FGDC–STD-004-2013
Second Edition

Classification of Wetlands and Deepwater Habitats of the United States

Adapted from Cowardin, Carter, Golet and LaRoe (1979)

Wetlands Subcommittee
Federal Geographic Data Committee

August 2013

Federal Geographic Data Committee

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This standard should be cited as:

Federal Geographic Data Committee. 2013. Classification of wetlands and deepwater habitats of the United States. FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service, Washington, DC.

Preface

The *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979) was developed to support a detailed inventory and periodic monitoring of the Nation's wet habitats using remote sensing. It became a National Standard in 1996 (FGDC-STD-004), but has been the *de facto* standard for mapping U.S. wetlands and deepwater habitats since 1976. As of February 2013, the U.S Fish and Wildlife Service's (FWS) National Wetlands Inventory (NWI) had produced wetland data for nearly the entire country. Digital data were available for 89% of the continental United States, 34% of Alaska, 100% of the Hawaiian Islands, 76% of Puerto Rico and the U.S. Virgin Islands and 100% of Guam and Saipan in the Pacific Trust Territories. These data have been incorporated in five reports to Congress on the *Status and Trends of Wetlands and Deepwater Habitats of the Conterminous United States* and more than a hundred regional, state, local, watershed and special interest reports. The classification system (Cowardin et al. 1979) has been cited extensively in the scientific literature and applied internationally.

Shortly after publication of the classification, a National list of hydrophytes and other plants occurring in wetlands and deepwater habitats and a National list of hydric soils were released to support the classification and inventory work. Maintenance of these lists has been a significant, complex task. The U.S. Department of Agriculture's Natural Resources Conservation Service has responsibility for managing the hydric soils list (USDA 2010), and the U.S. Army Corps of Engineers maintains the plant list (Lichvar and Kartesz 2009).

Preparation of this second edition of the Wetlands Classification Standard began in the spring of 2010. Over the last three years, a great number of people reviewed drafts of the revised report and submitted edits, questions, and suggestions for improvement. Among the reviewers were present and past staff of the National Wetlands Inventory; members of the Wetlands Mapping Standard Working Group, which was reconvened specifically to work on this revision; and other Federal and private-sector wetland specialists and contractors. Among the most important contributors were: Ralph Tiner, National Wetlands Inventory, FWS; Larry Handley, U.S. Geological Survey; and Jane Awl, Wetland Mapping Consortium. Thanks also go to Mark Newcastle, Printing and Publishing, FWS for his professional help in redrafting the figures. I am indebted to my wife, Carol Wilen, for allowing me to spend too many Saturdays, Sundays and holidays focused on this, and other, work-related projects.

Special thanks go to Dr. Frank Golet, Professor Emeritus at the University of Rhode Island and one of the authors of the original classification (Cowardin et al. 1979). His detailed, comprehensive reviews of numerous drafts helped to assure that all revisions were technically sound and consistent with both current science and the structure and intent of the original classification. His careful editing also has enhanced the clarity and user-friendliness of this document.

I look back on a long haul made pleasurable by the opportunity of working again with old friends, as well as a new generation of colleagues who will use this classification system going forward.

Bill Wilen
National Wetlands Inventory
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March 2013

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1. Introduction

Wetlands and deepwater habitats are essential breeding, rearing, and feeding grounds for many species of fish and wildlife. They also perform flood protection, pollution control and a variety of other important functions. National and international recognition of the beneficial roles of wetlands has intensified the need for reliable information on the status and extent of wetland resources. To develop comparable information over large areas, a clear definition and classification of wetlands and deepwater habitats are required.

The United States Fish and Wildlife Service (USFWS) has a long history of involvement in wetlands classification and inventory. Conservation and management of migratory waterfowl are a responsibility of the USFWS based on migratory bird treaties with Canada and Mexico. Thus, conservation of wetland habitats is one of the agency's primary objectives. The USFWS conducted the first quantitative national inventory of wetlands in the mid-1950s; the results were summarized in U.S. Fish and Wildlife Service Circular 39 (Shaw and Fredine 1956). That inventory was based on a classification, developed by Martin et al. (1953), which included 20 classes of wetlands. The Martin et al. classification was inconsistently applied among regions primarily because of a lack of detail in the definitions of wetland types (Cowardin et al. 1979). By the mid-1970s, there was a surge of public and professional interest in wetlands that transcended the habitat function for migratory birds.

In January of 1975, the USFWS convened a small number of interested individuals from various agencies and regions to formulate the skeleton of a new classification that could serve as the basis for a new National Wetlands Inventory (NWI). Three important points were agreed upon: (1) none of the existing classifications met the requirement for national uniformity, (2) regional classifications would not suffice because of the confusion resulting at regional boundaries, and (3) a new classification should be hierarchical in structure.

Following that meeting, Lewis M. Cowardin, USFWS, and Virginia Carter, U.S. Geological Survey (USGS), prepared a tentative classification that was presented at a July 1975 national workshop, where 150 Federal, Tribal and state wetlands management personnel were invited to comment on the proposed classification (Sather 1976). Input from that workshop resulted in major modifications of the Cowardin and Carter paper and led to the preparation of a revision*, Interim Classification of Wetlands and Aquatic Habitats of the United States* (Cowardin et al. 1976). Francis C. Golet, University of Rhode Island, and Edward T. LaRoe, National Oceanographic and Atmospheric Administration (NOAA), joined Cowardin and Carter as co-authors of the 1976 document and subsequent versions of the classification system. The Interim Classification was tested using both high- and low-altitude aerial photographs and field-checks at 21 sites scattered across the country. NWI staff worked with the authors to resolve practical problems encountered during extensive test mapping. At the same time, the authors tested the evolving classification at numerous locations throughout the U.S. The final version was published in 1979 as the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979). It was reprinted with technical revisions and additional plates in 1985 and reprinted again in larger format in 1992. The classification was adopted by the Federal Geographic Data Committee (FGDC) as a National Standard (FGDC-STD-004) in 1996. That was the governing document until the Second Edition was published in 2013.

1.1 Objectives

The primary objective of the *Classification of Wetlands and Deepwater Habitats of the United States*, as originally drafted by Cowardin et al. (1979:3), was "to impose boundaries on natural ecosystems for the purposes of inventory, evaluation, and management." The FGDC Wetlands Classification Standard (WCS) provides minimum requirements and guidelines for classification of both wetlands and deepwater habitats that are consistent with the FGDC Wetlands Mapping Standard (FGDC-STD-015-2009).

1.2 Scope

Any new, updated, or revised mapping of wetlands or deepwater habitats shall conform to the FGDC Wetlands Classification Standard. More general mapping activities may incorporate wetlands data from the National Spatial Data Infrastructure (NSDI), rather than conducting new wetlands classification (see further information in the FGDC Wetlands Mapping Standard).

The *Classification of Wetlands and Deepwater Habitats of the United States* was developed by wetland ecologists, with the assistance of many private individuals and organizations and local, state, and Federal agencies. It was designed for use over a broad geographic area—all U.S. States and Territories—by individuals and organizations with varied interests and objectives. The definition of wetland in this classification delimits the biological extent of wetland, as influenced by substrate properties and the hydrologic characteristics at each site. This robust classification system has been successfully applied throughout the United States and its Territories since the mid-1970s, making it a truly national system.

1.2.1 Exemptions to the FGDC Wetlands Classification Standard

Circumstances under which the FGDC Wetlands Classification Standard is *not* required include the following:

1. Wetlands inventory mapping activities that are not federally-funded. However, such projects are strongly encouraged to comply with the WCS. The builders of the NSDI will not incorporate non-compliant wetlands inventory data from any source except USFWS wetlands maps created prior to implementation of the Wetlands Mapping Standard (FGDC-STD-015- 2009).

2. Mapping designed, or intended, to support legal, regulatory, or jurisdictional analyses by Federal, Tribal, state, and local regulatory agencies or to differentiate between regulatory and non-regulatory wetlands.

3. Marine and estuarine benthic habitat mapping because it currently necessitates the use of definitions and classifications that differ from the WCS.

4. Classification data developed during site-specific wetland studies for scientific research, environmental assessments (EA), environmental impact statements (EIS), and wetland determinations for regulatory purposes when these site-specific activities necessitate the use of definitions and classifications that are incompatible with the WCS. However, the use of the WCS is strongly encouraged for these types of studies, whenever possible, so that the results can be interpolated or extrapolated across the country.

1.2.2 Coordination with FGDC Coastal and Marine Ecological Classification Standard

The FGDC Wetlands Classification Standard (WCS; FGDC-STD-004-2013) will be used to map all nontidal deepwater habitats except for the Great Lakes, and all coastal and inland wetlands except for permanently flooded tidal freshwater wetlands. The Coastal and Marine Ecological Classification Standard (CMECS; FGDC-STD-018-2012) will be used to map deepwater habitats in the Great Lakes and in the Marine and Estuarine Systems, as well as all permanently flooded tidal freshwater habitats (deepwater and wetland). The WCS will use 0.5 parts per thousand (ppt) ocean-derived salinity as the upstream boundary for the Estuarine System, and CMECS will use head-of-tide.

1.3 Applicability

The FGDC Wetlands Classification Standard is intended for all Federal or federally-funded wetlands inventory mapping including those activities conducted by Federal agencies, states, and federally-recognized tribal entities, non-governmental organizations, universities, and others. Specifically, if Federal funding is used in support of wetlands inventory mapping activities, then use of this Standard is mandatory. The adoption of this Standard for all other wetlands inventory mapping efforts (non-federally funded) is strongly encouraged to maintain and expand the wetlands layer of the NSDI.

The FGDC Wetlands Classification Standard is neither designed, nor intended, to support legal, regulatory, or jurisdictional analyses of wetlands mapping products, nor does it attempt to differentiate between regulatory and non-regulatory wetlands. Federal, Tribal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than the FGDC Wetlands Classification Standard and the FGDC Wetlands Mapping Standard. There is no attempt to define the limits of proprietary jurisdiction of any Federal, Tribal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, Tribal, state, or local agencies concerning specified agency regulatory programs and jurisdictions that may affect such activities.

1.4 Related Standards

Related FGDC Standards:

Wetlands Mapping Standard, FGDC-STD-015-2009

Coastal and Marine Ecological Classification Standard, FGDC-STD-018-2012

Soil Geographic Data Standard, FGDC-STD-006

National Vegetation Classification Standard (Version 2), FGDC-STD-005-2008

Information Technology—Geographic Information Framework Data Content Standard, Part 5: Governmental unit and other geographic area boundaries, FGDC-STD-014.5-2008

FGDC Standards are available at: http://www.fgdc.gov/

Other Related Practices:

A System for Mapping Riparian Areas in the Western United States (Dick 2009), http://www.fws.gov/wetlands/Documents/A-System-for-Mapping-Riparian-Areas-In-The-Western-United-States-2009.pdf See further documentation on riparian area standards at http://www.fws.gov/stand/standards/dl_riparian_WWW.html

Primary Indicators Method. Tiner, R. W. 1993. The primary indicators method—a practical approach to wetland recognition and delineation in the United States. Wetlands 13(1): 50-64. (This method is typically used for verifying Service Wetland Database wetlands on the ground.) http://www.fws.gov/wetlands/Documents/The-Primary-Indicators-Method-A-Practical-Approach-to-Wetland-Recognition-and-Delineation-in-the-United-States.pdf

National Hydrography Dataset (NHD) maintained by the USGS, http://nhd.usgs.gov/

Canadian Wetland Inventory maintained by Agriculture and Agri-Food Canada (AAFC), http://www.wetkit.net/modules/1/showtool.php?tool_id=83

RAMSAR Classification for Wetland Type maintained by Convention on Wetlands (Ramsar, Iran, 1971), http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-26-76%5E21235_4000_0__

Guidance for Benthic Habitat Mapping: An Aerial Photographic Approach maintained by the NOAA Coastal Services Center, http://www.csc.noaa.gov/benthic/mapping/pdf/bhmguide.pdf

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia, http://www.natureserve.org/library/usEcologicalsystems.pdf

1.5 Standards Maintenance Procedures

The intent of the FGDC Wetlands Subcommittee was to produce a newly edited and updated version of the FGDC Wetlands Classification Standard (FGDC-STD-004-1996), *Classification of Wetlands and Deepwater Habitats of the United States* (originally authored by Cowardin et al. 1979). This revised Standard has been formatted to be consistent with more recently endorsed FGDC Standards. The text has been edited, refined, clarified, and rewritten as necessary. Some portions were rewritten because the scientific foundation upon which the original classification (Cowardin et al. 1979) was developed has advanced. The Wetlands Mapping Standard FGDC-STD-015-2009, also developed by the FGDC Wetlands Subcommittee, was endorsed by the FGDC in July of 2009. NWI's *Data Collection Requirements and Procedures for Mapping Wetland, Deepwater, and Related Habitats of the United States* (Dahl et al. 2009) will be revised as necessary to keep pace with advances in technology.

1.6 Maintenance Authority

The maintenance authority resides with the USFWS. Pertinent enabling authority resides in the Emergency Wetlands Resources Act of 1986. The USFWS has designated its NWI Project to undertake the responsibilities to satisfy the requirements of Circular A-16. In carrying out Federal Government-wide leadership in spatial wetlands data coordination, the USFWS is directly responsible to the FGDC, and the NWI ensures compliance with the objectives and guidance provided by the FGDC.

2. Wetlands and Deepwater Habitats

2.1 Concepts and Definitions

The definitions used in the FGDC Wetlands Classification Standard are neither designed, nor intended, to support legal, regulatory, or jurisdictional analyses of wetlands and deepwater habitats, nor do they attempt to differentiate between regulatory and non-regulatory wetlands or waters.

Marshes, swamps, and bogs have been well-known terms for centuries, but only since the mid-1970s have attempts been made to group these landscape units under the single term "wetlands." This general term has grown out of a need to understand and describe the characteristics and values of all types of land, and to effectively manage wetland habitats. There is no single, correct, indisputable, ecologically sound definition for wetlands, primarily because of the diversity of wetlands and because the demarcation between dry and wet environments lies along a continuum or gradient. Because reasons or needs for defining wetlands also vary, multiple definitions and criteria have been developed for different purposes. The primary purpose of this classification is to identify and describe wet habitats to aid in their inventory, assessment, and management. The definition used in this classification is habitat-based and amenable to remote sensing technology.

2.1.1 Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of substrate development and the types of plant and animal communities living in the substrate and on its surface. The single feature that most wetlands share is a substrate that is at least periodically saturated with or covered by water. The water creates severe physiological problems for all plants and animals except those that are specially adapted for such conditions.

Wetland "substrates" consist of unconsolidated mineral material, organic material, or rock that is flooded or saturated long enough each year to support wetland organisms (see glossary in Appendix A). Most wetland substrates also qualify as "soil." According to the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), "soil" is a natural body that occurs at the land surface and has recognizable horizons, or layers, or has the ability to support rooted plants (Soil Survey Staff 1999; see Appendix A for a more detailed technical definition). As noted, the great majority of wetlands have soil; obvious exceptions include bedrock and boulder or cobble shores which lack horizons and have too little fine material to support rooted plants. In this classification, the term "soil" is only used for wetland substrates that meet the USDA definition. The more generic term "substrate" may be applied to *any* wetland, but is most often used in this classification when referring to nonvegetated habitats and when defining terms (e.g., individual Water Regimes and Marine and Estuarine Subsystems) that apply to, or include, both habitats that have soil and habitats that do not.

The following definition of wetlands is neither designed, nor intended, to support legal, regulatory, or jurisdictional analyses, nor does it attempt to differentiate between regulatory and non-regulatory wetlands.

The FGDC Wetlands Classification Standard (WCS) defines "wetlands" according to Cowardin et al. (1979):

WETLANDS *are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes*[1]*; (2)*

[1] Lichvar, R. W., and J. T. Kartesz. 2009. North American Digital Flora: National Wetland Plant List, version 2.4.0 U.S. Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, and BONAP, Chapel Hill, North Carolina

the substrate is predominantly undrained hydric soil[2]*; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.*

As noted in this definition, plant community composition, soil morphology, and site wetness (hydrology) are the principal indicators of whether a site is a wetland for ecological purposes. Site wetness, i.e., the presence of water, while central to the concept of wetland, is often the most difficult indicator to assess accurately because it is more dynamic (temporally variable) than plant community composition or soil properties. Plants and soil tend to reflect the prevailing degree of wetness at a site over time. For this reason, they frequently are excellent indicators of relative wetness, and this is why they are listed first as indicators of wetlands.

Cowardin et al. (1979) intended that *all available information* should be used in making a wetland identification, as follows:

- If plants and soil are present at a site, then both a predominance of hydrophytes and a predominance of undrained hydric soil, as well as wetland hydrology, should be required for positive wetland identification.
- If plants are present but soil is absent (e.g., Algal Aquatic Beds on rock substrates), then a predominance of hydrophytic vegetation, as well as wetland hydrology, should be required for a positive wetland identification.
- If plants are absent but soil is present, then a predominance of undrained hydric soil, as well as wetland hydrology, should be required for positive wetland identification.
- If neither plants nor soil is present, then the wetland identification must be made strictly on the basis of hydrology. In this case, the substrate should be "saturated with water or covered by shallow water at some time during the growing season of each year." Cowardin et al. (1979) fully realized how vague this hydrologic definition was but, given the lack of detailed hydrologic data from the diversity of wetland types, geologic regions, and climatic regions of the U.S., there was no way they could have been more specific. Even today, these data are not readily available across the nation.

In these examples, three (3) indicators – hydrophytic vegetation, undrained hydric soil, and wetland hydrology; two (2) indicators—hydrophytic vegetation and wetland hydrology or undrained hydric soil and wetland hydrology; and one (1) indicator—wetland hydrology, respectively, would be used to make the identification, based on the features available at the particular site.

[2] U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Field indicators of hydric soils in the United States. Version 7. L.M. Vasilas, G.W. Hunt, and C.V. Noble, eds. USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

2.1.2 Deepwater Habitats

DEEPWATER HABITATS *are permanently flooded lands lying below the deepwater boundary of wetlands* (see Section 2.2 for explanation of wetland limits). Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium within which the dominant organisms live, whether or not they are rooted in, or attached to, the substrate. As in wetlands, the dominant plants are hydrophytes.

Wetlands and deepwater habitats are defined separately because traditionally the term wetlands has not included deep, permanent water; however, both must be considered in an ecological approach to classification. The WCS includes five major Systems: Marine, Estuarine, Riverine, Lacustrine, and Palustrine. The first four of these include both wetlands and deepwater habitats but the Palustrine includes only wetland habitats.

2.2 Limits

The upland limit of wetlands is characterized by (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; and (3) the boundary between land that is flooded or saturated at some time during the growing season each year and land that is not.

The boundary between wetlands and deepwater habitats in the Marine and Estuarine Systems coincides with the elevation of the extreme low water of spring tide; all permanently flooded areas are considered deepwater habitats in these Systems. The boundary between wetlands and deepwater habitat in the Riverine and Lacustrine Systems lies at a depth of 2.5 m (8.2 ft) below low water; however, if emergents, shrubs, or trees grow beyond this depth at any time, their deepwater edge is the boundary.

