wetlands.

According to the U. S. Soil Conservation Service (U. S. Soil Conservation Service, Soil Survey Staff 1975:1-2), soil is limited to terrestrial situations and shallow waters; however, "areas are not considered to have soil if the surface is permanently covered by water deep enough [so] that only floating plants are present. . . ." Since emergent plants do not grow beyond a depth of approximately 2 m in inland waters, the waterward limit of soil is virtually equivalent to the waterward limit of wetland, according to our definition. In marine and estuarine areas, subtidal lands do not have soil. Wetlands can then be regarded as having soil in most cases, while deep-water habitats are never considered to have soil.

The most basic distinction in soil classification in the United States is between mineral soil and organic soil (U. S. Soil Conservation Service, Soil Survey Staff 1975). The Soil Conservation Service recognizes nine orders of mineral soils and one order of organic soils (Histosols) in their taxonomy. Their classification is hierarchical and permits the description of soils at several levels of detail. For example, suborders of Histosols are recognized according to the degree of decomposition of the organic matter.

We have chosen the modifiers mineral and organic for use in this classification. Mineral soils and organic soils are differentiated on the basis of very specific criteria which are enumerated in the Soil Taxonomy (U. S. Soil Conservation Service, Soil Survey Staff 1975:13-14, 65). These criteria have been restated in Appendix C of this classification for ready reference. If more detail is desired, the U. S. Soil Conservation Service classification system should be used.

## Special Modifiers

Many wetlands and deep-water habitats are man-made, and natural ones have been modified to some degree by the activities of man or beavers. Since the nature of these modifications often greatly influences the character of such habitats, special modifying terms have been included here to emphasize their importance. The following modifiers should be used singly or in combination wherever they apply to wetlands and deep-water habitats.

1. EXCAVATED

Lies within a basin or channel excavated by man.

2. IMPOUNDED

Created or modified by a barrier or dam designed to obstruct the outflow of water. Both man-made and beaver dams are included.

3. DIKED

Created or modified by a man-made barrier or dike designed to obstruct the inflow of water.

4. PARTIALLY DRAINED

Water level has been artificially lowered, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes. Included under this heading also are lands where low water levels are maintained by continuous pumping; although such areas may not support hydrophytes presently, they could if pumping ceased. Permanently drained areas are not considered wetland.

5. FARMED

The soil surface has been mechanically or physically altered for production of crops, but wetland plants will become reestablished if farming is discontinued.

6. ARTIFICIAL

Refers to substrates classified as Bottom, Rocky Shore, Flat or Beach/Bar that were emplaced by man using either natural materials such as dredge spoil or synthetic materials such as discarded automobiles, tires or concrete. Jetties and breakwaters are examples of Artificial Rocky Shores. Man-made reefs are an example of Artificial Rock Bottoms.

## IV. REGIONALIZATION

In this classification system, a given taxon has no particular regional alliance; its representatives may be found in one or many parts of the United States. However, regional variations in climate, geology, soils and vegetation are important in the development of different wetland habitats; and, often, different regions have bery different management problems. For these reasons, we felt the need to recognize regional differences. Regionalization is designed to facilitate: 1) planning at the national level, where it is necessary to study management problems and potential solutions on a regional basis; 2) organization and retrieval of data gathered in a resource inventory; and 3) interpretation of inventory data, including differences in indicator plants and animals among the regions.

We have recommended the classification and map of Bailey (1976) to fill the need for regionalization inland. Bailey's classification of ecoregions is hierarchical. The upper four levels are: domain, defined as including subcontinental areas of related climates; division, defined as including regional climate at the level of Köppen's (1931) types; province, defined as including broad vegetational types; and section, defined as including climax vegetation at the level of Küchler's (1964) types. On the map, the boundaries between the different levels are designated by various lines of various widths and the sections are numbered with a four-digit code; digits 1 through 4 represent the first four levels in the hierarchy. The reader is referred to Bailey's map for a discussion and description of the units appearing on the map.

The Bailey system terminates at the ocean, whereas this wetland classification includes marine and estuarine habitats. Many workers have divided marine and estuarine realms into series of biogeographic provinces (e.g., U. S. Senate 1970, Ketchum 1972). These provinces differ somewhat in detail, but the broader concepts are similar. We have developed the following marine and estuarine provinces for North America:

## ARCTIC PROVINCE

Arctic Province extends from the southern tip of Newfoundland (Avalon Peninsula), northward around Canada to the west coasts of the Arctic Ocean, Bering Sea, and Baffin and Laborador Basins. It is characterized by the southern extension of floating ice, the 4°C summer isotherm, and arctic biota.

## ACADIAN PROVINCE

Acadian Province extends along the northeast Atlantic coast from the Avalon Peninsula to Cape Cod and is characterized by a well-developed algal flora and boreal biota. The shoreline is very indented and frequently rocky. It has a large tidal range and is strongly influenced by the Laborador Current.