The 2.5-m lower limit for inland wetlands was selected because it approximates the maximum depth to which emergent plants normally grow (Welch 1952, Zhadin and Gerd 1963, Sculthorpe 1967) and the depth beyond which soil does not occur, according to the USDA Natural Resources Conservation Service (Soil Survey Staff 1999). As Daubenmire (1968:138) stated, emergents are not true aquatic plants, but are “amphibious,” growing in both permanently flooded and wet, nonflooded soils.

3. 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. Figure 1 illustrates the classification structure through the Class level. Table 1 lists the Subclasses that occur within each System, Subsystem and Class. Modifiers for Water Regime, Water Chemistry, and Soil are applied to Classes and Subclasses. Special Modifiers describe wetlands and deepwater habitats that have been either created or highly modified by humans or beaver.

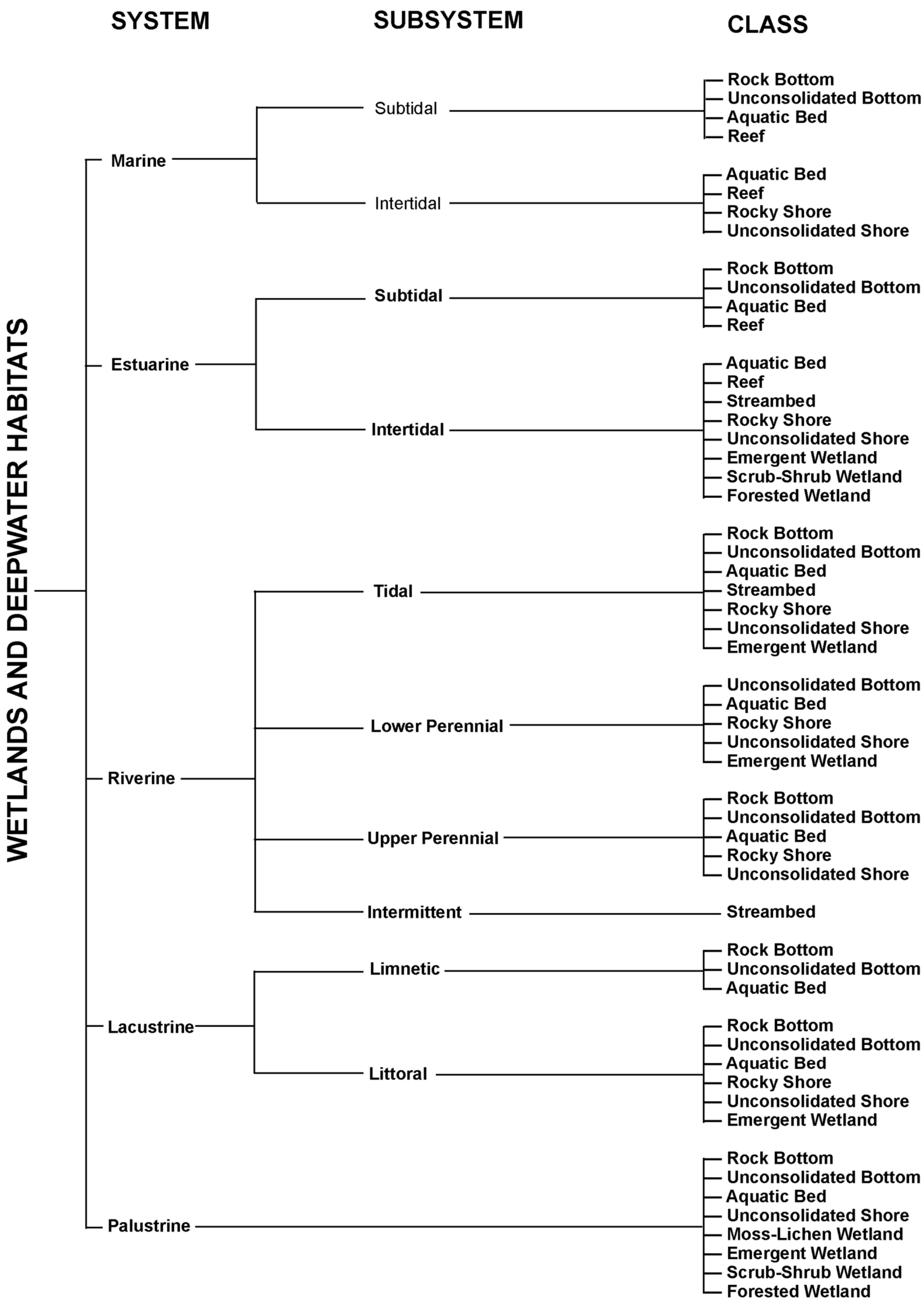

Figure 1. Classification hierarchy of wetlands and deepwater habitats, showing Systems, Subsystems, and Classes. The Palustrine System does not include deepwater habitats.

Table 1. Distribution of Subclasses within the classification hierarchy

	Systems and Subsystems										
	Marine		**Estuarine**		**Riverine**				**Lacustrine**		**Palustrine**
Classes and Subclasses	**ST**	**IT**	**ST**	**IT**	**TI**	**LP**	**UP**	**IN**	**LM**	**LT**	**–**
Rock Bottom											
Bedrock	✓		✓		✓		✓		✓	✓	✓
Rubble	✓		✓		✓		✓		✓	✓	✓
Unconsolidated Bottom											
Cobble-Gravel	✓		✓		✓	✓	✓		✓	✓	✓
Sand	✓		✓		✓	✓	✓		✓	✓	✓
Mud	✓		✓		✓	✓	✓		✓	✓	✓
Organic			✓		✓	✓			✓	✓	✓
Aquatic Bed											
Algal	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Aquatic Moss					✓	✓	✓		✓	✓	✓
Rooted Vascular	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Floating Vascular			✓	✓	✓	✓	✓		✓	✓	✓
Reef											
Coral	✓	✓									
Mollusk			✓	✓							
Worm	✓	✓	✓	✓							
Streambed											
Bedrock				✓	✓			✓			
Rubble				✓	✓			✓			
Cobble-Gravel				✓	✓			✓			
Sand				✓	✓			✓			
Mud				✓	✓			✓			
Organic				✓	✓			✓			
Vegetated (pioneer plants)								✓			
Rocky Shore											
Bedrock		✓		✓	✓	✓	✓			✓	
Rubble		✓		✓	✓	✓	✓			✓	
Unconsolidated Shore											
Cobble-Gravel		✓		✓	✓	✓	✓			✓	✓
Sand		✓		✓	✓	✓	✓			✓	✓
Mud		✓		✓	✓	✓	✓			✓	✓
Organic		✓		✓	✓	✓	✓			✓	✓
Vegetated (pioneer plants)						✓	✓			✓	✓
Moss-Lichen Wetland											
Moss											✓
Lichen											✓
Emergent Wetland											
Persistent				✓							✓
Nonpersistent				✓	✓	✓				✓	✓
Scrub-Shrub Wetland											
Broad-leaved Deciduous				✓							✓
Needle-leaved Deciduous				✓							✓
Broad-leaved Evergreen				✓							✓
Needle-leaved Evergreen				✓							✓
Dead				✓							✓
Forested Wetland											
Broad-leaved Deciduous				✓							✓
Needle-leaved Deciduous				✓							✓
Broad-leaved Evergreen				✓							✓
Needle-leaved Evergreen				✓							✓
Dead				✓							✓

ST = Subtidal, **IT** = Intertidal, **TI** = Tidal, **LP** = Lower Perennial, **UP** = Upper Perennial, **IN** = Intermittent, **LM** = Limnetic, **LT** = Littoral

Artificial keys to the Systems and Classes are given in Appendix B. Scientific and common names of plants (Appendix C) are based on Lichvar and Kartesz (2009). Scientific and common names of animals (Appendix D) are based on the Integrated Taxonomic Information System (http://www.itis.gov); no attempt has been made to resolve nomenclatorial problems where there is a taxonomic dispute. Many of the terms in this classification have various meanings, even in the scientific literature, and in some instances our use of terms is new. Therefore, we have provided a glossary (Appendix A) to guide the reader in our usage of terms.

3.1 Systems and Subsystems

The term SYSTEM refers here to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. We further subdivide Systems into more specific categories called SUBSYSTEMS.

The characteristics of the five major Systems—Marine, Estuarine, Riverine, Lacustrine, and Palustrine—have been discussed at length in the scientific literature and the concepts are well recognized; however, 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 practical needs.

3.1.1 Marine System

Definition. The Marine System (Figure 2) 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. Salinities exceed 30 parts per thousand (ppt), with little or no dilution except outside the mouths of estuaries. Shallow coastal indentations or bays without appreciable freshwater 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 shoreward to one of three lines: (1) the landward limit of tidal inundation (extreme high water of spring tides), including the splash zone from breaking waves; (2) the seaward limit of wetland emergents, trees, or shrubs; or (3) the seaward limit of the Estuarine System, where this limit is determined by factors other than vegetation. Deepwater habitats lying beyond the seaward limit of the Marine System are outside the scope of the WCS.

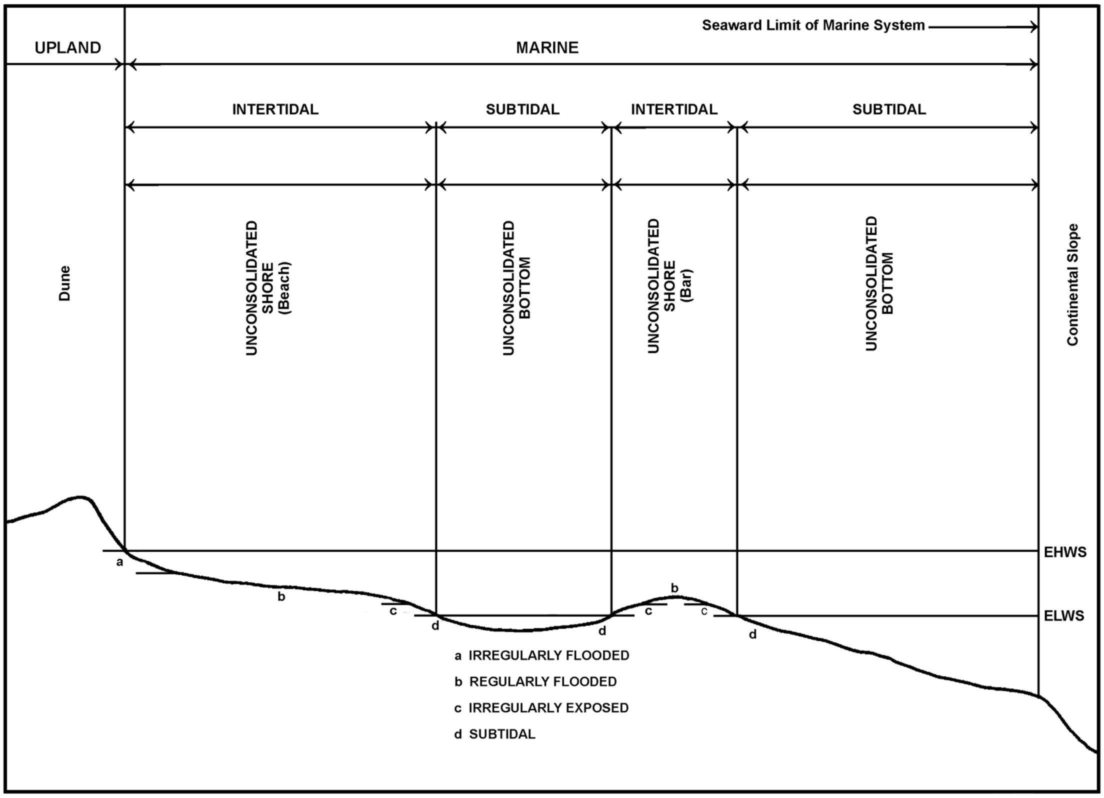

Figure 2. Distinguishing features and examples of habitats in the Marine System.
EHWS = extreme high water of spring tides; ELWS = extreme low water of spring tides.

Description. The distribution of plants and animals in the Marine System primarily reflects differences in four factors: (1) degree of exposure of the site to waves; (2) texture and physicochemical nature of the substrate; (3) 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.

Subtidal. The substrate in these habitats is continuously covered with tidal water (i.e., located below extreme low water).

Intertidal. The substrate in these habitats is flooded and exposed by tides; includes the associated splash zone.

Classes. Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Reef, Rocky Shore, and Unconsolidated Shore.

3.1.2 Estuarine System

Definition. The Estuarine System (Figure 3) consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semienclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater 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. Offshore areas with typical estuarine plants and animals, such as red mangroves (*Rhizophora mangle*) and eastern oysters (*Crassostrea virginica*), are also included in the Estuarine System.[3]

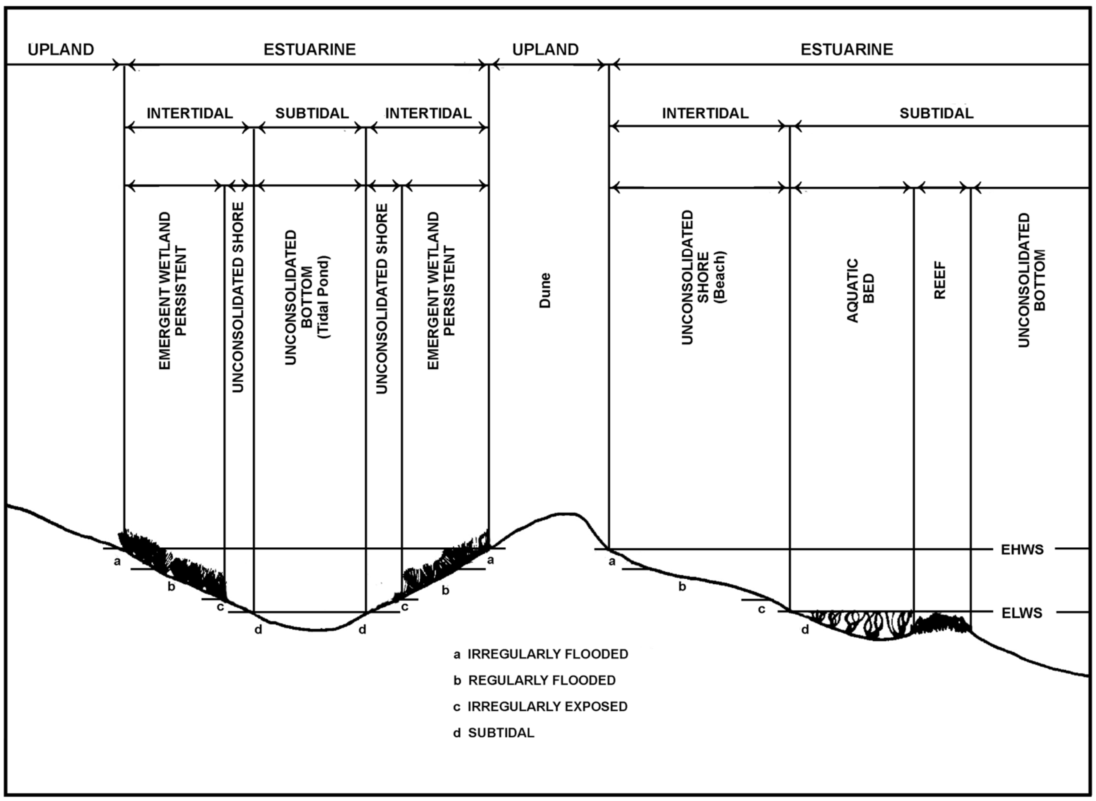

Figure 3. Distinguishing features and examples of habitats in the Estuarine System. EHWS = extreme high water of spring tides; ELWS = extreme low water of spring tides.

Limits. The Estuarine System extends (1) upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow; (2) seaward to an imaginary line closing the mouth of a river, bay, or sound; and (3) to the seaward

[3] 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 freshwater derived from land drainage." The Act further states that "the term includes estuary-type areas of the Great Lakes." However, in the WCS we do not consider areas of the Great Lakes as Estuarine.

limit of wetland emergents, shrubs, or trees where they are not included in (2). The Estuarine System also includes offshore areas of continuously diluted sea water.

Description. The Estuarine System includes both estuaries and lagoons. It is more strongly influenced by its association with land than is the Marine System. In terms of wave action, estuaries are generally considered to be low-energy systems (Chapman 1977).

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 (see Section 3.3.2.1 for Salinity Modifiers). The salinity may be variable, as in hyperhaline lagoons (e.g., Laguna Madre, Texas) and most estuaries (e.g., Chesapeake Bay, Virginia-Maryland); or it may be relatively stable, as in sheltered euhaline embayments (e.g., Chincoteague Bay, Maryland) or embayments with partly obstructed access or small tidal range (e.g., Pamlico Sound, North Carolina). (For an extended discussion of estuaries and lagoons, see Lauff 1967.)

Subsystems.

Subtidal. The substrate in these habitats is continuously covered with tidal water (i.e., located below extreme low water).

Intertidal. The substrate in these habitats is flooded and exposed by tides; includes the associated splash zone.

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

3.1.3 Riverine System

Definition. The Riverine System (Figure 4) includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater. 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 and man-made levees), or by wetlands dominated by trees, shrubs, persistent emergents, emergent 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 equals or exceeds 0.5 ppt 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, or where the channel leaves a lake. Springs discharging into a channel are considered part of the Riverine System.

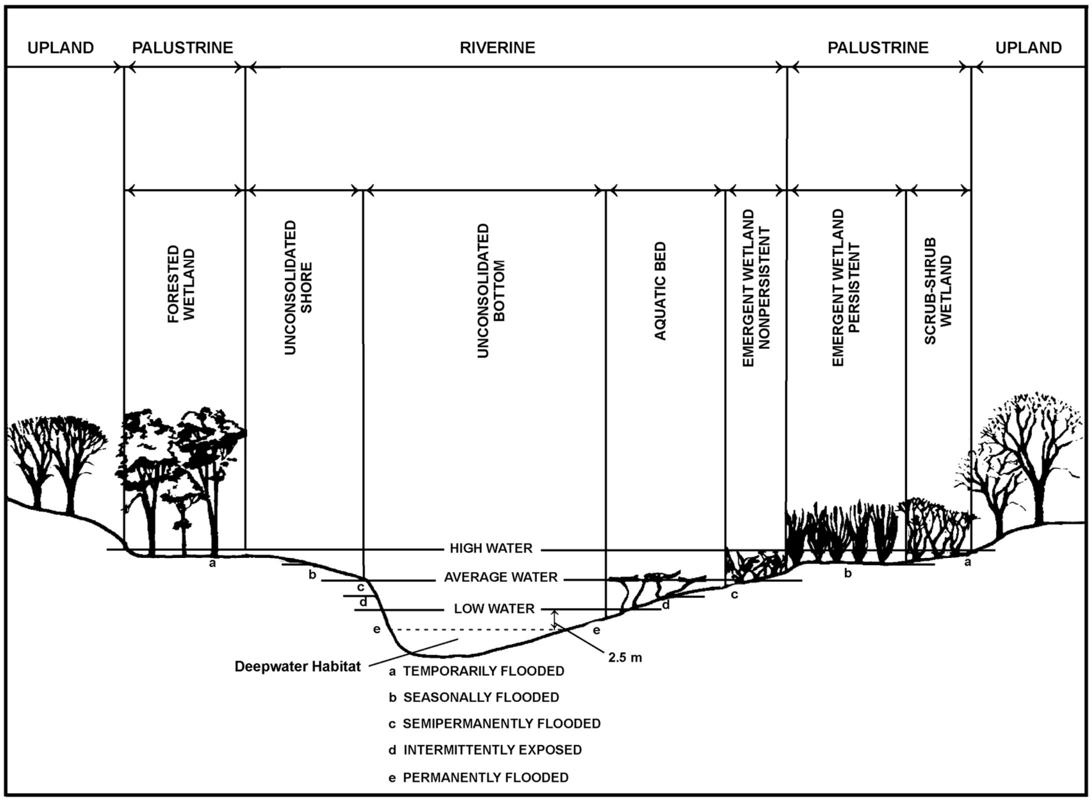

Figure 4. Distinguishing features and examples of habitats in the Riverine System.

Description. Water is usually, but not always, flowing in the Riverine System. Upland islands or Palustrine wetlands may occur in the channel, but they are not included in the Riverine System. Palustrine Moss-Lichen Wetlands, Emergent Wetlands, Scrub-Shrub Wetlands, and Forested Wetlands may occur adjacent to the Riverine System, often on a floodplain. Many biologists have suggested that all the wetlands occurring on the river floodplain should be a part of the Riverine System because they consider their presence to be the result of river flooding. However, this classification follows Reid and Wood (1976:72,84) who stated, "The floodplain is a flat expanse of land bordering an old river…. Often the floodplain may take 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 groundwater) 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, substrate, and the extent of floodplain development. The Subsystems have characteristic flora and fauna (see Illies and Botosaneau 1963; Hynes 1970; Reid and Wood 1976). All four Subsystems are not necessarily present in all rivers, and the order of occurrence may be other than that given below.

Tidal. This Subsystem extends from the upstream limit of tidal fluctuations down to the upper boundary of the Estuarine System, where the concentration of ocean-derived salts reaches 0.5 ppt during the period of average annual low flow. The gradient is low and water velocity fluctuates under tidal influence. The stream bottom is mainly mud with occasional patches of sand. Oxygen deficits may sometimes occur and the fauna is similar to that in the Lower Perennial Subsystem. The floodplain is typically well developed.

Lower Perennial. This Subsystem is characterized by a low gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.

Upper Perennial. This Subsystem is characterized by a high gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. 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 with that of the Lower Perennial Subsystem, and there is very little floodplain development.

Intermittent. This Subsystem includes channels that contain flowing water only part of the year. 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, Streambed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent).

3.1.4 Lacustrine System

Definition. The Lacustrine System (Figure 5) includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with 30 percent or greater areal coverage; and (3) total area of at least 8 hectares (ha) (20 acres). Similar wetlands and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin equals or exceeds 2.5 m (8.2 ft) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity is always less than 0.5 ppt.

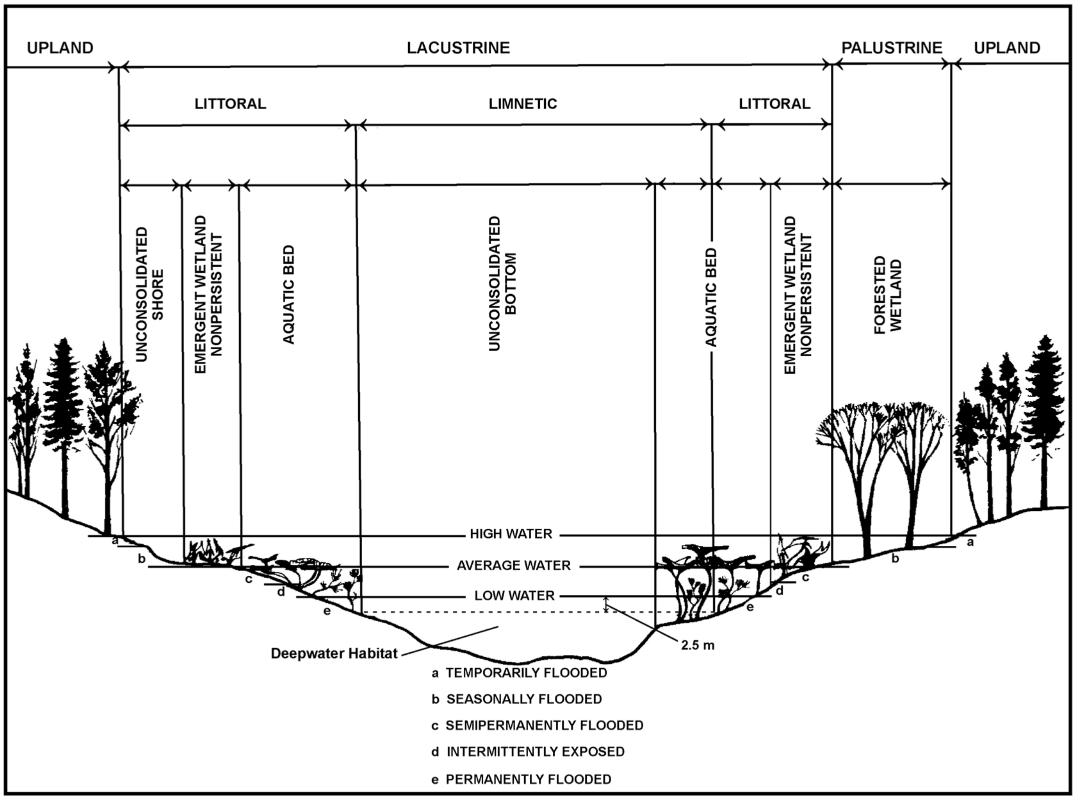

Figure 5. Distinguishing features and examples of habitats in the Lacustrine System.

Limits. The Lacustrine System is bounded by upland or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. Lacustrine Systems formed by damming a river channel are bounded by a 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 ppt (e.g., Grand Lake, Louisiana). Typically, there are extensive areas of deep water and there is considerable wave action. Islands of Palustrine wetlands may lie within the boundaries of the Lacustrine System.

Subsystems.
Limnetic. This subsystem includes all deepwater habitats (i.e., areas ≥ 2.5 m [8.2 ft] deep below low water) in the Lacustrine System. Many small Lacustrine Systems have no Limnetic Subsystem.

Littoral. This subsystem includes all wetland habitats in the Lacustrine System. It extends from the shoreward boundary of the System to a depth of 2.5 m (8.2 ft) below low water, or to the maximum extent of nonpersistent emergents if these grow at depths greater than 2.5 m.

Classes: Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent).

3.1.5 Palustrine System

Definition. The Palustrine System (Figure 6) includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than 2.5 m (8.2 ft) at low water; and (4) salinity due to ocean-derived salts less than 0.5 ppt.

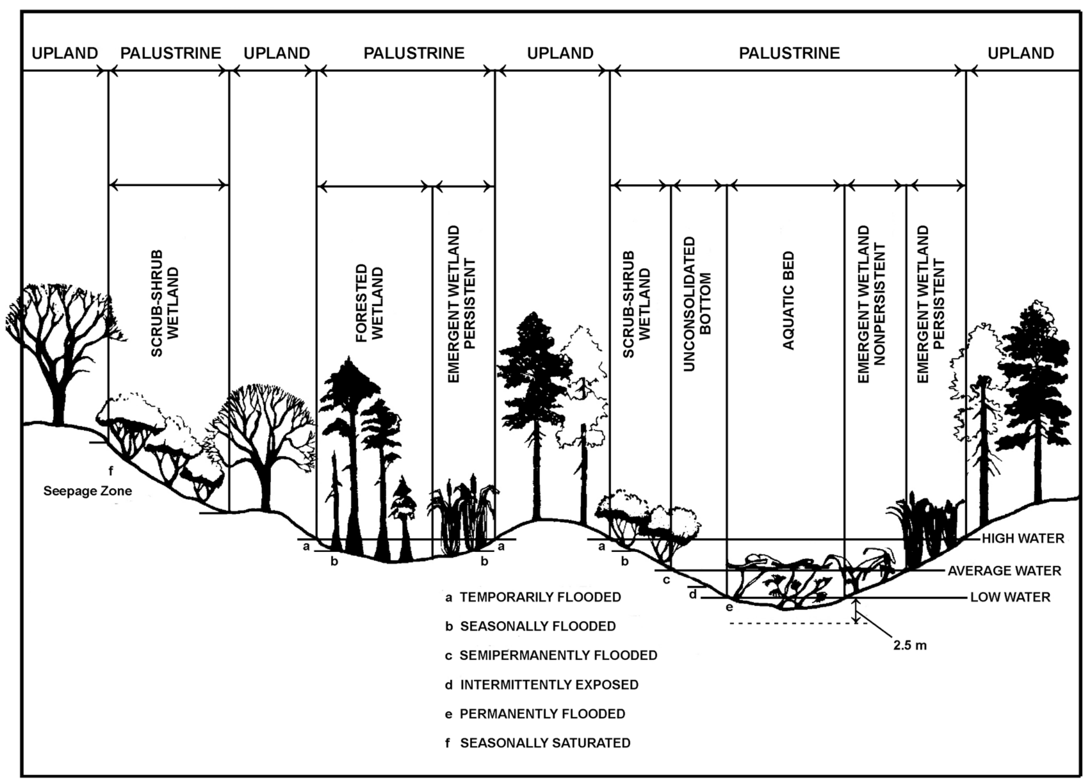

Figure 6. Distinguishing features and examples of habitats in the Palustrine System.

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 vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie, which are found throughout the U.S. It also includes the small, shallow, permanent or intermittent water bodies often called ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; 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 during severe floods.

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 separately from the river or lake. As an example, Hynes (1970:85) wrote 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. None.

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

3.2 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 the dominant life form of the vegetation or the physiography and composition of the substrate—features that can be recognized without the aid of detailed environmental measurements. Vegetation is used at two different levels in the classification. The basic life form layers, from highest to lowest—trees, shrubs, emergents, emergent mosses or lichens, and surface plants or submergents—are used to define Classes because they are relatively easy to distinguish, do not change distribution rapidly, and have traditionally been used for classification of wetlands and habitat assessment.[4] Pioneer plants that colonize wetlands during dry periods, but disappear when surface water returns, are treated at the Subclass level because they are transient and may be mesophytes or xerophytes. Use of life forms at the Class level has two major advantages: (1) extensive biological knowledge is not required to distinguish between various life forms, and (2) many life forms can be readily identified on a variety of remote sensing products (e.g., Radforth 1962; Anderson et al. 1976).

[4] The initial 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 based the Classes on the fundamental components (life form, water regime, substrate type, water chemistry) that give rise to such terms. This approach has greatly reduced the misunderstandings and confusion that result from the use of the familiar terms.

If living vegetation (except pioneer species) covers 30 percent or more of the substrate, we distinguish Classes on the basis of the life form of the plants that constitute the uppermost layer of vegetation and that possess an areal coverage 30 percent or greater. 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 Forested Wetland; an area with 20 percent areal coverage of trees over the same (60 percent) shrub layer would be classified as Scrub-Shrub Wetland. When trees or shrubs alone cover less than 30 percent of an area but in combination cover 30 percent or more, the wetland is assigned to the Class Scrub-Shrub. When trees and shrubs cover less than 30 percent of the area but the total cover of vegetation (except pioneer species) is 30 percent or greater, the wetland is assigned to the appropriate Class for the predominant life form below the shrub layer.

When the height of two or more plant life forms in an area is equal, and each covers 30 percent or more of the area, the Class is based on the life form that has the greater cover. If the cover of the life forms is equal, then the Class is based on the life form that is more persistent. If the life forms are equally persistent, then the Class is based on the life form that would normally be considered to be more advanced from a successional standpoint (e.g., shrub > emergent plant > emergent moss or lichen).

Finer distinctions in life forms are recognized at the SUBCLASS level. Subclasses are named on the basis of the specific life form with the greatest areal coverage. In Scrub-Shrub and Forested Wetlands, for example, most Subclasses are distinguished by leaf type (broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, and needle-leaved evergreen).

When an area is covered more or less uniformly by dead trees or dead shrubs—regardless of their abundance—and living vegetation covers less than 30 percent of that area, the site would be placed in either the Dead Forested Wetland Subclass or the Dead Scrub-Shrub Wetland Subclass, depending on whether dead trees or dead shrubs predominate. However, if living vegetation covers 30 percent or more of a stand of dead trees or shrubs, then the dominant life form, Class, and Subclass would be based on the living vegetation, using the rules outlined above.

If living vegetation covers less than 30 percent of the substrate, the physiography and composition of the substrate are the principal characteristics used to distinguish Classes. Substrate particle sizes include boulders, stones, cobbles, gravel, sand, silt, and clay (see Appendix A for definitions). Cowardin et al. (1979) employed these, alone or in combination, along with the term 'bedrock,' as Subclasses for nonvegetated wetlands and deepwater habitats.

The nature of the substrate reflects regional and local variations in geology and the influence of wind, waves, and currents on erosion and deposition of substrate materials. Bottoms, Shores, and Streambeds are separated on the basis of duration of inundation. In the Riverine, Lacustrine, and Palustrine Systems, Bottoms are submerged all or most of the time, whereas Streambeds and Shores are exposed much of the time. In the Marine and Estuarine Systems, Bottoms are Subtidal, whereas Streambeds and Shores are Intertidal. Bottoms, Shores, and Streambeds are further divided at the Class level on the basis of the important characteristic of rock versus unconsolidated substrate. Subclasses are based on finer distinctions in substrate material unless, as with Streambeds and Shores, pioneer plants (often mesophytes or xerophytes) cover 30 percent or more of the substrate; the Subclass then is simply "vegetated." Further detail as to the type of vegetation must be obtained at the level of Dominance Type. Reefs are a unique Class in which the substrate itself is composed primarily of living and dead animals. Subclasses of Reefs are designated on the basis of the type of organism that formed the reef.

The DOMINANCE TYPE is 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), and this plant is also usually the predominant species (Cain and Castro 1959). When the Subclass is based on life form, the Dominance Type is named for the dominant species or combination of species (codominants) in the same layer of vegetation used to determine the Subclass.[5] For example, a Needle-leaved Evergreen Forested Wetland with 70 percent areal cover of black spruce (*Picea mariana*) and 30 percent areal cover of American larch (*Larix laricina*) would be designated as a *Picea mariana* Dominance Type. When the relative abundance of codominant species is nearly equal, the Dominance Type consists of a combination of species names. For example, an Emergent Wetland with about equal areal cover of broad-leaf cattail (*Typha latifolia*) and hardstem bulrush (*Scirpus acutus*) would be designated a *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, mollusks, crustaceans, worms, ascidians, and echinoderms may all be part of the community represented by the *Macoma balthica* Dominance Type. Sometimes it is necessary to designate two or more codominant species as a Dominance Type. Thorson (1957) recommended guidelines and suggested definitions for establishing community types and dominants on level bottoms.

3.2.1 Rock Bottom

Definition. The Class Rock Bottom includes all wetlands and deepwater habitats with substrates having an areal cover of stones, boulders, or bedrock 75 percent or greater and vegetative cover of less than 30 percent. Water Regimes are restricted to Subtidal, Permanently Flooded, Intermittently Exposed, Semipermanently Flooded, Permanently Flooded-Tidal Fresh, and Semipermanently Flooded-Tidal Fresh.

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[5] Percent areal cover is seldom measured in the application of the WCS, but the term must be defined in terms of area. We suggest 2 m^2 for herbaceous and moss layers, 16 m^2 for shrub layers, and 100 m^2 for tree layers (Mueller-Dombois and Ellenberg 1974). When percent areal cover is the key for establishing boundaries between units of the classification, it may occasionally be necessary to measure cover on plots, in order to maintain uniformity of ocular estimates made in the field or interpretations made from aerial imagery.

Description. The 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 occasionally move about over the substrate. 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 the finer substrates between boulders. Plants are also firmly attached (e.g., by hold-fasts), and in the Riverine System both plants and animals are commonly streamlined or flattened in response to high water velocities.

Subclasses and Dominance Types.

Bedrock. Bottoms in which bedrock covers 75 percent or more of the surface.

Rubble. Bottoms with less than 75 percent areal cover of bedrock, but stones and boulders alone, or in combination with bedrock, cover 75 percent or more of the surface.

Examples of Dominance Types for these two Subclasses in the Marine and Estuarine Systems are the encrusting sponges *Hippospongia*, the tunicate *Cnemidocarpa*, the sea urchin *Strongylocentrotus*, the sea star *Pisaster*, the sea whip *Muricea*, and the American lobster *Homarus americanus*. Examples of Lacustrine, Palustrine, and Riverine Dominance Types are the freshwater sponges *Spongilla* and *Heteromeyenia*, the pond snail *Lymnaea*, the mayfly *Ephemerella*, various midges of the Chironomidae, the caddisfly *Hydropsyche*, the leech *Helobdella*, the riffle beetle *Psephenus*, the chironomid midge *Eukiefferiella*, the crayfish *Procambarus*, and the black fly *Simulium*.

Dominance Types for Rock Bottoms in the Marine and Estuarine Systems were taken primarily from Smith (1964) and Ricketts and Calvin (1968), and those for Rock Bottoms in the Lacustrine, Riverine, and Palustrine Systems from Krecker and Lancaster (1933), Stehr and Branson (1938), Ward and Whipple (1959), Clarke (1973), Hart and Fuller (1974), Ward (1975), Slack et al. (1977), and Pennak (1978).

3.2.2 Unconsolidated Bottom

Definition. The Class Unconsolidated Bottom includes all wetlands and deepwater habitats with at least 25 percent cover of particles smaller than stones and a vegetative cover less than 30 percent. Water Regimes are restricted to Subtidal, Permanently Flooded, Intermittently Exposed, Semipermanently Flooded, Permanently Flooded-Tidal Fresh, and Semipermanently Flooded-Tidal Fresh.

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

Most macroalgae attach to the substrate by means of basal hold-fast cells or discs; in sand and mud, however, algae penetrate the substrate and higher plants can successfully root if wave action and currents are not too strong. Most animals in unconsolidated sediments live within the substrate, e.g., *Macoma* and the amphipod *Melita*. Some, such as the polychaete worm *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 on salinity. Thorson (1957) summarized and described characteristic types of level-bottom communities in detail.

In the Riverine System, the substrate type is largely determined by current velocity, and plants and animals exhibit a high degree of morphologic and behavioral adaptation to flowing water. Certain species are confined to specific substrates and some are at least more abundant in one type of substrate than 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 the 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 and Wood 1976).

Subclasses and Dominance Types.

Cobble-Gravel. The unconsolidated particles smaller than stones are predominantly cobbles and gravel, although finer sediments may be intermixed. Examples of Dominance Types for the Marine and Estuarine Systems are the mussels *Modiolus* and *Mytilus*, the brittle star *Amphipholis*, the soft-shell clam *Mya*, and the Venus clam *Saxidomus*. Examples for the Lacustrine, Palustrine, and Riverine Systems are the midge *Diamesa*, stonefly-midge *Nemoura-Eukiefferiella* (Slack et al. 1977), chironomid midge-caddisfly-snail *Chironomus-Hydropsyche-Physa* (Krecker and Lancaster 1933), the pond snail *Lymnaea*, the mayfly *Baetis*, the freshwater sponge *Eunapius*, the oligochaete worm *Lumbriculus*, the scud *Gammarus*, and the freshwater mollusks *Anodonta*, *Elliptio*, and *Lampsilis*.