## VIRGINIAN PROVINCE

Virginian Province extends along the middle Atlantic coast from Cape Cod to Cape Hatteras. The province is transitional between Acadian and Carolinian. The biota is primarily temperate with some boreal representatives. The Laborador Current occasionally extends down to Cape

Hatteras and winter temperatures may approach 4°C. The tidal range is moderate.

## CAROLINIAN PROVINCE

Carolinian Province is situated along the south Atlantic coast from Cape Hatteras to Cape Kennedy. It contains extensive marshes and well-developed barrier islands. Waters are turbid and productive. The biota is temperate with seasonal tropical elements. The Gulf Stream is the primary influence and winter temperatures reach a minimum of 10°C; summer temperatures are tropical (in excess of 20°C). The tidal range is small to moderate.

## WEST INDIAN PROVINCE

West Indian Province extends from Cape Kennedy to Cedar Key, Florida and also includes the southern Gulf of Mexico, the Yucatan Peninsula, Central America and the Carribbean Islands. The shoreland is usually low lying limestone with calcareous sands and marls except for volcanic islands. The biota is tropical and includes reef corals and mangroves. Minimum winter temperatures are about 20°C and the tidal range is small.

## LOUISIANIAN PROVINCE

Louisianian Province extends along the northern coast of the Gulf of Mexico from Cedar Key to Port Aransas, Texas. The characteristics of the province are similar to those of the Carolinian, reflecting the past submergence of the Florida Peninsula. The biota is primarily temperate and the tidal range is small.

## CALIFORNIAN PROVINCE

Californian Province extends along the Pacific coast from Mexico northward to Cape Mendocino. The shoreland is strongly influenced by coastal mountains and the coasts are rocky with limited freshwater runoff. In the southern part volcanic sands are present; marshes and swamps are scarce throughout the province. The climate is Mediterranean and influenced by the California Current. The biota is temperate, and includes well-developed offshore kelp beds. The tidal range is moderate.

## COLUMBIAN PROVINCE

Columbian Province extends along the northern Pacific coast from Cape Mendocino to Vancouver Island. Mountainous shoreland with rocky foreshores are prevalent. Estuaries are strongly influenced by freshwater runoff. The biota is primarily temperate with some boreal components, and there are extensive algal communities. The province is influenced by both the Aleutian and California Currents. The tidal range is moderate to large.

## FJORD PROVINCE

Fjord Province extends along the Pacific coast from Vancouver Island to the southern tip of the Aleutian Islands. Precipitous mountains, deep estuaries (some with glaciers), and a heavily indented shoreline subject to winter icing are typical of the coast. The biota is boreal to subarctic. The province is influenced by the Aleutian and Japanese Currents, and the tidal range is large.

## PACIFIC INSULAR PROVINCE

Pacific Insular Province surrounds all of the Hawaiian Islands. The coasts have precipitous mountains and wave action is stronger than in most of the other provinces. The biota is largely endemic and composed of tropical and subtropical forms. The tidal range is small.

Use of Bailey's sections for the riverine, lacustrine and palustrine systems and the provinces defined above for the marine and estuarine systems provide a regional locator for any wetland in the United States.

## V. USE OF THE CLASSIFICATION SYSTEM

This system was designed for use over an extremely wide geographic area and for use by individuals and organizations with varied interests and objectives. The classification employs 5 system names, 8 subsystem names, 12 class names, 24 subclass names and an unspecified number of dominance types. It is, of necessity, a complex system when viewed in its entirety, but use of the system for a specific purpose at a local site should be simple and straightforward. The purpose of this section is to illustrate how the system should be used and some of the potential pitfalls that could lead to its misuse.

Before attempting to apply the system, the user should consider certain important points:

1) Information about the area to be classified must be available before the system can be applied. This information may be in the form of historical data, aerial photographs, brief on-site inspection or detailed and intensive studies. The system is designed for use at varying degrees of detail. There will be few areas where sufficient information is available to allow the most detailed application of the system. If the level of detail provided by the classification is not sufficient for the needs of the user, additional data gathering is mandatory.
2) Below the level of class, the system is open-ended and incomplete. We give only examples of the vast number of Dominance Types that occur. The user may identify additional

dominance types and determine where these fit into the classification hierarchy. It is also probable that as the system is used the need for additional subclasses may become apparent.

3) One of the main purposes of the new classification is to assure uniformity throughout the United States. It is important that the user pay particular attention to the definitions in the classification. Any attempt at modification of these definitions will lead to lack of uniformity in application.

4) One of the principal uses of the classification system will be the inventory and mapping of wetlands and deep-water habitats. A classification used in mapping is scale-specific, both for the minimum size of units mapped and for the degree of detail attainable. It is necessary for the user to develop a specific set of mapping conventions for each application and to demonstrate their relationship to the generalized classification described here. For example, there are a number of possible mapping conventions for a small wetland basin 50 m (164 ft) in diameter with concentric rings of vegetation about the deepest zone. At a scale of 1:500 each zone may be classified and mapped; at 1:200,000 it might be necessary to map the entire basin as one zone and ignore the peripheral bands; at 1:100,000 the entire wetland basin may be smaller than the smallest mappable unit. In the latter case, maps will seldom be adequate for a detailed

inventory and must be supplemented by detailed information gathered by sampling. In other cases, it may be necessary to develop mapping conventions for taxa that cannot be easily recognized; for instance, submergent aquatic beds in turbid waters may have to be mapped simply as water.