Sand. The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed. Examples of Dominance Types in the Marine and Estuarine Systems are the wedge shell *Donax*, the scallop *Pecten*, the tellin shell *Tellina*, the heart urchin *Echinocardium*, the lugworm *Arenicola*, the sand dollar *Dendraster*, and the sea pansy *Renilla*. Examples for the Lacustrine, Palustrine, and

Riverine Systems are the snail *Physa*, the scud *Gammarus*, the oligochaete worm *Limnodrilus*, the mayfly *Ephemerella*, the freshwater mollusks *Elliptio* and *Anodonta*, and the fingernail clam *Sphaerium*.

Mud. The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed. Organisms living in mud must be able to adapt to low oxygen concentrations. Examples of Dominance Types for the Marine and Estuarine Systems include the terebellid worm *Amphitrite*, the boring clam *Platyodon*, the deep-sea scallop *Placopecten*, the quahog *Mercenaria*, the macoma *Macoma*, the echiurid worm *Urechis*, the mud snail *Nassarius*, and the sea cucumber *Thyone*. Examples of Dominance Types for the Lacustrine, Palustrine, and Riverine Systems are the sewage worm *Tubifex*, freshwater mollusks *Anodonta*, *Anodontoides*, and *Elliptio*, the fingernail clams *Pisidium* and *Sphaerium*, and the midge *Chironomus*.

Organic. The unconsolidated material smaller than stones is predominantly organic; there is no minimum depth requirement. The organic material is dead plant tissue in varying stages of decomposition. The number of species is limited and faunal productivity is very low (Welch 1952). Examples of Dominance Types for Estuarine and Marine Systems are the soft-shell clam *Mya*, the false angel wing *Petricola pholadiformis*, the clam worm *Nereis*, and the mud snail *Nassarius*. Examples for the Lacustrine, Palustrine, and Riverine Systems are the sewage worm *Tubifex*, the snail *Physa*, the harpacticoid copepod *Canthocamptus*, and the oligochaete worm *Limnodrilus*. Dominance Types for Unconsolidated Bottoms in the Marine and Estuarine Systems were taken predominantly from Miner (1950), Smith (1964), Abbott (1968), and Ricketts and Calvin (1968). Dominance Types for Unconsolidated Bottoms in the Lacustrine, Riverine, and Palustrine Systems were taken predominantly from Krecker and Lancaster (1933), Stehr and Branson (1938), Johnson (1970), Brinkhurst and Jamieson (1972), Clarke (1973), Hart and Fuller (1974), Ward (1975), and Pennak (1978).

3.2.3 Aquatic Bed

Definition. The Class Aquatic Bed includes wetlands and deepwater habitats where plants that grow principally on or below the surface of the water (i.e., surface plants or submergents) are the uppermost life form layer with at least 30 percent areal coverage. Water Regimes include Subtidal, Irregularly Exposed, Regularly Flooded, Permanently Flooded, Intermittently Exposed, Semipermanently Flooded, Seasonally Flooded, Permanently Flooded-Tidal Fresh, Semipermanently Flooded-Tidal Fresh, Regularly Flooded-Tidal Fresh, and Seasonally Flooded-Tidal Fresh. Not all Water Regimes apply to all subclasses.

Description. Aquatic Beds represent a diverse group of plant communities that require surface water for optimum growth and reproduction. They include submerged or floating-leaved rooted vascular plants, free-floating vascular plants, submergent mosses, and algae. They are best developed in relatively permanent water or under conditions of repeated flooding. The plants are either attached to the substrate or float freely on, or beneath, the water surface.

Subclasses and Dominance Types.

Algal. In these Aquatic Beds, algae have the greatest areal coverage. Algal Beds are widespread and diverse in the Marine and Estuarine Systems, where they occupy substrates characterized by a wide range of sediment depths and textures. They occur in both the Subtidal and Intertidal Subsystems and may grow to depths of 30 m (98 ft). Coastal Algal Beds are most luxuriant along the rocky shores of the Northeast and West. Kelp (*Macrocystis*) beds are especially well developed on the rocky substrates of the Pacific Coast. Dominance Types such as the rockweeds *Fucus* and *Ascophyllum* and the kelp *Laminaria* are common along both coasts. In tropical regions, green algae, including forms containing calcareous particles, are more characteristic; *Halimeda* and *Penicillus* are common examples. The red alga *Laurencia*, and the green algae *Caulerpa*, *Enteromorpha*, and *Ulva* are also common Estuarine and Marine Dominance Types; *Enteromorpha* and *Ulva* are tolerant of fresh water and flourish near the upper end of some estuaries. The stonewort *Chara* also is found in estuaries.

Inland, the stoneworts *Chara*, *Nitella*, and *Tolypella* are examples of algae that look much like vascular plants and may grow in similar situations. However, meadows of *Chara* may be found in Lacustrine water as deep as 40 m (131 ft) (Zhadin and Gerd 1963), where hydrostatic pressure limits the survival of vascular submergents (phanaerogams) (Welch 1952). Other algae bearing less resemblance to vascular plants are also common. Mats of filamentous algae may cover the bottom in dense blankets, may rise to the surface under certain conditions, or may become stranded on Unconsolidated or Rocky Shores.

Aquatic Moss. In this Subclass, aquatic mosses have the greatest areal coverage. Aquatic mosses are far less common than algae or vascular plants. Aquatic Moss Beds 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*. *Fontinalis* may grow to depths as great as 120 m (394 ft) (Hutchinson 1975). For simplicity, aquatic liverworts of the genus *Marsupella* are included in this Subclass.

Rooted Vascular. In this Subclass, rooted vascular plants have the greatest areal coverage. In the Marine and Estuarine Systems, Rooted Vascular Beds include a large array of species that grow primarily below water. They have been referred to by others as temperate grass flats (Phillips 1974); tropical marine meadows (Odum 1974); and eelgrass beds, turtlegrass beds, and seagrass beds (Akins and Jefferson 1973; Eleuterius 1973; Phillips 1974). The greatest number of species occurs 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 turtlegrass (*Thalassia testudinum*), shoalgrass (*Halodule writghtii*), manatee grass (*Cymodocea filiformis*), widgeon grass (*Ruppia martima*), sea grasses (*Halophila* spp.), and wild celery (*Vallisneria americana*).

Five major vascular species dominate along the temperate coasts of North America: shoalgrass, surf grasses (*Phyllospadix scoulleri, P. torreyi*), widgeon grass, and eelgrass (*Zostera marina*). Eelgrass 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 widgeon grass, pondweed (*Potamogeton*), and wild celery often occur, along with naiads (*Najas*) and water milfoil (*Myriophyllum*).

In the Riverine, Lacustrine, and Palustrine Systems, rooted vascular submergent plants occur at all depths within the photic zone. They often occur in sheltered areas where there is little water movement (Wetzel 1975); however, they also occur in the flowing water of the Riverine System, where they may be streamlined or flattened in response to high water velocities. Typical inland genera include pondweeds, horned pondweed (*Zannichellia palustris*), ditch grasses (*Ruppia*), wild celery, and waterweed (*Elodea*). The riverweed (*Podostemum ceratophyllum*) is included in this Class despite its lack of truly recognizable roots (Sculthorpe l967).

Some rooted vascular aquatic plants have floating leaves. Typical dominants include water lilies (*Nymphaea, Nuphar*), floating-leaf pondweed (*Potamogeton natans*), and water shield (*Brasenia schreberi*). Plants such as yellow water lily (*Nuphar luteum*) and water smartweed (*Polygonum amphibium*), which may stand erect above the water surface or substrate, may be considered either emergents or rooted vascular aquatic plants, depending on the life form adopted at a particular site.

Floating Vascular. In this Subclass, vascular plants that float freely on or below the water surface have the greatest areal coverage. Floating Vascular Beds occur mainly in the Lacustrine, Palustrine, and Riverine Systems and in the less saline waters of the Estuarine System. Dominant plants that float on the surface include the duckweeds (*Lemna, Spirodela*), water lettuce (*Pistia stratiotes*), common water hyacinth (*Eichhornia crassipes*), water chestnut (*Trapa natans*), water mosses (*Salvinia* spp.), and mosquito ferns (*Azolla* spp.). These plants are found primarily in protected portions of slow-flowing rivers and in the Lacustrine and Palustrine Systems. They are easily moved about by wind or water currents and cover a large area of water in some parts of the country, particularly the Southeast. Dominance Types for beds floating below the surface include bladderworts (*Utricularia*), coontails (*Ceratophyllum*), and watermeals (*Wolffia*) (Sculthorpe 1967; Hutchinson 1975).

3.2.4 Reef

Definition. The Class Reef includes ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates. Water Regimes are restricted to Subtidal, Irregularly Exposed, and Regularly Flooded

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 tube worms are the most visible organisms and are mainly responsible for reef formation, other mollusks, foraminifera, coralline algae, and other forms of life also contribute substantially to reef growth. Frequently, reefs contain far more dead skeletal material and shell fragments than living matter.

Subclasses and Dominance Types.

Coral. Coral Reefs are widely distributed in shallow waters of warm seas, in Hawaii, Puerto Rico, the Virgin Islands, and southern Florida. They were 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 Subtidal Subsystem of the Marine System, although the upper part of certain Reefs may be Intertidal. Examples of Dominance Types are the corals *Porites*, *Acropora*, and *Montipora*. The distribution of these types reflects primarily their elevation, wave exposure, the age of the Reef, and its exposure to waves.

Mollusk. This Subclass occurs in both the Intertidal and Subtidal Subsystems of the Estuarine System. These Reefs are found on the Pacific, Atlantic, and Gulf Coasts and in Hawaii and the Caribbean. Mollusk Reefs may become extensive, affording a substrate for sedentary and boring organisms and a shelter for many others. Reef mollusks 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* and *Crassostrea* (Smith 1964; Abbott 1968; Ricketts and Calvin 1968).

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 Mollusk 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 Intertidal and Subtidal Systems of the Marine and Estuarine Systems where the salinity approximates that of sea water. The reef worm *Sabellaria* is an example of a Dominance Type for this Subclass (Ricketts and Calvin 1968).

3.2.5 Streambed

Definition. The Class Streambed includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide. Water Regimes are restricted to Irregularly Exposed, Regularly Flooded, Irregularly Flooded, Seasonally Flooded, Temporarily Flooded, Intermittently Flooded, and Regularly Flooded-Tidal Fresh. Not all Water Regimes apply to all subclasses.

Description. Streambeds vary greatly in substrate and form depending on the gradient of the channel, the velocity of the water, and the sediment load. The substrate material frequently changes abruptly between riffles and pools, and complex patterns of bars may form on the convex side of single channels or be included as islands within the bed of braided streams (Crickmay 1974). In mountainous areas the entire channel may be cut through bedrock. In most cases streambeds are not vegetated because of the scouring effect of moving water, but, like Unconsolidated Shores, they may be colonized by "pioneer" annuals or perennials during periods of low flow or they may have perennial emergents and shrubs that are too scattered to qualify the area for classification as Emergent Wetland or Scrub-Shrub Wetland.

Subclasses and Dominance Types.

Bedrock. This Subclass is characterized by a bedrock substrate covering 75 percent or more of the stream channel. It occurs most commonly in the Riverine System in high mountain areas or in glaciated areas where bedrock is exposed. Examples of Dominance Types are the mollusk *Ancylus*, the oligochaete worm *Limnodrilus*, the snail *Physa*, the fingernail clam *Pisidium*, and the mayflies *Caenis* and *Ephemerella*.

Rubble. This Subclass is characterized by stones, boulders, and bedrock that, combined, cover 75 percent or more of the channel; however, bedrock alone covers less than 75 percent. Like Bedrock Streambeds, Rubble Streambeds are most common in mountainous areas and the dominant organisms are similar to those of Bedrock and are often forms capable of attachment to rocks in flowing water.

Cobble-Gravel. In this Subclass at least 25 percent of the substrate is covered by unconsolidated particles smaller than stones; cobbles or gravel predominate. The Subclass occurs in riffle areas or in the channels of braided streams. Examples of Dominance Types in the Intermittent Subsystem of the Riverine System are the snail *Physa*, the oligochaete worm *Limnodrilus*, the mayfly *Caenis*, the midge *Chironomus*, and the mosquito *Anopheles*. Examples of Dominance Types in the Estuarine System or Tidal Subsystem of the Riverine System are the mussels *Modiolus* and *Mytilus*.

Sand. In this Subclass, sand-sized particles predominate among the particles smaller than stones. Sand Streambed often contains bars and beaches interspersed with Mud Streambed or it may be interspersed with Cobble-Gravel Streambed in areas of fast flow or heavy sediment load. Examples of Dominance Types in the Riverine System are the scud *Gammarus*, the snails *Physa* and *Lymnaea*, and the midge *Chironomus*; in the Estuarine System the ghost shrimp *Callianassa* is a common Dominance Type.

Mud. In this Subclass, the particles smaller than stones are chiefly silt or clay. Mud Streambeds are common in arid areas where intermittent flow is characteristic of streams of low gradient. Such species as tamarisk (*Tamarix gallica*) may occur, but are not dense enough to qualify the area for classification as Scrub-Shrub Wetland. Mud Streambeds are also common in the Estuarine System and the Tidal Subsystem of the Riverine System. Examples of Dominance Types for Mud Streambeds include the crayfish *Procambarus*, the pouch snail *Aplexa*, the fly *Tabanus*, the snail *Lymnaea*, the fingernail clam *Sphaerium*, and (in the Estuarine System) the mud snail *Nassarius*.

Organic. This Subclass is characterized by channels formed in peat or muck. Organic Streambeds are common in the small creeks draining Estuarine Emergent Wetlands with organic soils. Examples of Dominance Types are the mussel *Modiolus* in the Estuarine System and the oligochaete worm *Limnodrilus* in the Riverine System.

Vegetated. These Streambeds are exposed long enough to be colonized by pioneer plants that, unlike Emergent Wetland plants or Scrub-Shrub Wetland plants, are usually killed by rising water levels. Many of the pioneer species are weedy mesophytes or xerophytes. At least 30 percent cover of pioneer plants is required. Common panic grass (*Panicum capillare*) is a typical Dominance Type in the Riverine System.

Dominance Types for Streambeds in the Estuarine System were taken primarily from Smith (1964), Abbott (1968), and Ricketts and Calvin (1968) and those for streambeds in the Riverine System from Krecker and Lancaster (1933), Stehr and Branson (1938), van der Schalie (1948), Kenk (1949), Cummins et al. (1964), Clarke (1973), and Ward (1975).

3.2.6 Rocky Shore

Definition. The Class Rocky Shore includes wetland habitats characterized by bedrock, stones, or boulders, which singly or in combination have an areal cover of 75 percent or more, and an areal coverage by vegetation of less than 30 percent. Water Regimes are restricted to Irregularly Exposed, Regularly Flooded, Irregularly Flooded, Seasonally Flooded, Temporarily Flooded, Intermittently Flooded, and Regularly Flooded-Tidal Fresh

Description. In Marine and Estuarine Systems, Rocky Shores are generally high-energy habitats that 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 that 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.

Bedrock. These wetlands have bedrock covering 75 percent or more of the surface and less than 30 percent areal coverage of macrophytes.

Rubble. These wetlands have less than 75 percent areal cover of bedrock, but stones and boulders alone or in combination with bedrock cover 75 percent or more of the area. The areal coverage of macrophytes is less than 30 percent.

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

The uppermost zone (here 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 semimarine genera such as the slater *Ligia*.

The next lower zone (the balanoid zone) is commonly dominated by mollusks, green algae, and barnacles of the balanoid group. The zone appears white. Dominance Types such as the barnacles *Balanus*, *Chthamalus*, and *Tetraclita* may form an almost pure sheet, or these animals may be interspersed with mollusks, tube worms, and algae such as *Pelvetia*, *Enteromorpha*, and *Ulva*.

The transition between the littorine-lichen and balanoid zones is frequently marked by the replacement of the periwinkles with 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. *Mytilus* and gooseneck barnacles (*Pollicipes*) form communities exposed to strong wave action. Aquatic Beds dominated by *Fucus* and *Laminaria* lie slightly lower, just above those dominated by coralline algae (*Lithothamnion*). 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.

In the Palustrine, Riverine, and Lacustrine Systems, various species of lichens such as *Verrucaria* spp. and *Dermatocarpon fluviatile*, as well as blue-green algae, frequently form characteristic zones on Rocky Shores. The distribution of these species depends on the duration of flooding or wetting by spray and is similar to the zonation of species in the Marine and Estuarine Systems (Hutchinson 1975). Though less abundant than lichens, aquatic liverworts such as *Marsupella emarginata* var. *aquatica* or mosses such as *Fissidens julianus* are found on the Rocky Shores of lakes and rivers. If aquatic liverworts or mosses cover 30 percent or more of the substrate, they should be placed in the Class Aquatic Bed. Other examples of Rocky Shore Dominance Types are the caddisfly *Hydropsyche* and the fingernail clam *Pisidium*.

3.2.7 Unconsolidated Shore

Definition. The Class Unconsolidated Shore includes all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; (2) less than 30 percent areal cover of vegetation other than pioneer plants; and (3) any of the following Water Regimes: Irregularly Exposed, Regularly Flooded, Irregularly Flooded, Seasonally Flooded, Seasonally Flooded-Saturated, Temporarily Flooded, Intermittently Flooded, Regularly Flooded-Tidal Fresh, Seasonally Flooded-Tidal Fresh, and Temporarily Flooded-Tidal Fresh. Intermittent or intertidal channels of the Riverine System and intertidal channels of the Estuarine System are classified as Streambed. Not all Water Regimes apply to all subclasses.

Description. Unconsolidated Shores are characterized by substrates lacking vegetation except for pioneer plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms such as beaches, bars, and flats, all of which are included in this Class. Unconsolidated Shores are commonly found adjacent to Unconsolidated Bottoms in all Systems; in the Palustrine and Lacustrine Systems, the Class may occupy the entire basin. As in Unconsolidated Bottoms, the particle size of the substrate and the water regime are the important factors determining the types of plant and animal communities present. Different substrates usually support characteristic invertebrate fauna. Faunal distribution is controlled by waves, currents, interstitial moisture, salinity, and grain size (Hedgpeth 1957; Ranwell 1972; Riedl and McMahan 1974).

Subclasses and Dominance Types.

Cobble-Gravel. The unconsolidated particles smaller than stones are predominantly cobbles and gravel. Shell fragments, sand, and silt often fill the spaces between the larger particles. Stones and boulders may be found scattered on some Cobble-Gravel Shores. In areas of strong wave and current action these shores take the form of beaches or bars, but occasionally they form extensive flats. Examples of Dominance Types in the Marine and Estuarine Systems are: the acorn barnacle *Balanus*, the limpet *Patella*, the periwinkle *Littorina*, the rock shell *Thais*, the mussels *Mytilus* and *Modiolus*, and the Venus clam *Saxidomus*. In the Lacustrine, Palustrine, and Riverine Systems examples of Dominance Types are the freshwater mollusk *Elliptio*, the snails *Lymnaea* and *Physa*, the toad bug *Gelastocoris*, the leech *Erpodella*, and the springtail *Agrenia*.