## HIERARCHICAL LEVELS AND MODIFIERS

We have designed the various levels of the system for specific purposes and the relative importance of each will vary among users. The systems and subsystems are most important in applications involving large regions or the entire country. They serve to organize the classes into meaningful assemblages of information for data storage and retrieval.

The classes and subclasses are the most important part of the system for many users and are basic to wetland mapping. Most classes should be easily recognizable by users in a wide variety of disciplines. However, the class designations apply to average conditions over a period of years, and since many wetlands are dynamic and subject to rapid changes in appearance, it will frequently be necessary to have data that span a period of years and several seasons in each of those years in order to place a wetland in its proper class.

The dominance type is most important to users interested in detailed regional studies. It may be necessary to identify dominance types in order to determine which modifying terms are appropriate because plants and animals present in an area tend to reflect environmental conditions over a period of time. Water regime can be determined from long term hydrologic studies where these are available. The more common procedure will be to estimate this parameter from the dominance types. Several studies have related water regimes to the presence and distribution of plants or animals (e.g., Chapman 1960, Stephenson and Stephenson 1972, Stewart and Kantrud 1972).

Similarly, we do not intend that salinity measurements be made for all wetlands except where these data are required; in many cases, plant species or associations can be used to indicate broad salinity classes. Lists of halophytes have been prepared for both coastal and inland areas (e.g., Duncan 1974, MacDonald and Barbour 1974, Ungar 1974), and a number of floristic and ecological studies have described plants that are indicators of salinity (e.g., Penfound and Hathaway 1938, Moyle 1945, Kurz and Wagner 1957, Dillon 1966, Anderson 1968, Chabreck 1972, Stewart and Kantrud 1972, Ungar 1974).

In some areas the dominance types to be expected under different water regimes and types of water chemistry conditions have not been identified, and detailed regional studies will be required before the classification can be applied in detail. In areas where detailed soil maps are available, it is also possible to infer water regime and water chemistry from soil series (U. S. Soil Conservation Service, Soil Survey Staff 1975).

Some of the modifiers are an integral part of this system and their use is essential; others are used only for detailed applications or for special cases. Modifiers are never used with systems and subsystems; however, at least one water regime modifier, one water chemistry modifier, and one soil modifier must be used at all lower levels in the hierarchy. Use of the modifiers listed under mixosaline and mixohaline (Table 1) is optional but these finer categories should be used where data are available. The user is cautioned not to rely on single observations of water regime or water chemistry. Such measurements will give misleading results in all but the most stable wetlands. The soil modifiers, mineral or organic, must also be used. If a more detailed modifier, such as soil order or suborder (U. S. Soil Conservation Service, Soil Survey Staff 1975) can be obtained, it should be used in place of the modifiers, mineral and organic. Special modifiers are used where appropriate.

## RELATIONSHIP TO OTHER WETLAND CLASSIFICATIONS

There are numerous wetland classifications in use in the United States. Here we relate this system to three published classifications that have gained widespread acceptance. It is not possible to equate these systems directly for several reasons: 1) The criteria selected for establishing categories differ, 2) some of the classifications are not applied consistently in different parts of the country, and 3) the elements classified are not the same in various classifications.

The most widely used classification system in the United States is that of Martin et al. (1953) which was republished in "Circular 39" (Shaw and Fredine 1956). The wetland types are based on criteria such as water depth and permanence, water chemistry, life form of vegetation and dominant plant species. Table 3 compares some of the major components of our system with the type descriptions listed in Circular 39.

In response to the need for more detailed wetland classification in the glaciated northeast, Golet and Larson (1974) refined the fresh water wetland types of Circular 39 by writing more detailed descriptions

Table 3. Comparison of Wetland Types Described in Circular 39 with Some of the Major Components of this Classification System.

| Circular 39 Type | References for Examples Typical Vegetation | Classification of Wetlands and Deep-Water Habitats | | |
|---|---|---|---|---|
| | | Classes | Water Regimes | Water Chemistry |
| Type 1 | Wet Meadow (Stewart & Kantrud 1972, Dix & Smeins 1967<br>Bottomland Hardwoods (Braun 1950)<br>Shallow-Freshwater Swamps (Penfound 1952) | Emergent Wetland<br>Forested Wetland | Temporarily Flooded<br>Intermittently Flooded | Fresh<br>Mixosaline |
| Type 2 | Fen (Heinselman 1963)<br>Fen, Northern Sedge Meadow (Curtis 1959) | Emergent Wetland | Saturated | Fresh<br>Mixosaline |
| Type 3 | Shallow Marsh (Golet & Larson 1974, Stewart & Kantrud 1972) | Emergent Wetland | Semipermanently Flooded<br>Seasonally Flooded | Fresh<br>Mixosaline |
| Type 4 | Deep Marsh (Golet & Larson 1974, Stewart & Kantrud 1972) | Emergent Wetland<br>Aquatic Bed | Permanently Flooded<br>Intermittently Flooded<br>Semipermanently Flooded | Fresh<br>Mixosaline |
| Type 5 | Open Water (Golet & Larson 1974)<br>Submerged Aquatic (Curtis 1959) | Aquatic Bed<br>Unconsolidated Bottom | Permanently Flooded<br>Intermittently Exposed | Fresh<br>Mixosaline |
| Type 6 | Shrub Swamp (Golet & Larson 1974)<br>Shrub-Carr, Alder Thicket (Curtis 1959) | Scrub/Shrub Wetland | All Nontidal Regimes Except Permanently Flooded | Fresh |
| Type 7 | Wooded Swamp (Golet & Larson 1974)<br>Swamps (Penfound 1952, Heinselman 1963) | Forested Wetland | All Nontidal Regimes Except Permanently Flooded | Fresh |

Table 3. (continued)

| Circular 39 Type | References for Examples Typical Vegetation | Classes | Water Regimes | Water Chemistry |
|---|---|---|---|---|
| Type 8 | Bog (Heinselman 1963, Dansereau & Segadasvianna 1952)<br>Pocosin (Kologiski 1977)<br>Peaty Fresh-Water Swamps (Penfound 1952) | Scrub/Shrub Wetland<br>Forested Wetland<br>Moss/Lichen Wetland | Saturated | Fresh (acid only) |
| Type 9 | Intermittent Alkali Zone (Stewart & Kantrud, 1972) | Flat | Seasonally Flooded<br>Intermittently Flooded<br>Temporarily Flooded | Eusaline<br>Hypersaline |
| Type 10 | Inland Salt Marshes (Ungar 1974) | Emergent Wetland | Seasonally Flooded<br>Semipermanently Flooded | Eusaline |
| Type 11 | Inland Saline Lake Community (Ungar 1974) | Aquatic Bed<br>Unconsolidated Bottom | Permanently Flooded<br>Intermittently Flooded | Eusaline |
| Type 12 | Marsh (Anderson 1968)<br>Estuarine Bay Marshes, Estuarine River Marshes (Stewart 1962)<br>Fresh & Intermediate Marshes (Chabreck 1972) | Emergent Wetland | Regularly Flooded<br>Irregularly Flooded<br>Semipermanently Flooded-Tidal | Mixohaline<br>Fresh |
| Type 13 | Marsh (Anderson 1968)<br>Estuarine Bay Marshes, Estuarine River Marshes (Stewart 1962)<br>Fresh & Intermediate Marshes (Chabreck 1972) | Emergent Wetland | Regularly Flooded<br>Semipermanently Flooded-Tidal | Mixohaline<br>Fresh |
| Type 14 | Estuarine Bays (Stewart & Kantrud, 1972) | Aquatic Bed<br>Unconsolidated Bottom | Subtidal<br>Permanently Flooded-Tidal | Mixohaline<br>Fresh |
| Type 15 | Panne, Marsh Slough (Redfield 1972)<br>Marsh Pans (Pestrong 1965) | Flat | Regularly Flooded<br>Irregularly Flooded | Hyperhaline<br>Euhaline |

Table 3. (continued)

| Circular 39 Type | References for Examples Typical Vegetation | Classes | Water Regimes | Water Chemistry |
|---|---|---|---|---|
| Type 16 | Salt Marsh (Chapman 1960, Redfield 1972) | Emergent Wetland | Irregularly Flooded | Euhaline<br>Mixohaline |
| Type 17 | Salt Marsh (Chapman 1960)<br>Saline, Brackish & Intermediate (Eleuterius 1972) | Emergent Wetland | Irregularly Flooded | Euhaline<br>Mixohaline |
| Type 18 | Salt Marsh (Chapman 1960) | Emergent Wetland | Regularly Flooded | Euhaline<br>Mixohaline |
| Type 19 | Kelp Beds, Temperate Grass Flats (Phillips 1974)<br>Tropical Marine Meadows (Odum 1974)<br>Eelgrass Beds (Akins & Jefferson 1973, Eleuterius 1973 | Unconsolidated Bottom<br>Aquatic Bed<br>Flat | Subtidal<br>Irregularly Exposed<br>Regularly Flooded<br>Irregularly Flooded | Euhaline<br>Mixohaline |
| Type 20 | Mangrove Swamps (Walsh 1974)<br>Mangrove Swamp Systems (Kuenzler 1974)<br>Mangroves (Chapman 1976) | Scrub/Shrub Wetland<br>Forested Wetland | Irregularly Exposed<br>Regularly Flooded<br>Irregularly Flooded | Hyperhaline<br>Euhaline<br>Mixohaline |

and subdividing classes on the basis of finer differences in plant life forms. Golet and Larson's classes are roughly equivalent to Types 1-8 of Circular 39, except that they restricted Type 1 to river floodplains. The Golet and Larson system does not recognize the coastal (tidal) fresh wetlands of Circular 39 (Types 12-14) as a separate category, but classifies these areas in the same manner as nontidal wetlands. In addition to devising 24 subclasses, they also created five size categories; six site types, giving a wetland's hydrologic and topographic location; eight cover types (modified from Stewart and Kantrud 1971) expressing the distribution and relative proportions of cover and water; three vegetative interspersion types; and six surrounding habitat types. Since this system is based on the classes of Martin et al. (1953), Table 3 may also be used to compare the Golet and Larson system to the one described here. Although our system does not include size categories and size types, this information will be available from the results of the new inventory of wetlands and deep-water habitats of the United States.