Sand. The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed. Sand may be either calcareous or terrigenous in origin. Sand shores are a prominent feature of the Marine, Estuarine, Riverine, and Lacustrine Systems where the substrate material is exposed to the sorting and washing action of waves. Examples of Dominance Types in the Marine and Estuarine Systems are the wedge shell *Donax*, the soft-shell clam *Mya*, the quahog *Mercenaria*, the olive shell *Oliva*, the blood worm *Euzonus*, the beach hopper *Orchestia*, the pismo clam *Tivela stultorum*, the mole crab *Emerita*, and the lugworm *Arenicola*. Examples of Dominance Types in the Riverine, Lacustrine, and Palustrine Systems are the copepods *Parastenocaris* and *Phyllognathopus*, the oligochaete worm *Pristina*, the freshwater mollusks *Anodonta* and *Elliptio*, and the fingernail clams *Pisidium* and *Sphaerium*.

Mud. The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed. Anaerobic conditions often exist below the surface. Mud Shores have a higher organic content than Cobble-Gravel or Sand Shores. They are typically found in areas of minor wave action. They tend to have little slope and are frequently called flats. Mud Shores support diverse populations of tube-dwelling and burrowing invertebrates that include worms, clams, and crustaceans (Gray 1974). They are commonly colonized by algae and diatoms which may form a crust or mat.

Irregularly flooded Mud Shores in the Estuarine System 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). In many arid areas, Palustrine and Lacustrine Mud Shores are encrusted 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. Mud Shores may also result from removal of vegetation by man, animals, or fire, or from the discharge of thermal waters or pollutants.

Examples of Dominance Types in the Marine and Estuarine Systems include the fiddler crab *Uca*, the ghost shrimp *Callianassa*, the mud snails *Nassarius* and *Macoma*, the clam worm *Nereis*, the sea anemone *Cerianthus*, and the sea cucumber *Thyone*. In the Lacustrine, Palustrine, and Riverine Systems, examples of Dominance Types are the fingernail clam *Pisidium*, the snails *Aplexa* and *Lymaea*, the crayfish *Procambarus*, the harpacticoid copepods *Canthocamptus* and *Bryocamptus*, the fingernail clam *Sphaerium*, the freshwater mollusk *Elliptio*, the shore bug *Saldula*, the isopod *Asellus*, the crayfish *Cambarus*, and the mayfly *Tortopus*.

Organic. The unconsolidated material smaller than stones is predominantly organic; there is no minimum depth requirement. The organic material is dead plant tissue in varying stages of decomposition. In the Marine and Estuarine Systems, Organic Shores are often dominated by microinvertebrates such as foraminifera, and by *Nassarius*, *Littorina*, *Uca*, *Modiolus*, *Mya*, *Nereis*, and the false angel wing *Petricola pholadiformis*. In the Lacustrine, Palustrine, and Riverine Systems, examples of Dominance Types are *Canthocamptus*, *Bryocamptus*, *Chironomus*, and the backswimmer *Notonecta*.

Vegetated. Some nontidal Shores are exposed for a sufficient period to be colonized by pioneer plants that, unlike Emergent Wetland plants or Scrub-Shrub Wetland plants, are usually killed by rising water levels. Many of the pioneer species are weedy mesophytes or xerophytes. At least 30 percent cover of pioneer plants is required. Examples of Dominance Types are rough cocklebur (*Xanthium strumarium*) and large barnyard grass (*Echinochloa crusgalli*).

Dominance Types for Unconsolidated Shores in the Marine and Estuarine Systems were taken primarily from Smith (1964), Morris (1966), Abbott (1968), Ricketts and Calvin (1968), and Gosner (1971). Dominance Types for Unconsolidated Shores in the Lacustrine, Riverine, and Palustrine Systems were taken primarily from Stehr and Branson (1938), Kenk (1949), Ward and Whipple (1959), Cummins et al. (1964), Johnson (1970), Ingram (1971), Clarke (1973), and Hart and Fuller (1974).

3.2.8 Moss-Lichen Wetland

Definition. The Moss-Lichen Wetland Class includes areas where mosses or lichens cover at least 30 percent of substrates other than rock and where emergents, shrubs, or trees alone or in combination cover less than 30 percent. Water Regimes include Seasonally Flooded, Seasonally Flooded-Saturated, Continuously Saturated and Seasonally Saturated.

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 U.S. where they occur most frequently.

Subclasses and Dominance Types.

Moss. In this Subclass, the areal coverage of mosses exceeds that of lichens. Moss dominated wetlands are most abundant in the far northern boreal forests and Arctic tundra, where they are dominated by peat mosses such as *Sphagnum fuscum* and *S. warnstorfii*. These wetlands are typically called bogs (Golet and Larson 1974; Jeglum et al. 1974; Zoltai et al. 1975), whether *Sphagnum* or higher plants dominate. In Alaska, *Drepanocladus revolvans*, *D. lycodiodes*, and the liverwort *Chiloscyphus fragilis* may dominate shallow pools with semipermanent water. Other mosses, including *Campylium stellatum*, *Aulacomnium palustre*, *A. turgidum* and *Oncophorus wahlenbergii*, are typical of wet, saturated soils in these regions (Britton 1957, Drury 1962).

Lichen. In this Subclass, the areal coverage of lichens exceeds that of mosses. Lichen Wetlands also are a Northern Subclass. Reindeer moss (*Cladina* and *Cladonia*), the principal Dominance Type, occurs primarily in boreal and Arctic regions. Lichen cover is generally elevated above moss, sedge-moss, or dwarf shrub-sedge-moss layers. 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. The presence of Lichen Wetlands has been noted in the Hudson Bay Lowlands (Sjörs 1959) and in Ontario (Jeglum et al. 1974).

3.2.9 Emergent Wetland

Definition. In this wetland Class, emergent plants—i.e., erect, rooted, herbaceous hydrophytes, excluding mosses and lichens—are the tallest life form with at least 30% areal coverage. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All Water Regimes are included except Subtidal and Irregularly Exposed. Not all Water Regimes apply to all subclasses.

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 U.S., violent climatic fluctuations cause them to revert to an open water phase in some years (Stewart and Kantrud 1972). Emergent Wetlands are found throughout the U.S. and occur in all Systems except the Marine. Emergent Wetlands are known by many names, including marsh, wet meadow, fen, prairie pothole, and slough. Areas that are dominated by pioneer plants, which become established during periods of low water, are not Emergent Wetlands and should be classified as Vegetated Unconsolidated Shores or Vegetated Streambeds.

Subclasses and Dominance Types.

Persistent. In this Subclass, the areal coverage of persistent emergents exceeds that of nonpersistent emergents. Persistent emergents are emergent hydrophytes whose stems and leaves are evident all year above the surface of the water, or above the soil surface if water is absent. Persistent Emergent Wetlands occur only in the Estuarine and Palustrine Systems.

Persistent Emergent Wetlands dominated by saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*S. patens*), big cordgrass (*S. cynosuroides*), Roemer's rush (*Juncus roemerianus*), narrow-leaved cattail (*Typha angustifolia*), and mash-millet (*Zizaniopsis miliacea*) are major components of the Estuarine Systems of the Atlantic and Gulf Coasts of the U.S. On the Pacific Coast, woody saltwort (*Salicornia virginica*), broom seepweed (*Suaeda californica*), seaside arrow-grass (*Triglochin maritimum*), and California cordgrass (*Spartina foliosa*) are common dominants.

Palustrine Persistent Emergent Wetlands contain a vast array of grasslike plants such as cattails (*Typha* spp.), bulrushes (*Scirpus* spp.), saw grass (*Cladium jamaicense*), sedges (*Carex* spp.); and true grasses such as manna grasses (*Glyceria* spp.), slough grass (*Beckmannia syzigachne*), and common river grass (*Scolochloa festucacea*). There is also a variety of broad-leaved persistent emergents such as purple loosestrife (*Lythrum salicaria*), Mexican dock (*Rumex mexicanus*), swamp loosestrife (*Decodon verticillatus*), and some species of smartweeds (*Polygonum*).

Nonpersistent. In this Subclass, the areal coverage of nonpersistent emergents exceeds that of persistent emergents. Nonpersistent emergents are emergent hydrophytes whose stems and leaves are evident above the water surface, or above the soil surface if surface water is absent, only during the growing season or shortly thereafter. During the dormant season, there is no obvious sign of emergent vegetation. Nonpersistent Emergent Wetlands occur in all Systems except the Marine. Nonpersistent emergents also include species such as green arrow-arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), and arrowheads (*Sagittaria* spp.). Movement of ice in Estuarine, Riverine, or Lacustrine Systems often removes all traces of emergent vegetation during the winter. Where this occurs, the area should be classified as Nonpersistent Emergent Wetland.

3.2.10 Scrub-Shrub Wetland

Definition. In Scrub-Shrub Wetlands, woody plants less than 6 m (20 ft) tall are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. The “shrub” life form actually includes true shrubs, young specimens of tree species that have not yet reached 6 m in height, and woody plants (including tree species) that are stunted because of adverse environmental conditions. All Water Regimes except Subtidal and Regularly Flooded-Tidal Fresh are included. Not all Water Regimes apply to all subclasses.

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 U.S. (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), fen (Jeglum 1974), and pocosin (Kologiski 1977). For practical reasons we have also included stands of young trees less than 6 m tall.

Subclasses and Dominance Types.

Broad-leaved Deciduous. In this Subclass, broad-leaved deciduous species have the greatest areal coverage within the shrub layer. In the Estuarine System, Dominance Types include species such as sea-myrtle (*Baccharis halimifolia*) and high-tide bush (*Iva frutescens*). In the Palustrine System, typical Dominance Types are alders (*Alnus* spp.), willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), red osier dogwood (*Cornus stolonifera*), honeycup (*Zenobia pulverulenta*), Douglas' meadowsweet (*Spiraea douglasii*), bog birch (*Betula pumila*), and young red maple (*Acer rubrum*).

Needle-leaved Deciduous. In this Subclass, needle-leaved deciduous species have the greatest areal coverage within the shrub layer. Dominance Types include young or stunted tamarack and southern bald-cypress (*Taxodium distichum*).

Broad-leaved Evergreen. In this Subclass, broad-leaved evergreen species have the greatest areal coverage within the shrub layer. In the Estuarine System, vast wetland acreages are dominated by mangroves (*Rhizophora mangle*, *Languncularia racemosa*, *Conocarpus erectus*, and *Avicennia germinans*). In the Palustrine System, the broad-leaved evergreen species are typically found on organic soils. Northern representatives are labrador tea (*Ledum groenlandicum*), bog rosemary (*Andromeda polifolia L.*), bog laurel (*Kalmia polifolia*), and the semi-evergreen, leatherleaf (*Chamaedaphne calyculata*). In the South, shinyleaf (*Lyonia lucida*), coastal dogbobble (*Leucothoe axillaris*), inkberry (*Ilex glabra*), and the semi-evergreen, swamp titi (*Cyrilla racemiflora*), are characteristic broad-leaved evergreen species.

Needle-leaved Evergreen. In this Subclass, needle-leaved evergreen species have the greatest areal coverage within the shrub layer. Examples of Dominance Types include young or stunted black spruce (*Picea mariana*) and pond pine (*Pinus serotina*).

Dead. This Subclass includes stands of dead woody plants less than 6 m tall, regardless of their density, with less than 30 percent cover of living vegetation. If living vegetation equals or exceeds 30 percent in such stands, the Class and Subclass are based on the dominant life form of the living plants. Dead Scrub-Shrub Wetlands usually are produced by a prolonged rise in the water level resulting from impoundment by humans or beavers. In tidal areas, hurricanes, coastal subsidence, and sea level rise also may be responsible.

3.2.11 Forested Wetland

Definition. In Forested Wetlands, trees are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. Trees are defined as woody plants at least 6 m (20 ft) in height. All Water Regimes except Subtidal and Regularly Flooded-Tidal Fresh are included. Not all Water Regimes apply to all subclasses.

Description. Forested Wetlands are most common in the eastern U.S. 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 and normally possess an overstory of trees, an understory of young trees or shrubs, and an herbaceous layer. Forested Wetlands in the Estuarine System, which include the mangrove forests of Florida, Puerto Rico, and the Virgin Islands, are known by such names as swamps, hammocks, heads, and bottoms. Such common names are often applied, in combination with species names or plant association names, in Palustrine forests as well (e.g., cedar swamp, bottomland hardwoods).

Subclasses and Dominance Types.

Broad-leaved Deciduous. In this Subclass, broad-leaved deciduous species have the greatest areal coverage in the tree layer. Broad-leaved Deciduous Forested Wetlands, which are represented throughout the United States, are most common in the South and East. Common Dominance Types include red maple, American elm (*Ulmus americana*), ashes (*Fraxinus pennsylvanica* and *F. nigra*), black gum (*Nyssa sylvatica*), tupelo gum (*N. aquatica*), swamp white oak (*Quercus bicolor*), overcup oak (*Q. lyrata*), and swamp chestnut oak (*Q. michauxii*). Wetlands in this Subclass generally occur on mineral soils or highly decomposed organic soils.

Needle-leaved Deciduous. In this Subclass, needle-leaved deciduous species have the greatest areal coverage in the tree layer. The southern representative of the Needle-leaved Deciduous Subclass is bald cypress, which is noted for its ability to tolerate long periods of surface inundation. Tamarack is characteristic of the Boreal Forest Region, where it occurs as a dominant on organic soils. Relatively few other species are included in this Subclass.

Broad-Leaved Evergreen. In this Subclass, broad-leaved evergreen species have the greatest areal coverage in the tree layer. In the Southeast, Broad-leaved Evergreen Forested Wetlands reach their greatest development. Red bay (*Persea borbonia*), loblolly bay (*Gordonia lasianthus*), and sweet bay (*Magnolia virginiana*) are prevalent, especially on organic soils. Other Dominance Types include red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Languncularia racemosa*), which are adapted to varying levels of salinity.

Needle-leaved Evergreen. In this Subclass, needle-leaved evergreen species have the greatest areal coverage in the tree layer. Black spruce, growing on nutrient-poor organic soils, represents a major dominant of the Needle-leaved Evergreen Subclass in the North. Eastern arborvitae (*Thuja occidentalis*) dominates northern wetlands on more nutrient-rich sites. Along the Atlantic Coast, Atlantic white cedar (*Chamaecyparis thyoides*) is one of the most common dominants on organic soils. Pond pine is a common needle-leaved evergreen found in the Southeast in association with dense stands of broad-leaved evergreen and deciduous shrubs.

Dead. This Subclass includes stands of dead woody plants at least 6 m tall, regardless of their density, with less than 30 percent cover of living vegetation. If living vegetation equals or exceeds 30 percent in such stands, the Class and Subclass are based on the dominant life form of the living plants. Dead Forested Wetlands usually are produced by a prolonged rise in the water level resulting from impoundment by humans or beavers. In tidal areas, hurricanes, coastal subsidence, and sea level rise also may be responsible.

3.3 Modifiers

To fully describe wetlands and deepwater habitats, one must apply certain Modifiers to the classification hierarchy. The Modifiers described were adapted from existing classifications or were developed specifically for this classification system.

3.3.1 Water Regime Modifiers

Description of hydrologic characteristics requires detailed knowledge of the duration and timing of surface inundation, both yearly and long-term, as well as an understanding of groundwater fluctuations. Because such information is seldom available, the Water Regimes that, in part, determine characteristic wetland and deepwater plant and animal communities are described here in only general terms. Water Regimes are grouped under three major headings, Tidal Salt, Nontidal, and Tidal Fresh.

Tidal Salt.

Tidal Salt Water Regime Modifiers are used for wetlands and deepwater habitats in the Marine and Estuarine Systems, where ocean-derived salinity equals or exceeds 0.5 ppt. These Water Regimes are primarily a function of oceanic tides.

Subtidal. Tidal salt water continuously covers the substrate.

Irregularly Exposed. Tides expose the substrate less often than daily.

Regularly Flooded. Tides alternately flood and expose the substrate at least once daily.

Irregularly Flooded. Tides flood the substrate less often than daily.

The periodicity and amplitude of tides vary in different parts of the U.S., mainly because of differences in latitude and geomorphology. On the Atlantic Coast, two nearly 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); and on the Pacific Coast there are usually two unequal high tides and two unequal low tides (mixed semidiurnal).

Tides range in height from about 9.5 m (31 ft) at St. John, New Brunswick (NOAA 1973) to less than 1 m (3.3 ft) along the Louisiana coast (Chabreck 1972). Tides of only 10 cm (4.0 inches) are not uncommon in Louisiana. Therefore, although no hard and fast rules apply, the division between Regularly Flooded and Irregularly Flooded Water Regimes would probably occur approximately at mean high water on the Atlantic Coast, at the lowest level of the 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 waves.

Nontidal.

Nontidal Water Regime Modifiers are used for all nontidal parts of the Palustrine, Lacustrine, and Riverine Systems. Although not influenced by oceanic tides, Nontidal Water Regimes may be affected by wind or seiches in lakes. Nontidal Water Regimes are defined in terms of the growing season which, for the purposes of this classification, begins with green-up and bud-break of native plants in the spring and ends with plant dieback and leaf-drop in the fall due to the onset of cold weather. During the rest of the year, which is defined as the dormant season, even extended periods of flooding may have little influence on the development or survival of plant communities.

Permanently Flooded. Water covers the substrate throughout the year in all years.

Intermittently Exposed. Water covers the substrate 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.

Seasonally Flooded. Surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the depth to substrate saturation may vary considerably among sites and among years.

Seasonally Flooded-Saturated. Surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the substrate typically remains saturated at or near the surface.

Seasonally Saturated. The substrate is saturated at or near the surface for extended periods during the growing season, but unsaturated conditions prevail by the end of the season in most years. Surface water is typically absent, but may occur for a few days after heavy rain and upland runoff.

Continuously Saturated. The substrate is saturated at or near the surface throughout the year in all, or most, years. Widespread surface inundation is rare, but water may be present in shallow depressions that intersect the groundwater table, particularly on a floating peat mat.

Temporarily Flooded. Surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season.

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 Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.

Artificially Flooded. The amount and duration of flooding are controlled by means of pumps or siphons in combination with dikes, berms, or dams. The vegetation growing on these areas cannot be considered a reliable indicator of Water Regime. Examples of Artificially Flooded wetlands are some agricultural lands managed under a rice-soybean rotation, and wildlife management areas where forests, crops, or pioneer plants may be flooded or dewatered to attract wetland wildlife. Neither wetlands within or resulting from leakage from man-made impoundments, nor irrigated pasture lands supplied by diversion ditches or artesian wells, are included under this Modifier. The Artificially Flooded Water Regime Modifier should not be used for impoundments or excavated wetlands unless both water inputs and outputs are controlled to achieve a specific depth and duration of flooding.

Tidal Fresh.