Stewart and Kantrud (1971) devised a new classification system to better serve the needs of researchers and wetland managers in the glaciated prairies. Their system recognizes seven classes of wetlands which are distinguished by the vegetational zone occupying the central or deepest part and covering five percent or more of the wetland basin. The classes thus reflect the wetland's water regime; for example, temporary ponds (Class II) are those where the wet-meadow zone occupies the deepest part of the wetland. Six possible subclasses were created, based on differences in plant species composition that are correlated with variations in average salinity of surface water. The third component of classification in their system is the cover type which represents differences in the spatial relation of emergent cover to open water or exposed bottom soil. The zones of Stewart and Kantrud's system are readily related to our water regime modifiers (Table 4), and the subclasses are roughly equivalent to our water chemistry modifiers (Table 5).

A classification system is most easily learned through use. To illustrate the application of this system, we have classified a representative group of wetlands and deep-water habitats of the United States.[1]

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[1]The final publication will include a classification of a representative group of wetlands and deep-water habitats of the United States. Photographs of these habitats will also be provided.

Table 4. Comparison of the Zones of Stewart and Kantrud's (1971) Classification with the Water Regime Modifiers used in this Classification System

| Zone (Stewart and Kantrud) | Water Regime Modifier |
|---|---|
| Wetland-low-prairie zone | non wetland by one definition |
| Wet Meadow Zone | Temporarily Flooded |
| Shallow Marsh Zone | Seasonally Flooded |
| Deep Marsh Zone | Semipermanently Flooded<br>Intermittently Exposed |
| Permanent Deep Water Zone | Permanently Flooded |
| Intermittent-alkali Zone | Intermittently Flooded (with saline or hypersaline water) |
| Fen (Alkaline Bog) Zone | Saturated |

Table 5

Comparison of the Water Chemistry Subclasses of Stewart and Kantrud (1972) with the Water Chemistry Modifiers used in this Classification System

| Stewart and Kantrud (1972) | Approximate specific conductances (μMhos) | This classification | |
| --- | --- | --- | --- |
| | 100.000 | | |
| Saline | | Hypersaline | |
| | 60.000 | | |
| | | Eusaline | |
| | 45.000 | | |
| Subsaline | | Polysaline | |
| | 30.000 | | |
| | 15.000 | Mesosaline | |
| Brackish | | | Mixosaline |
| | 8.000 | | |
| | 5.000 | | |
| Moderately Brackish | | Oligosaline | |
| | 2.000 | | |
| Slightly Brackish | | | |
| | 800 | | |
| | 500 | Fresh | |
| Fresh | | | |
| | 40 | | |
| | 0 | | |

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# APPENDIX A

## SCIENTIFIC AND COMMON NAMES OF PLANTS

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| Acer rubrum L. | Red Maple |
| Alnus spp. | Alders |
| A. rugosa (DuRoi) Spreng. | Speckled Alder |
| Andromeda glaucophylla Link | Bog-rosemary |
| Aulacomnium palustre (Hedw.) Schwaegr. | |
| Avicennia germinans (L.) L. (A. nitida Jacq.) | Black Mangrove |
| Azolla spp. | Mosquito-fern |
| Baccharis halmifolia L. | Sea-myrtle |
| Beckmannia syzigachne (Steud.) Fern. | American Sloughgrass |
| Betula pumila L. | Swamp Birch |
| Brasenia schreberi | Water-shield |
| Campylium stellatum (Hedw.) C. Jens. | |
| Carex spp. | Sedges |
| Cephalanthus occidentalis L. | Buttonbush |
| Ceratophyllum spp. | Hornwort |
| C. demersum L. | Coontail |
| Chamaecyparis thyoides (L.) BSP. | White Cedar |
| Chamaedaphne calyculata (L.) Moench | Leather-leaf |
| Chara spp. | Stonewort |
| Chenopodium rubrum L. | Coast-blight |
| Chilosyphus fragilis (Roth) Schiffn. | |
| Cladium jamaicens Crantz | Sawgrass |
| Cladonia spp. | Reindeer Moss |
| Conocarpus erecta L. | Buttonwood |
| Decodon verticillatus (L.) Ell. | Water-willow |
| Desmatodon heimii (Hedw.) Mitt. | |
| Drepanocladus (C. Muell.) Roth | Aquatic Moss |

APPENDIX A (continued)

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| Echinochloa crusgalli (L.) Beauv. | Wild Millet |
| Eichhornia crassipes (Mart.) Solms. | Water-hyacinth |
| Eleocharis acicularis (L.) R. & S. | Spike-rush |
| Equisetum fluviatile L. | Water Horsetail |
| Fissidens spp. | Water Moss |
| F. julianus (Mont.) Schimp. | Water Moss |
| Fontinalis | Water Moss |
| Fraxinus nigra Marsh | Black Ash |
| F. pennsylvanica Marsh | Red Ash |
| Glyceria spp. | Manna-grasses |
| Gordonia lasianthus (L.) Ellis | Loblolly Bay |
| Halodule beaudettei (den Hartog) den Hartog | Shoalgrass |
| Halophila spp. | Sea-grass |
| Iva frutescens L. | Marsh Elder |
| Juncus roemerianus Scheele | Needle Rush |
| Kalmia polifolia Wang. | Pale or Bog-laurel |
| Laguncularia racemosa Gaertn. f. | White Mangrove |
| Ledum groenlandicum Oeder | Labrador-tea |
| Larix laricina (Du Roi) K. Koch | American Larch or Tamarock |
| Lemna spp. | Duckweeds |
| Leucothoe axillaris (Lam.) D. Don | Leucothoe |
| Lyonia lucida (Lam.) K. Koch | Tetter-bush |
| Lythrum salicaria L. | Purple Loosestrife |
| Macrocystis spp. | Brown Algae |
| Magnolia virginiana L. | Sweet Bay |
| Marsupella spp. | Liverwort |
| Myriophyllum spp. | Water-milfoil |
| Najas spp. | Naiads |
| Nitella spp. | Nitella |
| Nuphar spp. | Spatter-dock |
| N. advena (Ait.) f. | Yellow Pond-lily |
| N. variegatum | Variegated Pond-lily |

APPENDIX A (continued)

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| Nymphaea spp. | Water-lily |
| Nymphoides aquatica (Walt.) O. Kuntze | Floating-heart |
| Nyssa aquatica L. | Water Gum or Tupelo Gum |
| N. sylvatica Marsh | Black Gum |
| Peltandra virginica (L.) Kunth | Arrow-arum |
| Pelvetia spp. | Slim Brown Rockweed |
| Persea borbonia (L.) Spreng. | Red Bay |
| Phragmites communis Trin. | Reed |
| Phyllospadix scouleri Hook. | Surf Grass |
| P. torreyi Wats. | Surf Grass |
| Picea mariana (Mill.) BSP | Black or Bog-spruce |
| Pinus serotina Michx. f. | Pond or Marsh-pine |
| Pistia stratiotes L. | Water-lettuce |
| Podostemum ceratophyllum Michx. | Threadfoot |
| Polygonum spp. | Smartweeds |
| P. amphibium L. | Water-smartweed |
| Pontederia cordata L. | Pickerelweed |
| Potamogeton spp. | Pondweeds |
| P. epihydrus Raf. | Ribbonleaf Pondweed |
| P. natans L. | Floating-leaf Pondweed |
| Quercus bicolor Willd. | Swamp White-oak |
| Q. lyrata Walt. | Over-cup Oak |
| Q. michauxii Nutt. | Basket Oak |
| Rhizophora mangle L. | Red Mangrove |
| Rumex mexicanus Meisn. | |
| Ruppia maritima L. | Widgeon-grass |
| Sagittaria spp. | Arrowhead |
| Salicornia pacifica Standl. | Glasswort or Common Pickleweed |
| Salix spp. | Willow |
| Salvinia spp. | Water Fern |
| S. rotundifolia Willd. | Water Fern |

APPENDIX A (continued)

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| Scirpus acutus Muhl. | Hard-stem Bulrush |
| Scolochloa festucacea (Willd.) Link | White-top |
| Spartina alterniflora Loisel. | Salt-water Cordgrass |
| S. cynosuroides (L.) Roth | Big Cordgrass |
| S. foliosa Trin. | Cordgrass |
| S. patens (Ait.) Muhl. | Saltmeadow Cordgrass |
| Sphagnum spp. | Peat Moss |
| Spirodela polyrhiza (L.) Schleid. | Big Duckweed |
| Suaeda californica Wats. | Sea-blite |
| Syringodium filiformis Kuetz | Manatee-grass |
| Taxodium ascendens Brogn. | Pond Cypress |
| T. distichium (L.) Richard | Bald Cypress |
| Thalassia testudinum Koenig & Sims | Turtle-grass |
| Thuja occidentalis L. | White Cedar or Arbor Vitae |
| Trapa spp. | Water-nut |
| Triglochin maritima L. | Arrow-grass |
| Typha angustifolia L. | Narrow-leaved Cat-tail |
| T. latifolia L. | Common Cat-tail |
| Ulmus americana | American or White Elm |
| Ulva spp. | Sea lettuce |
| Utricularia vulgaris L. | Bladderwort |
| Vallisneria americana Michx. | Wild Celery |
| Xanthium italicum Moretti | Cocklebur |
| Zenobia pulverulenta (Bartr.) Pollard | Zenobia |
| Zizania aquatica L. | Wild Rice |
| Zostera marina L. | Grass-wrack or Eelgrass |
| Zizaniopsis miliacea (Michx.) Ddl & Asch. | Water Millet |