The Tidal Subsystem of the Riverine System and tidally influenced parts of the Palustrine and Lacustrine Systems are unique because the hydrology of their habitats is driven primarily by nontidal inputs and outputs, but influenced by tides as well. In these habitats, ocean-derived salts measure less than 0.5 ppt. The hydrologic regimes of Tidal Fresh habitats are described through the use of four Nontidal Water Regime Modifiers, coupled with the suffix '-Tidal Fresh', as in Seasonally Flooded-Tidal Fresh, and an additional Modifier based on tidal action. Each of the first four Modifiers reflects the relative duration of substrate inundation during the growing season. It also indicates that, in response to oceanic tides, the water level at each site rises and falls daily. The fifth Modifier focuses specifically on the daily flooding and exposure of the substrate by tides at the water's edge. Use of certain Modifiers is limited to certain Systems.

Permanently Flooded-Tidal Fresh. Tidal fresh water covers the substrate throughout the year in all years. This Modifier is used for Riverine, Lacustrine, and Palustrine habitats.

Semipermanently Flooded-Tidal Fresh. Tidal fresh 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. This Modifier is used for Riverine, Lacustrine, and Palustrine habitats.

Seasonally Flooded-Tidal Fresh. Tidal fresh surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the depth to substrate saturation may vary considerably among sites and among years. This Modifier is used for Palustrine habitats only.

Temporarily Flooded-Tidal Fresh. Tidal fresh surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season. This Modifier is used for Palustrine habitats only.

Regularly Flooded-Tidal Fresh. Tides alternately flood and expose the substrate daily for variable periods (from a few weeks to several months) during the growing season. This Modifier is used for Riverine and Lacustrine habitats.

3.3.2 Water Chemistry Modifiers

The accurate characterization of water chemistry in wetlands and deepwater habitats is difficult, 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 marked influence on the types of plants or animals that inhabit an area. A description of water chemistry, therefore, must be an essential part of this classification system.

Two kinds of Water Chemistry Modifiers are employed in this classification: Salinity Modifiers and pH (hydrogen-ion) Modifiers. All habitats are classified according to salinity, and freshwater habitats are further classified by pH levels.

3.3.2.1 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 salinity in inland wetlands (Moyle 1946; Bayly 1967; Stewart and Kantrud 1971). Since the gradation between fresh and hypersaline or hyperhaline waters is continuous, any boundary is artificial, and few classification systems agree completely. The salinity classification adopted here for both coastal and inland waters is a modified version of the Venice System (1959), which was originally proposed at an international "Symposium on the Classification of Brackish Waters."

Estuarine and Marine waters are a complex solution of salts, 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 water 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 water within the substrate.

The salinity of inland water is dominated by four major cations, calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K); and three major anions, carbonate ($C0_3$), sulfate (SO_4), and chloride (Cl) (Wetzel 1975). Salinity is governed by the interactions between precipitation, surface runoff, groundwater flow, evaporation, and sometimes evapotranspiration by plants. The ionic ratios of inland waters usually differ appreciably from those in the sea, although there are exceptions (Bayly 1967). The great chemical diversity of these waters, the wide variation in physical conditions such as temperature, and often the relative impermanence of surface water, make it extremely difficult to subdivide the inland salinity range in a meaningful way. Bayly (l967) attempted a subdivision on the basis of animal life; Moyle (1945) and Stewart and Kantrud (1971) have suggested two very different divisions on the basis of plant life.

The term *saline* is used to indicate that any of a number of ions may be dominant or codominant. These salinities are expressed in units of specific conductance as well as percent salt (Ungar 1974) and they are also covered by the salinity ranges in Table 2.

Table 2. Salinity Modifiers

Coastal Modifiers[a]	Inland Modifiers[b]	Salinity (ppt)	Approximate Specific Conductance (µMhos at 25°C)
Hyperhaline	Hypersaline	>40	>60,000
Euhaline	Eusaline	30.0-40	45,000-60,000
Mixohaline	Mixosaline	0.5-30	800-45,000
Polyhaline	Polysaline	18.0-30	30,000-45,000
Mesohaline	Mesosaline	5.0-18	8,000-30,000
Oligohaline	Oligosaline	0.5-5	800-8,000
Fresh	Fresh	<0.5	<800

[a] Coastal Modifiers are used in the Marine and Estuarine Systems.
[b] Inland Modifiers are used in the Riverine, Lacustrine, and Palustrine Systems.

3.3.2.2 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 pH of moist peat.

There seems to be little doubt that, where a peat layer isolates plant roots from the underlying mineral substrate, the scarcity 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 3) 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 agreement with usage of the term in the U.S. 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 3. pH Modifiers

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

3.3.3 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.

As noted in Section 2.2, we have placed the boundary between wetlands and deepwater habitats in the Riverine and Lacustrine Systems at a depth of 2.5 m (8.2 ft) below low water because this represents the approximate limit of soil as defined in Soil Taxonomy (Soil Survey Staff 1999) and the approximate maximum depth to which emergent plants normally grow (Welch 1952, Zhadin and Gerd 1963, Sculthorpe 1967). Thus, according to our definitions, inland wetlands may have soil, but inland deepwater habitats do not. All Palustrine waters are less than 2.5 m deep; therefore, potentially all Palustrine habitats have soil. In the Marine and Estuarine Systems, the deep limit of soil lies at a depth of 2.5 m below extreme low water; however, we separate wetlands from deepwater habitats precisely at the extreme low water mark in those Systems. So, according to our definitions, Marine and Estuarine wetlands may have soil, and deepwater habitats also may have soil out to the 2.5-m depth limit.

The most basic distinction in soil classification in the U.S. is between mineral soil and organic soil (Soil Survey Staff 1999). In general *"a soil is classified as an organic soil (Histosols) if more than half of the upper 80 cm (32 inches) of the soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic matter*." Soil that does not meet this criterion is considered mineral soil. Organic soil material is soil material that contains at least 12-18 percent organic carbon by weight, the required amount depending on the clay content in the mineral fraction (Soil Survey Staff 1999). See Appendix E for additional details on the differences between mineral and organic soils.

The U.S. soil classification is hierarchical and permits the description of soils at several levels of detail. For example, suborders of the order Histosols are recognized according to the degree of decomposition of the organic matter. In the WCS, we use the Soil Modifiers Organic and Mineral, based on the criteria presented above. If a more detailed soil classification is desired, the latest edition of *Keys to Soil Taxonomy* (Soil Survey Staff 2010) should be used.

3.3.4 Special Modifiers

Many wetland and deepwater habitats are man-made, and natural ones have been modified to some degree by the activities of humans or beaver. With the exception of Beaver, all of the Special Modifiers describe human alterations to wetlands. 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. It may be difficult, in some instances, to choose the single Special Modifier that best describes the landscape modification. Because the Diked/Impounded Modifier is crucial for use in coastal watersheds as denoting wetland modifications for sea level rise models, it will be given priority over any other Modifiers (e.g., spoil areas that have been diked or impounded should be classified using the Diked/Impounded Modifier, not the Spoil Modifier.)

Beaver— These wetlands have been created or modified by beaver (*Castor canadensis*). Dam building by beaver may increase the size of existing wetlands or create small impoundments that are easily identified on aerial imagery. Such flooding frequently creates Dead Forested or Dead Scrub-Shrub Wetland initially, followed in a few years by Aquatic Bed and Emergent Wetland.

Partly Drained/Ditched—A partly drained wetland has been altered hydrologically, but soil moisture is still sufficient to support hydrophytes. Drained areas that can no longer support hydrophytes are not considered wetland. This Modifier is also used to identify wetlands containing, or connected to, ditches. The Partly Drained/Ditched Modifier can be applied even if the ditches are too small to delineate. The Excavated Modifier should be used to identify ditches that are large enough to delineate as separate features; however, the Partly Drained/Ditched Modifier also should be applied to the wetland area affected by the ditching.

Farmed—Farmed wetlands occur where the soil surface has been mechanically or physically altered for production of crops, but where hydrophytes would become reestablished if the farming were discontinued. Farmed wetlands should be classified as Palustrine-Farmed. Cultivated cranberry bogs may be classified Palustrine-Farmed or Palustrine Scrub-Shrub Wetland-Farmed.

Managed — This modifier is used to identify wetlands where water inputs are controlled to achieve a specific water regime or habitat type. Water control structures in combination with dikes and impoundments are common.

Excavated—This Modifier is used to identify wetland basins or channels that were excavated by humans.

Diked/Impounded—These wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.

Artificial Substrate—This Modifier describes concrete-lined drainageways, as well as Rock Bottom, Unconsolidated Bottom, Rocky Shore and Unconsolidated Shore where the substrate material has been emplaced by humans. Jetties and breakwaters are examples of Artificial Rocky Shores.

Spoil— The Spoil Modifier is used to describe wetlands where deposition of spoil material forms the primary substrate type. By definition, spoil is material that has been excavated and emplaced by humans. Ancillary data may be needed to accurately identify spoil in areas such as reclaimed strip mines that have become revegetated.

4. Use of the Classification System

We have designed the various levels of this classification 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 classification for many users and are basic to habitat 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 habitats are dynamic and subject to rapid changes in appearance, the proper classification will frequently require data that span a period of years and several seasons in each of those years.

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 is to estimate this characteristic from the Dominance Types. Several studies have related water regimes to the presence and distribution of plants or animals (e.g., Stephenson and Stephenson 1972; Stewart and Kantrud 1972; Chapman 1974).

Similarly, we do not intend that salinity measurements be made for all wetlands or deepwater habitats except where these data are required; often plant species or associations can be used to indicate broad salinity ranges. 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 et al. 1968; Chabreck 1972; Stewart and Kantrud 1972; Ungar 1974; Odum et al. 1984).

In areas where the Dominance Types to be expected under different Water Regimes and types of Water Chemistry Modifiers have not been identified, 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 map units.

Some of the Modifiers are an integral part of this classification and their use is essential; others are used only for detailed applications or for special cases. The minimum standard for wetland classification is: System, Subsystem (with the exception of Palustrine), Class, Subclass (only required for Forested, Scrub-Shrub, and Emergent Wetland Classes), Water Regime Modifier, and Special Modifier (only required where applicable). The minimum standard for deepwater habitat classification is: System, Subsystem, Class, and Water Regime Modifier.

Water Chemistry Modifiers and Soil Modifiers generally are not used when classification data are obtained using remote sensing. These Modifiers should be applied only when detailed, supporting data have been gathered in the field or from reliable sources such as soil surveys.

The user is urged not to rely on single observations of Water Regime or Water Chemistry. Such measurements give misleading results in all but the most stable habitats. If a more detailed Soil Modifier, such as soil order or suborder (Soil Survey Staff, 2010) can be obtained, it should be used in place of the Modifiers, Mineral and Organic.

5. Regionalization for the Classification System

In 1977 the USFWS adopted Bailey's (1976) ecoregions to give the inland wetlands and deepwater habitats of the United States an ecological address (see Cowardin et al. 1979). For the WCS, the 1995 version of Bailey's ecoregions is to be used wherever there is a need for regionalization in the U.S. interior
(see http://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-united-states/.)

See further information in Appendix F.

6. Application of the FGDC Wetlands Classification Standard

Before attempting to apply the WCS, the user should be aware of the following:

(1) Some information about the area to be classified must be available before the WCS can be applied. This information may be in the form of historical data, aerial photographs or digital images, brief on-site inspection, or detailed and intensive studies.

(2) The classification is designed for use at varying levels of detail. There are few areas for which sufficient information is currently available to allow the most detailed level of classification. If the level of detail provided by the data is not sufficient to meet the classification needs of the user, additional data gathering should be undertaken. In order for projects to conform to the Mapping Standard (FGDC-STD-015-2009), additional data gathering will be required whenever the detail is insufficient to meet the classification requirements of the Standard.

(3) When used in mapping projects, this classification is scale-specific, both for the minimum size of units mapped and for the degree of detail attainable.

(4) This classification provides examples of common Dominance Types for various wetland and deepwater habitats. Users should feel free to add to this list as other dominant species are encountered during regional and local applications of the classification system throughout the United States.

(5) One of the main purposes of the FGDC Wetlands Classification Standard is to ensure uniformity in wetland classification throughout the U.S. It is important that the user pay particular attention to the definitions in this classification. Any deviation from, or modification of, these definitions in the application of this classification system will lead to a lack of uniformity and defeat the purpose of the Standard.

(6) One of the principal uses of the WCS is for inventory and mapping. In order to maintain national consistency, the mapping conventions developed and refined by the USFWS over the first 30 years of NWI mapping were used as the basis for the FGDC Wetlands Mapping Standard (FGDC-STD-015-2009). The Mapping Standard was endorsed by the FGDC in July 2009. It specifies the minimum data quality components for wetlands inventory mapping needed to support inclusion of the data into the National Spatial Data Infrastructure (NSDI), which is mandatory when these activities are fully or partially funded or conducted by the Federal Government. The Mapping Standard balances the burden on the end-user community with the need for consistency and documented quality of digital mapping products. Additionally, the FGDC Wetlands Mapping Standard is created to coordinate wetlands mapping with the National Hydrography Dataset, a national geospatial framework recognized by the FGDC. Although the FGDC Wetlands Mapping Standard is structured to be extensible over time, it is deliberately developed with a forward-looking perspective to accommodate technology and map-scale enhancements to assure its long-term usability, and minimize the need for revisions and updates.

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APPENDIX A (Informative): Glossary of Technical Terms, Acronyms, and Abbreviations

Technical Terms

Definitions provided here come from a variety of sources, including some of the references in Section 7 of this document. Where definitions have been taken verbatim from a source, that source has been cited. In other cases, definitions have been modified or drafted specifically for this classification.

Term	Definition
Acid	Term applied to water with a pH less than 5.5.
Alkaline	Term applied to water with a pH greater than 7.4.
Bar	Elongated landform generated by waves and currents, usually running parallel to the shore, composed predominantly of unconsolidated sand, gravel, stones, cobbles, or rubble and with water on two sides.
Bay	Wide, curving open indentation, recess, or arm of a sea or lake into the land or between two capes or headlands; larger than a cove.
Beach	Sloping landform of unconsolidated material on the shore of larger water bodies, generated by washing waves, tides or currents and extending from the water to a distinct break in landform, substrate type (e.g., a foredune, cliff, or bank), or to the line of continuous vegetation, usually the effective limit of the highest storm waves.
Bedrock	Solid rock layer exposed at the land surface (outcrop) or underlying unconsolidated surface materials such as soil, alluvium, gravel or rock fragments.
Boulder	Rock fragment larger than 60.4 cm (24 inches) in diameter.
Brackish	Marine and Estuarine waters with Mixohaline salinity.
Broad-leaved deciduous	Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (*Fraxinus nigra*).
Broad-leaved evergreen	Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more; e.g., red mangrove (*Rhizophora mangle*).
Calcareous	Formed of calcium carbonate or magnesium carbonate by biological deposition or inorganic precipitation in sufficient quantities to effervesce carbon dioxide visibly when treated with cold 0.1 normal hydrochloric acid. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets (e.g., *Halimeda*).
Channel	"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).
Channel bank	The sloping land bordering a channel. The bank has steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.
Circumneutral	Term applied to water with a pH of 5.5 to 7.4.

Term	Definition
Clay	Mineral particles smaller than 0.002 mm composed of naturally occurring aluminum silicate.
Cliff	High, very steep or overhanging geologic face usually produced by erosion.
Codominant	Two or more species providing about equal areal cover which, in combination, control the environment.
Cobble	Rock fragment 7.6 cm (3 inches) to 25.4 cm (10 inches) in diameter.
Continental Shelf	Part of the continental margin that is between the shoreline and the continental slope.
Dam	Obstruction across a hydrologic flow impounding water to produce a lake, pond, wetland, or other widened aquatic feature.
Deciduous stand	Plant community where deciduous trees or shrubs represent more than 50 percent of the total areal coverage of trees or shrubs.
Dike	Artificial wall, embankment, ridge, or mound, usually of earth or rock fill, built around a relatively flat, low-lying area to protect it from flooding; a levee. A dike may also be constructed on the shore or border of a lake or estuary to prevent inflow of water to bordering lands.
Dominant	Species that are most numerous, or form the bulk of the biomass, and therefore have the greatest effect or influence on the ecological community, generally controlling the presence, abundance, or type of other species.
Dominant life form	That life form of plants (e.g., tree, shrub, moss) that constitutes the uppermost layer of vegetation at a site and possesses at least 30 percent areal cover. The dominant life form determines the Class of vegetated wetlands in this classification.
Dormant season	That part of the year that falls outside the growing season.
Embayment	Deep indentation or recess of a shoreline that forms a bay, which may be entirely or partially cut-off from the main water body by intervening features such as roads, railroad beds, culverts, or dams.
Emergent hydrophytes	Rooted herbaceous angiosperms, ferns, and fern allies (e.g., *Equisetum* spp.) that grow in wet soil, stand erect during most or all of the growing season, and may be periodically to permanently flooded at the base, but do not tolerate prolonged inundation of the entire plant. Examples include bulrushes (*Scirpus* spp.), grasses, and sedges.
Emergent mosses	Mosses occurring in wetlands, but generally not covered by water.
Euhaline	Characterizes water with a concentration of ocean-derived salts measuring 30 to 40 parts per thousand (ppt).
Eutrophic lake	Lake that has a high concentration of nutrients such as nitrogen and phosphorus which stimulate the growth of plants or algae such that the oxygen content is depleted and carbon sequestered.
Evergreen stand	Plant community where evergreen trees or shrubs represent more than 50 percent of the total areal coverage of trees and shrubs. The canopy is never without foliage; however, individual trees or shrubs may shed their leaves (Mueller-Dombois and Ellenberg 1974).
Extreme high water of spring tides	Highest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme higher high water of mixed semidiurnal tides.

Term	**Definition**
Extreme low water of spring tides	Lowest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme lower low water of mixed semidiurnal tides.
Flat	Level landform composed of unconsolidated sediments—usually mud or sand. Flats may be irregularly shaped or elongate and continuous with the shore, whereas bars are generally elongate, parallel to the shore, and separated from the shore by water.
Floating plant	Non-anchored plant that floats freely in the water or on the surface; e.g., water hyacinth (*Eichhornia crassipes*) or common duckweed (*Lemna minor*).
Floating-leaved plant	Rooted, herbaceous hydrophyte with some leaves floating on the water surface; e.g., white water lily (*Nymphaea odorata*), floating-leaved pondweed (*Potamogeton natans*). Plants such as yellow water lily (*Nuphar luteum*) which sometimes have leaves raised above the surface are considered floating-leaved plants or emergents, depending on their growth habit at a particular site.
Floodplain	“flat expanse of land bordering an old river . . .“ (Reid and Wood 1976:72, 84).
Fresh water	Water with a dissolved salt concentration measuring less than 0.5 ppt.
Gravel	Mixture composed primarily of rock fragments 2 mm (0.08 inch) to 7.6 cm (3 inches) in diameter. Usually contains much sand.
Growing season	That part of the year that begins with green-up and bud-break of native plants in the spring and ends with plant dieback and leaf-drop in the fall due to the onset of cold weather.
Haline	Indicates dominance of ocean salt (see also Saline).
Herbaceous	With the characteristics of an herb; a plant with no persistent woody stem above ground.
Histosols	The order of organic soils, as defined by USDA Natural Resources Conservation Service in *Soil Taxonomy* (Soil Survey Staff 1999); soils consisting primarily of organic soil material such as peat or muck (see also Organic soil and Appendix E).
Hydric soil	Soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation. (From http://soils.usda.gov/use/hydric/intro.html)
Hydrophytes, hydrophytic	Any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.
Hyperhaline	Water with a concentration of ocean-derived salts measuring greater than 40 ppt.
Hypersaline	Water with a concentration of land-derived salts measuring greater than 40 ppt.
Kelp	Any of numerous large seaweeds found in colder seas and belonging to the order Laminariales, brown algae.
Lagoon	A mostly-enclosed, shallow, saline water body with little freshwater input and damped tidal fluxes.