# APPENDIX B

## SCIENTIFIC AND COMMON NAMES OF ANIMALS

| SCIENTIFIC NAME | COMMON NAME* |
|---|---|
| Acmaea | False Limpet |
| Acropora | Coral |
| Amphitrite | Terebellid Polychaete |
| Amphiura | Starfish |
| Anodonta | Freshwater Clam |
| Anopheles | Mosquito |
| Arenicola | Lugworm |
| Baetis | Mayfly |
| Balanus | Barnacle |
| Caenis | Mayfly |
| Callianassa | Burrowing Shrimp |
| Cerianthiopsis | Sea Anemone |
| Cerithium | Snail |
| Chaeopterus | Polychaete |
| Chaoborus | Diptera |
| Chiredotea | Isopod |
| Chironomus | Midge |
| Chthamalus | Barnacle |
| Cnemidocarpa | Ascidian |
| Crassostrea | Oyster |
| Dendraster | Sea Star |
| Diamesa | Diptera |
| Donax | Wedge Shell |
| Echinocardium | Sea Urchin |
| Emerita | Sand Bug |
| Ephemera | May Fly |
| Eukiefferiella | Diptera |
| Gammarus | Amphipod |

APPENDIX B (continued)

| SCIENTIFIC NAME | COMMON NAME* |
|---|---|
| Haustorius | Amphipod |
| Herpobdella | Leech |
| Hippospongia | Encrusting Sponges |
| Hydropsyche | Caddis Fly |
| Leptosynapta | Holothurian |
| Limnea | |
| Limnodrilus | Oligochaete |
| Littorina | Periwinkle |
| Lumbriculus | Oligochaete |
| Lygia | Isopod |
| Lymnaea | Freshwater Snail |
| Macoma | Tellin Shell |
| Mellita | Amphipod |
| Mitella | Barnacle |
| Modiolus | Mussel |
| Montipora | Coral |
| Muricea | Alcyonarian |
| Mya | Long Neck Clam |
| Mytilus | Mussel |
| Nassarius | Mud Snail |
| Nemoura | Plecoptera |
| Nereis | Polychaete |
| Nerita | Periwinkle |
| Ocypode | Ghost Crab |
| Oliva | Amphipod |
| Orchestia | Oyster |
| Paractis | Sea Anemone |
| Parastenocaris | Copepod |
| Patella | Limpet |
| Pecten | Scallop |
| Penaeus | Shrimp |

APPENDIX B (continued)

| SCIENTIFIC NAME | COMMON NAME* |
|---|---|
| Phyllognathus | Capepod |
| Physa | Freshwater Snail |
| Pisaster | Seastar |
| Pisidium | Mollusk |
| Porites | Coral |
| Pristina | Oligochaete |
| Renilla | Sea Pansy |
| Sabellaria | Reefworm |
| Siphonaria | False Limpet |
| Spatangus | Heart Urchin |
| Spongilla | Sponge |
| Strongylocentrotus | Sea Urchin |
| Tellina | Tellin Shell |
| Tetraclita | Barnacle |
| Thais | Rock Shell |
| Thyone | Sea Cucumber |
| Thoracophelia | Bamboo Worm |
| Tivela | Pismo Clam |
| Tubifex | Sewage Worm |
| Uca | Fiddler Crab |
| Urechis | Echivrid |

* Organisms are identified only to genus, so the common name refers to general groupings.

# APPENDIX C

## CRITERIA FOR DISTINGUISHING ORGANIC SOILS FROM MINERAL SOILS

The criteria for distinguishing organic soils from mineral soils in the United States (U. S. Soil Conservation Service, Soil Survey Staff 1975:13-14, 65) are quoted here so that those without ready access to a copy of the Soil Taxonomy may employ this information in the classification of wetlands:

> For purposes of taxonomy, it is necessary, first, to define the limits that distinguish mineral soil material from organic soil material and, second, to define the minimum part of a soil that should be mineral if the soil is to be classified as a mineral soil.
>
> Nearly all soils contain more than traces of both mineral and organic components in some horizons, but most soils are dominantly one or the other. The horizons that are less than about 20 to 35 percent organic matter by weight have properties that are more nearly those of mineral than of organic soils. Even with this separation, the volume of organic matter at the upper limit exceeds that of the mineral material in the fine-earth fraction.
>
> MINERAL SOIL MATERIAL
>
> Mineral soil material either
>
> 1. Is never saturated with water for more than a few days and has <20 percent organic carbon by weight;
>
> or
>
> 2. Is saturated with water for long periods or has been artificially drained, and has
>    a. Less than 18 percent organic carbon by weight if 60 percent or more of the mineral fraction is clay;
>    b. Less than 12 percent organic carbon by weight if the mineral fraction has no clay; or
>    c. A proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent.
>
> Soil material that has more organic carbon than the amounts just given is considered to be organic material. A full definition of organic soil materials is given in Chapter 4.

## DISTINCTION BETWEEN MINERAL SOILS AND ORGANIC SOILS

Most soils are dominantly mineral material, but many mineral soils have horizons of organic material. For simplicity in writing definitions of taxa, a distinction between what is meant by a mineral soil and an organic soil is useful. In a mineral soil, the depth of each horizon is measured from the top of the first horizon of mineral material. In an organic soil, the depth of each horizon is measured from the base of the aerial parts of the growing plants or, if there is no continuous plant cover, from the surface of the layer of organic materials. To apply the definitions of many taxa, therefore, one must first decide whether the soil is mineral or organic.

If a soil has both organic and mineral horizons, the relative thickness of the organic and the mineral soil materials must be considered. At some point one must decide that the mineral horizons are more important. This point is arbitrary and depends in part on the nature of the materials. A thick layer of sphagnum has a very low bulk density and contains less organic matter than a thinner layer of well-decomposed muck. It is much easier to measure thickness of layers in the field than it is to determine tons of organic matter per hectare. The definition of a mineral soil, therefore, is based on thickness of the horizons or layers, but the limits of thickness must vary with the kinds of materials. The definition that follows is intended to classify as mineral soils those that have no more organic material than the amount permitted in the histic epipedon, which is defined later in this chapter.

To determine whether a soil is organic or mineral, the thickness of horizons is measured from the surface of the soil whether that is the surface of a mineral or an organic horizon. Thus, any O horizon at the surface is considered an organic horizon, if it meets the requirements of organic soil material as defined later, and its thickness is added to that of any other organic horizons to determine the total thickness of organic soil materials.

## DEFINITION OF MINERAL SOILS

Mineral soils, in this taxonomy, are soils that meet one of the following requirements:

1. Mineral soil material <2mm in diameter (the fine-earth fraction) makes up more than half the thickness of the upper 80 cm (31 in.) [sic];
2. The depth to bedrock is <40 cm and the layer or layers of mineral soil directly above the rock either are 10 cm or more thick or have half or more of the thickness of the overlying organic soil material; or
3. The depth to bedrock is ≥40 cm, the mineral soil material immediately above the bedrock is 10 cm or more thick, and either
    a. Organic soil material is <40 cm thick and is decomposed (consisting of hemic or sapric materials as defined later) or has a bulk density of 0.1 or more; or

b. Organic soil material is <60 cm thick and either is undecomposed sphagnum or moss fibers or has a bulk density that is <0.1.

ORGANIC SOIL MATERIALS

Organic soil materials and organic soils
1. Are saturated with water for long periods or are artificially drained and, excluding live roots, (a) have 18 percent or more organic carbon if the mineral fraction is 60 percent or more clay, (b) have 12 percent or more organic carbon if the mineral fraction has no clay, or (c) have a proportional content of organic carbon between 12 and 18 percent if the clay content of the mineral fraction is between zero and 60 percent; or
2. Are never saturated with water for more than a few days and have 20 percent or more organic carbon.

Item 1 in this definition covers materials that have been called peats and mucks. Item 2 is intended to include what has been called litter or O horizons. Not all organic soil materials accumulate in or under water. Leaf litter may rest on a lithic contact and support a forest. The only soil in this situation is organic in the sense that the mineral fraction is appreciably less than half the weight and is only a small percentage of the volume of the soil.

DEFINITION OF ORGANIC SOILS

Organic soils (Histosols) are soils that
1. Have organic soil materials that extend from the surface to one of the following:
    a. A depth within 10 cm or less of a lithic or paralithic contact, provided the thickness of the organic soil materials is more than twice that of the mineral soil above the contact; or
    b. Any depth if the organic soil material rests on fragmental material (gravel, stones, cobbles) and the interstices are filled with organic materials, or rests on a lithic or paralithic contact; or
2. Have organic materials that have an upper boundary within 40 cm of the surface and
    a. Have one of the following thicknesses:
        (1) 60 cm or more if three-fourths or more of the volume is moss fibers or the moist bulk density is <0.1 g per cubic centimeter (6.25 lbs per cubic foot);
        (2) 40 cm or more if
            (a) The organic soil material is saturated with water for long periods (>6 months) or is artificially drained; and
            (b) The organic material consists of sapric or hemic materials or consists of fibric materials that are less than three-fourths moss fibers by volume and have a moist bulk density of 0.1 or more; and

b. Have organic soil materials that
(1) Do not have a mineral layer as much as 40 cm thick either at the surface or whose upper boundary is within a depth of 40 cm from the surface; and
(2) Do not have mineral layers, taken cumulatively, as thick as 40 cm within the upper 80 cm.

It is a general rule that a soil is classed as an organic soil (Histosol) either if more than half of the upper 80 cm (32 in.) [sic] of soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic materials.

Soils that do not satisfy the criteria for classification as organic soils are mineral soils.