Term	Definition
Levee	An embankment of sediment, bordering one or both sides of natural or artificial channels.
Macrophytic algae	Algal plants large enough either as individuals or communities to be readily visible without the aid of optical magnification.
Mangrove	Tidally-influenced, tropical or subtropical shrub or forest dominated by true mangroves and associates.
Mean high water	Average height of the high water over 19 years.
Mean higher high tide	Average height of the higher of two unequal daily high tides over 19 years.
Mean low water	Average height of the low water over 19 years.
Mean lower low water	Average height of the lower of two unequal daily low tides over 19 years.
Mean tide level	A plane midway between mean high water and mean low water.
Mesohaline	Water with a concentration of ocean-derived salts measuring of 5 to 18 ppt.
Mesophye, mesophytic	Any plant growing where moisture and aeration conditions lie between extremes; plants typically found in habitats with average moisture conditions, not unusually dry or wet.
Mesosaline	Water with a concentration of land-derived salts measuring 5 to 18 ppt.
Mineral soil	Soil composed of predominantly mineral, rather than organic, material (see Appendix E).
Mixohaline	Water with a concentration of ocean-derived salts measuring 0.5 to 30 ppt. The term is roughly equivalent to the term brackish.
Mixosaline	Waters with a concentration of land-derived salts measuring 0.5 to 30 ppt.
Muck	Soil consisting primarily of highly decomposed organic matter (sapric soil material).
Mud	Wet soft earth composed predominantly of clay- and silt-sized mineral particles less than 0.074 mm in diameter (Black 1968; Liu 1970).
Needle-leaved deciduous	Woody gymnosperms (trees or shrubs) with needle-shaped or scale-like leaves that are shed during the cold or dry season; e.g., bald cypress (*Taxodium distichum*).
Needle-leaved evergreen	Woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year; e.g., black spruce (*Picea mariana*).
Nonpersistent emergents	Emergent hydrophytes whose stems and leaves are evident above the surface of the water, or above the soil surface if surface water is absent, only during the growing season or shortly thereafter. Typically, plant leaves and stems break down soon after the growing season or drop beneath the water surface (e.g., arrow arum, *Peltandra virginica*; burreed, *Sparganium* spp.; bayonet rush, *Juncus militaris*). Many nonpersistent emergents have fleshy or spongy tissues.
Obligate hydrophyte	Plant that under natural conditions occurs almost always (estimated probability 99 percent) in wetlands, e.g., cattail (*Typha latifolia*), as opposed to species that grow in both wetlands and upland, e.g., red maple (*Acer rubrum*).
Oligohaline	Water with a concentration of ocean-derived salts measuring 0.5 to 5.0 ppt.
Oligosaline	Water with a concentration of land-derived salts measuring 0.5 to 5.0 ppt.

Term	**Definition**
Organic matter	Organic fraction of the soil exclusive of undecayed plant and animal residues.
Organic soil	Soil composed of predominantly organic rather than mineral material (see Appendix E).
Peat	Soil consisting primarily of poorly to moderately decomposed organic matter (fibric to hemic soil material)
Persistent emergents	Emergent hydrophytes whose stems and leaves are evident throughout the year above the surface of the water, or above the soil surface if surface water is absent. In some species, such as cattails (*Typha* spp.), stems may remain erect all year; in others, stems and leaves may lie prostrate on the soil surface after the peak of the growing season due to tidal action, wind, heavy rain, or snow cover. Plants such as saltmarsh cordgrass (*Spartina alterniflora*), whose stems may be severed during Northern winters by ice, in combination with tidal action, along the edges of tidal creeks or other open water bodies, are considered persistent.
Photic zone	Upper water layer down to the depth of effective light penetration where photosynthesis balances respiration. This level (the compensation level) usually occurs at the depth of 1 percent light penetration and forms the lower boundary of the zone of net metabolic production.
Pioneer plants	Herbaceous annual and seedling perennial plants that colonize bare areas as a first stage in secondary succession.
Polyhaline	Water with a concentration of ocean-derived salts measuring18 to 30 ppt.
Polysaline	Water with a concentration of land-derived salts measuring 18 to 30 ppt.
Reef	Ridge or mound-like structure formed by the colonization and growth of sedentary invertebrates such as corals, mollusks, or tubeworms.
Saline	Water containing various dissolved salts. We restrict the term to inland waters where the ratios of the salts often vary; the term haline is applied to coastal waters where the salts are roughly in the same proportion as found in undiluted sea water.
Salinity	Total amount of solid material in grams contained in 1 kg of water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all the organic matter completely oxidized.
Salt water	Water with a dissolved salt concentration measuring at least 0.5 ppt.
Sand	Unconsolidated mineral sediment composed predominantly of particles with diameters larger than 0.074 mm (Black 1968) and smaller than 2 mm (Liu 1970; Weber 1973).
Shrub	Woody plant that at maturity is less than 6 m (20 ft) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance; e.g., speckled alder (*Alnus rugosa*) or buttonbush (*Cephalanthus occidentalis*).
Silt	Mineral particles smaller than a very fine sand grain (0.05 mm) and larger than coarse clay (0.002 mm).

Term	**Definition**
Soil	"Natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter *or* the ability to support rooted plants in a natural environment" (Soil Survey Staff 1999:9). Areas covered by surface water more than 2.5 m (8.2 ft) deep at low water are not considered to have soil.
Sound	Body of water that is usually broad, elongate, and parallel to the shore between the mainland and one or more islands.
Spring tide	Highest high and lowest low tides during the lunar month.
Stone	Rock fragment larger than 25.4 cm (10 inches) but less than 60.4 cm (24 inches).
Submergent plant	Vascular or nonvascular hygrophyte, either rooted or nonrooted, which lies entirely beneath the water surface, except for flowering parts in some species; e.g., wild celery (*Vallisneria americana*) or the stoneworts (*Chara* spp.).
Substrate	Any material at the land surface upon which, or within which, organisms may live. In this document, substrates consist primarily of unconsolidated mineral material, organic material, or rock that is flooded or saturated long enough each year to support wetland flora and fauna. Individual substrates may or may not qualify as *Soil* (see definition above).
Terrigenous	Derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or as a result of biologic activity (biogenous).
Tree	Woody plant which, at maturity, is 6 m (20 ft) or more in height and generally has a single trunk, unbranched for 1 m or more above the ground, and a more or less definite crown; e.g., red maple (*Acer rubrum*), northern white cedar (*Thuja occidentalis*).
Water table	Upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body (Langbein and Iseri 1960:21).
Woody plant	Seed plant (gymnosperm or angiosperm) that develops persistent, hard, fibrous tissues, basically xylem; e.g., trees and shrubs.
Xerophyte, xerophytic	Any plant growing in a habitat in which an appreciable portion of the rooting medium dries to the wilting coefficient at frequent intervals; plants typically found in very dry habitats.

Acronyms and Abbreviations

Acronym	Definition
AASHTO	American Association of State Highway and Transportation Officials
BBC	Benthic Biotic Component
CMECS	Coastal and Marine Ecological Classification Standard
EAs	environmental assessments
EHWS	extreme high water of spring tides
EIS	environmental impact statements
ELWS	extreme low water of spring tides
FGDC	Federal Geographic Data Committee
ha	hectare
m	meter
MIT	Massachusetts Institute of Technology
NHD	National Hydrography Dataset
NRCS	Natural Resources Conservation Service; formerly named Soil Conservation Service
NSDI	National Spatial Data Infrastructure
NWI	National Wetlands Inventory
ppt	parts per thousand
U.S.	United States
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
NOAA	National Oceanographic and Atmospheric Administration
WCS	Wetlands Classification Standard, also known as the FGDC Wetlands Classification Standard (FGDC-STD-004), “Classification of Wetlands and Deepwater Habitats of the United States”

APPENDIX B (Informative): Artificial Keys to the Systems and Classes

Artificial Key to the Systems

1. Water Regime influenced by ocean tides, and salinity due to ocean-derived salts 0.5 ppt or greater.
    2. Semi-enclosed by land, but with open, partly obstructed or sporadic access to the ocean. Halinity wide-ranging because of evaporation or mixing of seawater with runoff from land .... ESTUARINE
    2. Little or no obstruction to open ocean present. Halinity usually euhaline; little mixing of water with runoff from land 3
        3. Emergents, trees, or shrubs present... ESTUARINE
        3. Emergents, trees, or shrubs absent...MARINE
1. Water Regime not influenced by ocean tides, or if influenced by ocean tides, salinity less than 0.5 ppt.
    4. Persistent emergents, trees, shrubs, or emergent mosses or lichens cover 30 percent or more of the area .... PALUSTRINE
    4. Persistent emergents, trees, shrubs, or emergent mosses or lichens cover less than 30 percent of substrate but nonpersistent emergents may be widespread during some seasons of year...5
        5. Situated in a channel; water, when present, usually flowing...........RIVERINE
        5. Situated in a basin, catchment, or on level or sloping ground; water usually not flowing 6
            6. Area 8 ha (20 acres) or greater...LACUSTRINE
            6. Area less than 8 ha 7
                7. Wave-formed or bedrock shoreline feature present or water depth 2.5 m (8.2 ft) or more..LACUSTRINE
                7. No wave-formed or bedrock shoreline feature present and water less than 2.5-m deep.. PALUSTRINE

Artificial Key to the Classes

1. During the growing season of most years, areal cover by vegetation is less than 30 percent.
    2. Substrate a ridge or mound formed by colonization of sedentary invertebrates (corals, mollusks, tube worms) ....REEF
    2. Substrate of rock or various-sized sediments often occupied by invertebrates but not formed by colonization of sedentary invertebrates..3
        3. Water Regime Subtidal, Permanently Flooded, Intermittently Exposed, Semipermanently Flooded, Permanently Flooded-Tidal Fresh, or Semipermanently Flooded-Tidal Fresh...4
            4. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75 percent or more of the area..........ROCK BOTTOM
            4. Substrate of organic material, mud, sand, gravel, or cobbles with less than 75 percent areal cover of stones, boulders, or bedrock ....UNCONSOLIDATED BOTTOM

3. Water Regime Irregularly Exposed, Regularly Flooded, Irregularly Flooded, Seasonally Flooded, Seasonally Flooded-Saturated, Temporarily Flooded, Intermittently Flooded, Artificially Flooded, Regularly Flooded-Tidal Fresh, Seasonally Flooded-Tidal Fresh, or Temporarily Flooded-Tidal Fresh. 5
    5. Contained in a channel that does not have continuously flowing water (i.e., Intermittent Subsystem of Riverine System or Intertidal Subsystem of Estuarine System) .... STREAMBED
    5. Contained in a channel with continuously flowing water or not contained in a channel 6
        6. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75 percent or more of the area.... ROCKY SHORE
        6. Substrate of organic material, mud, sand, gravel, or cobbles; less than 75 percent areal cover of stones, boulders, or bedrock ....UNCONSOLIDATED SHORE

1. During the growing season of most years, percentage of area covered by vegetation 30 percent or greater.
    7. Vegetation composed of pioneer annuals or seedling perennials, often not hydrophytes, occurring only at time of substrate exposure 8
        8. Contained in a channel that does not have continuously flowing water ....STREAMBED (VEGETATED)
        8. Contained in a channel with continuously flowing water, or not contained in a channel .... UNCONSOLIDATED SHORE (VEGETATED)
    7. Vegetation composed of algae, mosses, lichens, or vascular plants that are usually hydrophytic perennials..9
        9. Vegetation composed predominantly of nonvascular species 10
            10. Vegetation macrophytic algae, mosses, or lichens growing in water or the splash zone of shores ....AQUATIC BED
            10. Vegetation mosses or lichens usually growing on organic soils and always outside the splash zone of shores...................MOSS-LICHEN WETLAND
        9. Vegetation composed predominantly of vascular species 11
            11. Vegetation herbaceous 12
                12. Vegetation emergents...................................EMERGENT WETLAND
                12. Vegetation submergent, floating-leaved, or floating ....AQUATIC BED
            11. Vegetation trees or shrubs...13
                13. Dominants less than 6 m (20 ft) tall........SCRUB-SHRUB WETLAND
                13. Dominants 6 m tall or taller ....FORESTED WETLAND

APPENDIX C (Informative): Scientific and Common Names of Plants

Scientific and Common Names of Plants[1]

Scientific Name	Common Name
Acer rubrum L.	Red maple
Alnus spp.	Alders
Andromeda polifolia L.	Bog rosemary
Ascophyllum spp.	Rockweeds
Avicennia germinans (L.) L.	Black mangrove
Azolla spp.	Mosquito ferns
Baccharis halimifolia L.	Groundsel tree
Beckmannia syzigachne (Steud.) Fernald	American slough grass
Betula nana L.	Swamp birch
B. pumila L.	Bog birch
Brasenia schreberi J. F. Gmel.	Water shield
Campylium stellatum (Hedw.) C. Jens	Moss
Carex spp.	Sedges
Caulerpa spp.	Green algae
Cephalanthus occidentalis L.	Common buttonbush
Ceratophyllum muricatum	Prickly hornwort
Chamaecyparis thyoides (L.) B.S.P.	Atlantic white cedar
Chamaedaphne calyculata (L.) Moench	Leatherleaf
Chara spp.	Stoneworts
Chenopodium glaucum L.	Oak-leaf goosefoot
Chiloscyphus fragilis (Roth) Schiffn.	Liverwort
Cladina spp.	Reindeer mosses
Cladium mariscus (L.) Pohl.	Swamp saw-grass
Conocarpus erectus L.	Button mangrove
Cornus alba L.	Red osier dogwood
Cymodocea filiformis (Kuetz) Correll	Manatee grass
Cyrilla racemiflora L.	Swamp titi

[1] Lichvar, R. W., and J. T. Kartesz. 2009. North American Digital Flora: National Wetland Plant List, version 2.4.0 (http://wetland_plants.usace.army.mil). U.S. Army Corps of Engineers, Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, and BONAP, Chapel Hill, North Carolina.

Scientific Name	**Common Name**
Decodon verticillatus (L.) Elliott	Swamp loosestrife
Dermatocarpon fluviatile (G. H. Web) Th. Fr.	Lichen
Drepanocladus spp.	Mosses
Echinochloa crusgalli (L.) Beauv.	Large barnyard grass
Eichhornia crassipes (Mart.) Solms	Common water hyacinth
Eleocharis spp.	Spike rushes
Elodea spp.	Water weeds
Fissidens spp.	Mosses
F. julianus (Mont.) Schimper	Moss
Fontinalis spp.	Mosses
Fraxinus nigra Marshall	Black ash
F. pennsylvanica Marshall	Green ash
Fucus spp.	Rockweeds
F. spiralis L.	Rockweed
Glyceria spp.	Manna grasses
Gordonia lasianthus (L.) J. Ellis	Loblolly bay
Halimeda spp.	Green algae
Halodule wrightii Aschers.	Shoal grass
Halophila spp.	Sea grasses
Iva frutescens L.	High-tide bush
Juncus spp.	Rushes
J. militaris Bigel.	Bayonet rush
J. roemerianus Scheele	Roemer's rush
Kalmia polifolia Wangenh.	Bog laurel
Laminaria spp.	Kelps
Langucularia racemosa (L.) C. F. Gaertn.	White mangrove
Larix laricina (DuRoi) K. Koch	American larch
Laurencia spp.	Red algae
Ledum groenlandicum Oeder	Rusty Labrador-tea
Lemna spp.	Duckweeds
L. minor L.	Common duckweed
Leucothoe axillaris (Lam.) D. Don	Coastal doghobble
Lithothamnion spp.	Coralline algae

Scientific Name	**Common Name**
Lyonia lucida (Lam.) K. Koch	Shinyleaf
Lythrum salicaria L.	Purple loosestrife
Macrocystis spp.	Kelps
Magnolia virginiana L.	Sweet bay
Marsupella spp.	Liverworts
M. emarginata (Ehrenberg) Dumortier	Liverwort
Myriophyllum spp.	Water milfoils
Najas spp.	Naiads
Nitella spp.	Stoneworts
Nuphar lutea (L.) Sibth. & J. E. Smith	Yellow water lily
Nymphaea spp.	Water lilies
N. odorata Soland. in Ait.	White water lily
Nyssa sylvatica Marshall	Black tupelo
Oncophorus wahlenbergii Brid.	Moss
Panicum capillare L.	Common panic grass
Peltandra virginica (L.) Schott	Green arrow-arum
Pelvetia spp.	Rockweeds
Penicillus spp.	Green algae
Persea borbonia (L.) Spreng.	Red bay
Persicaria amphibia (L.) S. F. Gray	Water smartweed
Phyllospadix scouleri Hook.	Scouler's surf-grass
P. torreyi S. Wats.	Torrey's surf-grass
Picea mariana (Mill.) B.S.P.	Black spruce
Pistia stratiotes L.	Water lettuce
Polygonum spp.	Smartweeds
Pontederia cordata L.	Pickerelweed
Potamogeton spp.	Pondweeds
Quercus bicolor Willd.	Swamp white oak
Q. lyrata Walter	Overcup oak
Q. michauxii Nutt.	Swamp chestnut oak
Rumex mexicanus Meisn.	Mexican dock
Ruppia spp.	Ditch grasses
R. maritima L.	Widgeon grass

Scientific Name	**Common Name**
Sagittaria spp.	Arrowheads
Salicornia spp.	Glassworts
S. depressa Standl.	Woody saltwort
Salix spp.	Willows
Salvinia spp.	Water mosses
Schoenoplectus acutus (Muhl. *ex* Bigelow) A. & D. Love	Hardstem club-rush
Scirpus spp.	Bulrushes
Scolochloa festucacea (Willd.) Link	Common river grass
Sparganium hyperboreum Beurling *ex* Laestad.	Bur-reed
Spartina alterniflora Loiseleur	Saltmarsh cordgrass
S. cynosuroides (L.) Roth	Big cordgrass
S. foliosa Trin.	California cordgrass
S. patens (Ait.) Muhl.	Saltmeadow cordgrass
Sphagnum spp.	Peat mosses
Spiraea douglasii Hook.	Douglas' meadowsweet
Spirodela spp.	Big duckweeds
Suaeda californica S. Wats.	Broom seepweed
Tamarix gallica L.	French tamarisk
Taxodium distichum (L.) L. C. Rich.	Southern bald-cypress
Thalassia testudinum Banks & Soland. *ex* Koenig	Turtle grass
Thuja occidentalis L.	Eastern arborvitae
Tolypella spp.	Stoneworts
Trapa natans L.	Water chestnut
Triglochin maritima L.	Seaside arrow-grass
Typha spp.	Cattails
T. angustifolia L.	Narrow-leaved cattail
T. latifolia L.	Broad-leaved cattail
Ulmus americana L.	American elm
Ulva spp.	Sea lettuces
Utricularia spp.	Bladderworts
Vaccinium oxycoccos L.	Small cranberry
Vallisneria americana Michx.	Wild celery
Verrucaria spp.	Lichens

Scientific Name	**Common Name**
Wolffia spp.	Watermeals
Xanthium strumarium L.	Rough cocklebur
Zannichellia palustris L.	Horned pondweed
Zenobia pulverulenta (W. Bartram) Pollard	Honeycup
Zizaniopsis miliacea (Michx.) Doell & Aschers.	Marsh-millet
Zostera marina L.	Eelgrass

APPENDIX D (Informative): Scientific and Common Names of Animals

Scientific and Common Names of Animals[1]

Scientific Name	**Common Name**
Acmaea spp.	Limpets
Acropora spp.	Staghorn corals
Agrenia spp.	Springtails
Amphipholis spp.	Brittle stars
Amphitrite spp.	Terebellid worms
Ancylus spp.	Freshwater limpets
Anodonta spp.	Freshwater mussels
Anodontoides spp.	Freshwater mussels
Anopheles spp.	Mosquitoes
Aplexa spp.	Pouch snails
Arenicola spp.	Lugworms
Asellus spp.	Aquatic sowbugs
Baetis spp.	Mayflies
Balanus spp.	Acorn barnacles
Bryocamptus spp.	Harpacticoid copepods
Caenis spp.	Mayflies
Callianassa spp.	Ghost shrimp
Crassostrea spp.	Oysters
C. virginica (Geml.)	Eastern oyster
Dendraster spp.	Sand dollars
Diamesa spp.	Midges
Donax spp.	Wedge bean clams
Echinocardium spp.	Heart urchins
Elliptio spp.	Freshwater mussels
Emerita spp.	Mole crabs
Ephemerella spp.	Mayflies
Erpobdella spp.	Leeches
Eukiefferiella spp.	Midges
Eunapius spp.	Freshwater sponges
Euzonus spp.	Blood worms
Gammarus spp.	Scuds
Gelastocoris spp.	Toad bugs
Gordonia ventalina L.	Common sea fans

[1] Scientific names validated against the Integrated Taxonomic Information System (ITIS) on 2/17/2012 at http://www.itis.gov/.

Scientific Name	**Common Name**
Helobdella spp.	Leeches
Heteromeyenia spp.	Horse sponges
Hippospongia spp.	Encrusting sponges
Homarus americanus Milne-Edwards	American lobster
Hydropsyche spp.	Caddisflies
Lampsilis spp.	Freshwater mussel
Ligia spp.	Sea slaters
Limnodrilus spp.	Oligochaete black worms
Littorina spp.	Periwinkles
Lumbriculus spp.	Oligochaete worms
Lymnaea spp.	Pond snails
Macoma spp.	Macomas
M. balthica (Linne)	Baltic macoma
Melita spp.	Amphipods
Mercenaria spp.	Quahogs
Modiolus spp.	Horse mussels
Montipora spp.	Corals
Muricea spp.	Sea whips
Mya spp.	Soft-shell clams
Mytilus spp.	Mussels
Nassarius spp.	Sand snails
Nemoura spp.	Stone flies
Nereis spp.	Clam worms
Nerita spp.	Black nerites
Notonecta spp.	Common backswimmers
Oliva spp.	Olive shells
Orchestia spp.	Beach sand fleas
Ostrea spp.	Oysters
Parastenocaris spp.	Copepods
Patella spp.	Limpets
Pecten spp.	Scallops
Petricola pholadiformis Lam.	False angel wings
Phyllognathopus viguieri Maryek	Copepod
Physa spp.	Bladder snail
Pisaster spp.	Sea stars
Pisidium spp.	Fingernail clams
Placopecten spp.	Deep-sea scallops
Platyodon spp.	Boring clams
Pollicipes spp.	Gooseneck barnacles

Scientific Name	Common Name
Porites spp.	Finger corals
Pristina spp.	Oligochaete worms
Procambarus spp.	Crayfish
Psephenus spp.	Water penny beetles
Renilla spp.	Sea pansies
Sabellaria spp.	Encrusted sand tubeworms
Saldula spp.	Shore bugs
Saxidomus spp.	Venus clams
Simulium spp.	Black flies
Siphonaria spp.	False limpets
Sphaerium spp.	Fingernail clams
Spongilla spp.	Freshwater sponges
Strongylocentrotus spp.	Sea urchins
Tabanus spp.	Flies
Tellina spp.	Tellin shells
Tetraclita spp.	Thatched barnacles
Thais spp.	Rock snails
Thyone spp.	Sea cucumbers
Tivela stultorum (Mawe)	Pismo clams
Tortopus spp.	Mayflies
Tubifex spp.	Sewage worms
Uca spp.	Fiddler crabs
Urechis spp.	Echiurid worms

APPENDIX E (Normative): Criteria for Differentiating between Mineral Soils and Organic Soils

Criteria for Differentiating between Mineral Soils[1] and Organic Soils

Note: We use the Soil Modifiers, Mineral and Organic, in this classification. Mineral soils and organic soils are differentiated based on specific criteria that are enumerated in Soil Taxonomy (Soil Survey Staff 1999:19-20). These criteria are restated below for ready reference. If a more detailed classification is desired, the latest edition of Keys to Soil Taxonomy (Soil Survey Staff 2010) should be used.

Soil taxonomy differentiates between mineral soils and organic soils. To do this, it is necessary to distinguish mineral soil material from organic soil material. Second, it is necessary to define the minimum part of a soil that should be mineral if a soil is to be classified as a mineral soil and the minimum part that should be organic if the soil is to be classified as an organic 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 (less than 2.0 mm in diameter) *either*:

1. Is saturated with water for less than 30 days (cumulative) per year in normal years and contains less than 20 percent (by weight) organic carbon; *or*

2. Is saturated with water for 30 days or more cumulative in normal years (or is artificially drained) and, excluding live roots, has an organic carbon content (by weight) of:

   a. Less than 18 percent if the mineral fraction contains 60 percent or more clay; *or*

   b. Less than 12 percent if the mineral fraction contains no clay; *or*

   c. Less than 12 + (clay percentage multiplied by 0.1) percent if the mineral fraction contains less than 60 percent clay.

Organic Soil Material

Soil material that contains more than the amounts of organic carbon described above for mineral soil material is considered organic soil material.

[1] Mineral soils include all soil except the suborder Histels and the order Histosols.

In the definition of mineral soil material above, material that has more organic carbon than in item 1 is intended to include what has been called litter or an O horizon. Material that has more organic carbon than in item 2 has been called peat or muck. Not all organic soil material accumulates in or under water. Leaf litter may rest on a lithic contact and support forest vegetation. The soil in this situation is organic only 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.

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. To apply the definitions of many taxa, one must first decide whether the soil is mineral or organic. An exception is the Andisols (defined later). These generally are considered to consist of mineral soils, but some may be organic if they meet other criteria for Andisols. Those that exceed the organic carbon limit defined for mineral soils have a colloidal fraction dominated by short-range-order minerals or aluminum-humus complexes. The mineral fraction in these soils is believed to give more control to the soil properties than the organic fraction. Therefore, the soils are included with the Andisols rather than the organic soils defined later as Histosols.

If a soil has both organic and mineral horizons, the relative thickness of the organic and 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 the 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 both thick mineral soils layers and no more organic material than the amount permitted in the histic epipedon, which is defined in chapter 4.

In the determination of 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, unless the soil is buried as defined in chapter 1. 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 are soils that have *either* of the following:

1. Mineral soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or have voids[2] that are filled with 10 percent or less organic materials *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with underlying cindery, fragmental, or pumiceous materials, total more than 10 cm between the soil surface and a depth of 50 cm; *or*

c. Constitute more than one-third of the total thickness of the soil to a densic, lithic, or paralithic contact or have a total thickness of more than 10 cm; *or*

d. If they are saturated with water for 30 days or more per year in normal years (or are artificially drained) and have organic materials with an upper boundary within 40 cm of the soil surface, have a total thickness of *either:*

(1) Less than 60 cm if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3 *or*

(2) Less than 40 cm if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more; *or*

2. More than 20 percent, by volume, mineral soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest; *and*

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

[2] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

Definition of Organic Soils

Organic soils have organic soil materials that:

1. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

2. Meet *one or more* of the following:

   a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices and directly below these materials have a densic, lithic, or paralithic contact; *or*

   b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

   c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

   d. Are saturated with water for 30 days or more per year in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either:*

      (1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

      (2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more; *or*

   e. Are 80 percent or more, by volume, from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest.

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

APPENDIX F (Informative): Regionalization for the Classification System

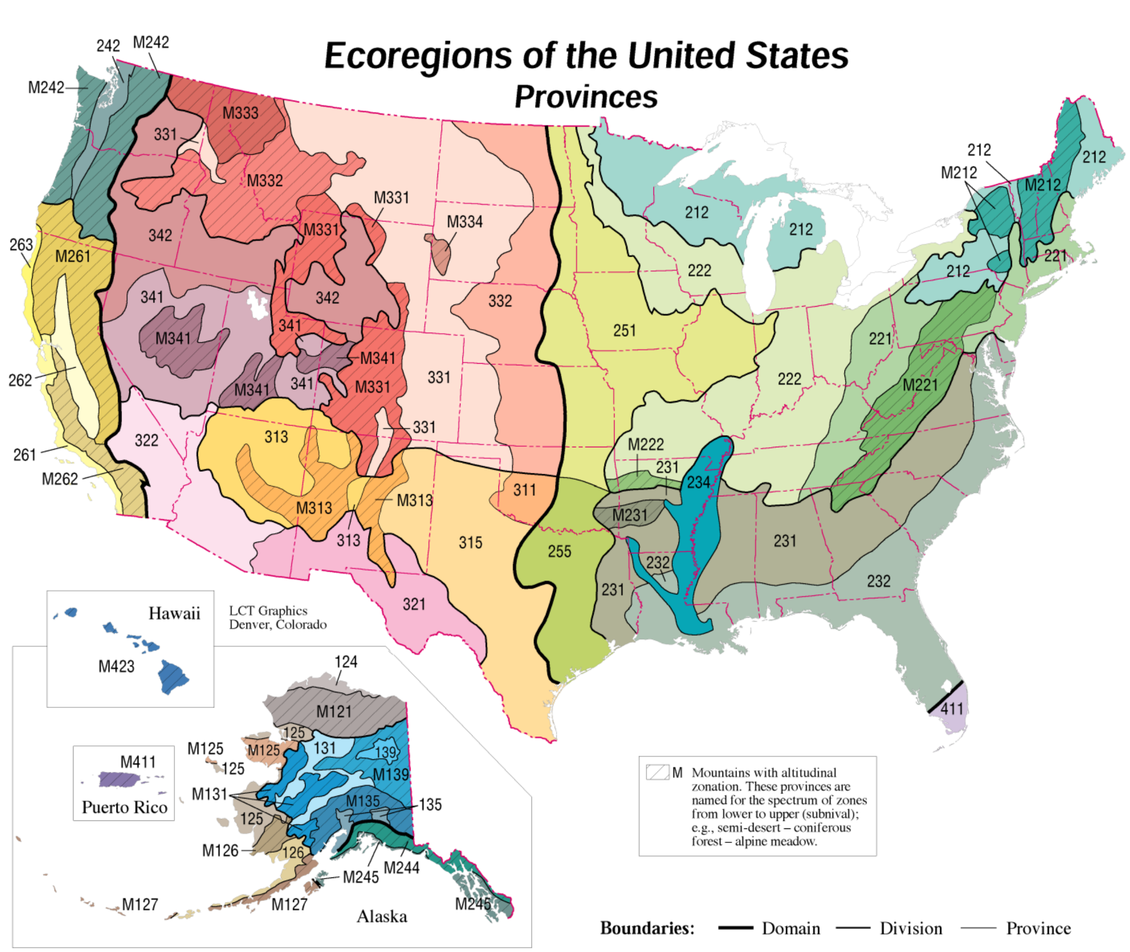
Regionalization for the Classification System

In this wetlands and deepwater classification, a given taxon has no particular regional alliance; its representatives may be found in one or many parts of the U.S. However, regional variations in climate, geology, soils, and vegetation are important in the development of different habitats, and management problems often differ greatly among regions. For these reasons, there is a need to recognize regional differences. Regionalization is designed to facilitate three activities: (1) planning, 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.

In 1977 the USFWS adopted Bailey's (1976) ecoregions to give the inland wetlands and deepwater habitats of the United States an ecological address (see Cowardin et al. 1979). In this Standard, the 1995 version of Bailey's system is to be used wherever there is a need for regionalization in the U.S. interior (see http://www.fs.fed.us/rm/ecoregions/products/map-ecoregions-united-states#).

Bailey's approach is based on understanding the role of climate in ecosystem differentiation. To a considerable extent, climatic factors determine the boundaries of ecosystems at all scales. This will be more important going forward. The most important of these is climatic regime, defined as the diurnal and seasonal fluxes of energy and moisture. As these fluxes change, the kinds and patterns of dominant life forms of plants and animals change and, over the course of centuries, the kinds of soils and water bodies. As a result, ecosystems of different climates differ significantly. The areas they occupy are not terrestrial or aquatic, but geographical, ecosystem units. Controls over the climatic effect change with scale. Understanding these controlling factors on a scale-related basis is key to setting ecosystem boundaries.

As with the wetlands and deepwater classification system, 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 plant formations), and *section* (defined on the basis of physiography by Bailey et al. [1994] and revised by Cleland et al. [2005] for the conterminous U.S. and Nowacki and Brock [1995] for Alaska). Mountainous provinces and sections exhibiting altitudinal zonation and having the climatic regime of the adjacent lowlands are distinguished according to the character of the zonation. On the map, ecoregion sections within each ecoregion province are shown in the same color and the sections are numbered with an alphanumeric code; numbers 1 through 3 represent the first three levels in the hierarchy. The numbers are followed by a capital letter representing the fourth level. The codes for mountains are preceded by the letter "M." The reader is referred to Bailey (1995, 2005) and McNab et al. (2005) for detailed discussion and description of the units appearing on this map, reproduced in Figure 7.



100 Polar Domain

120 Tundra Division
124 Arctic Tundra Province
125 Bering Tundra (Northern) Province
126 Bering Tundra (Southern) Province

M120 Tundra Regime Mountains
M121 Brooks Range Tundra – Polar Desert Province
M125 Seward Peninsula Tundra – Meadow Province
M126 Ahklun Mountains Tundra – Meadow Province
M127 Aleutian Oceanic Meadow – Heath Province

130 Subarctic Division
131 Yukon Intermontane Plateaus Tayga Province
135 Coastal Trough Humid Tayga Province
139 Upper Yukon Tayga Province

M130 Subarctic Regime Mountains
M131 Yukon Intermontane Plateaus Tayga – Meadow Province
M135 Alaska Range Humid Tayga – Tundra – Meadow Province
M139 Upper Yukon Tayga – Meadow Province

200 Humid Temperate Domain

210 Warm Continental Division
212 Laurentian Mixed Forest Province

M210 Warm Continental Regime Mountains
M212 Adirondack – New England Mixed Forest – Coniferous Forest – Alpine Meadow Province

220 Hot Continental Division
221 Eastern Broadleaf Forest (Oceanic) Province
222 Eastern Broadleaf Forest (Continental) Province

M220 Hot Continental Regime Mountains
M221 Central Appalachian Broadleaf Forest – Coniferous Forest – Meadow Province
M222 Ozark Broadleaf Forest – Meadow Province

230 Subtropical Division
231 Southeastern Mixed Forest Province
232 Outer Coastal Plain Mixed Forest Province
234 Lower Mississippi Riverine Forest Province

M230 Subtropical Regime Mountains
M231 Ouachita Mixed Forest – Meadow Province

240 Marine Division
242 Pacific Lowland Mixed Forest Province

M240 Marine Regime Mountains
M242 Cascade Mixed Forest – Coniferous Forest – Alpine Meadow Province
M244 Pacific Coastal Mountains Forest – Meadow Province
M245 Pacific Gulf Coastal Forest – Meadow Province

250 Prairie Division
251 Prairie Parkland (Temperate) Province
255 Prairie Parkland (Subtropical) Province

260 Mediterranean Division
261 California Coastal Chaparral Forest and Shrub Province
262 California Dry Steppe Province
263 California Coastal Steppe, Mixed Forest, and Redwood Forest Province

M260 Mediterranean Regime Mountains
M261 Sierran Steppe – Mixed Forest – Coniferous Forest – Alpine Meadow Province
M262 California Coastal Range Open Woodland – Shrub – Coniferous Forest – Meadow Province

300 Dry Domain

310 Tropical/Subtropical Steppe Division
311 Great Plains Steppe and Shrub Province
313 Colorado Plateau Semi-Desert Province
315 Southwest Plateau and Plains Dry Steppe and Shrub Province

M310 Tropical/Subtropical Steppe Regime Mountains
M313 Arizona-New Mexico Mountains Semi-Desert – Open Woodland – Coniferous Forest – Alpine Meadow Province

320 Tropical/Subtropical Desert Division
321 Chihuahuan Semi-Desert Province
322 American Semi-Desert and Desert Province

330 Temperate Steppe Division
331 Great Plains-Palouse Dry Steppe Province
332 Great Plains Steppe Province

M330 Temperate Steppe Regime Mountains
M331 Southern Rocky Mountains Steppe – Open Woodland – Coniferous Forest – Alpine Meadow Province
M332 Middle Rocky Mountains Steppe – Coniferous Forest – Alpine Meadow Province
M333 Northern Rocky Mountains Forest-Steppe – Coniferous Forest – Alpine Meadow Province
M334 Black Hills Coniferous Forest Province

340 Temperate Desert Division
341 Intermountain Semi-Desert and Desert Province
342 Intermountain Semi-Desert Province

M340 Temperate Desert Regime Mountains
M341 Nevada-Utah Mountains Semi-Desert – Coniferous Forest – Alpine Meadow Province

400 Humid Tropical Domain

410 Savanna Division
411 Everglades Province

M410 Savanna Regime Mountains
M411 Puerto Rico Province

M420 Rainforest Regime Mountains
M423 Hawaiian Islands Province

Source: R.G. Bailey [Ecoregions of the United States, USDA Forest Service (scale 1:7,500,000, revised 1994)]

Figure 7. Ecoregions of the United States.

APPENDIX G (Informative): Wetland Image Gallery

Wetland Image Gallery

http://www.wetlandgallery.cnlworld.org

The Wetland Image Gallery is a compilation of images that illustrate the types of wetlands and deepwater habitats in the United States. Established in 2010, it helps users to visualize, and better understand, the great diversity of wet habitats in this country. The general public, government personnel, wetland scientists, geographers, environmentalists, and other interested parties may contribute to the Wetland Image Gallery. This is a crowd-sourcing source effort, with all of its inherent advantages and disadvantages. The intent is to continuously update and add new images to complement the Wetlands Classification Standard (FGDC-STD-004-2013), the Wetlands Mapping Standard (FGDC-STD-015-2009) and the National Wetlands Inventory's Data Collection Requirements and Procedures document (Dahl et al. 2009).