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Chapter One

CLASSIFICATION OF WETLAND ECOSYSTEMS

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INTRODUCTION

Wetlands represent the diverse group of wet natural environments usually found at the interface between land and water along our Nation's waterways and waterbodies or in isolated depressions on the landscape. They may also occur on slopes in association with ground-water seepage areas, springs, or drainageways. Wetlands have been referred to by a host of terms, including marsh, wet meadow, bog, swamp, and bottomland forest. Unfortunately, many of these commonly used terms do not have a strict definition and, therefore, may mean different things to different people. In an effort to provide uniformity in wetland concept and terminology, the U.S. Fish and Wildlife Service (FWS), with assistance from numerous Federal and state agencies and others, developed a national wetland classification system. In 1979, the Service published *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin *et al.* 1979) which serves as the national standard for wetland classification. This new classification system replaced the original FWS wetland classification used to conduct a nationwide wetlands inventory in the 1950's and 1960's (Shaw and Fredine 1954). The following discussion outlines wetland classification after a brief overview of the definition of wetland.

WETLAND DEFINITION

Over time, wetlands have been variously defined by scientists working in specialized fields such as botany or hydrology. Each expert tended to define wetland according to his or her specialty. For example, the botanist generally focuses on plant species and community structure, while the hydrologist emphasizes ground-water and surface-water relationships. From the 1960s to the present, interest in wetlands, especially wetland protection through regulation, has increased tremendously. With wetland regulation came the need to better define wetlands and to delineate the upper limits of wetlands. It, therefore, became important to develop a multi-disciplinary definition. The U.S. Fish and Wildlife Service (FWS) took this approach in formulating its wetland definition and classification system.

In developing a multi-disciplinary definition of wetland, the FWS first acknowledged that "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" (Cowardin *et al.* 1979). Afterall, a wealth of wetland definitions grew out of different needs for defining wetlands among various groups and organizations, e.g., wetland regulators, waterfowl managers, hydrologists, flood control engineers and water quality experts. The FWS has not attempted to legally define wetland, since each State or Federal regulatory agency has defined wetland somewhat differently to suit its administrative purposes. Therefore, according to existing wetland laws, a wetland is whatever the law says it is. The FWS needed a definition that would allow accurate identification and delineation of the Nation's wetlands for resource management purposes.

The Service specifically defines wetlands as follows: "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; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is *nonsoil* [emphasis added] and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin *et al.* 1979).

In defining wetlands from an ecological standpoint, the FWS emphasizes three key attributes of wetlands: (1) hydrology - the degree of flooding or soil saturation, (2) wetland vegetation (hydrophytes), and (3) hydric soils. All areas considered wetland must have enough water at some time during the growing season to stress plants and animals not adapted for life in water or saturated soils. Most wetlands have hydrophytes and hydric soils present. The FWS has prepared a national list of wetland plants (Reed 1988) and the U.S.D.A. Soil Conservation Service has developed a list of hydric soils to help identify wetlands (U.S.D.A. Soil Conservation Service 1987).

Particular attention should be paid to the reference to flooding or soil saturation during the growing season in the FWS's wetland definition. When soils are covered by water or saturated to the surface, free oxygen is not available to plant roots. During the growing season, most plant roots must have access to free oxygen for respiration and growth; flooding at this time would have serious implications for the growth and survival of most plants. In a wetland

situation, plants must be adapted to cope with these stressful conditions. If, however, flooding only occurs in winter when the plants are dormant, there is little or no effect on their survival.

Wetlands typically fall within one of the following four categories: (1) areas with both hydrophytes and hydric soils (e.g., marshes, swamps and bogs), (2) areas without hydrophytes, but with hydric soils (e.g., tidal flats), (3) areas without soils but with hydrophytes (e.g., seaweed-covered rocky shores), and (4) periodically flooded areas without soil and without hydrophytes (e.g., gravel beaches or streambeds). Completely drained hydric soils that are no longer capable of supporting hydrophytes due to a drastic change in water regime are not considered wetland. Areas with completely drained hydric soils are, however, good indicators of historic wetlands, which may be suitable for restoration through mitigation projects.

It is important to mention that the FWS does not generally include permanently flooded deepwater areas as wetland, although shallow waters are classified as wetland. Instead, these deeper waterbodies are defined as deepwater habitats, since water and not air is the principal medium in which dominant organisms live. Along the coast in tidal areas, the deepwater habitat begins at the extreme spring low tide level. In nontidal freshwater areas, however, this habitat starts at a depth of 2m (6.6 feet) because the shallow water areas are often vegetated with emergent wetland plants.

WETLAND CLASSIFICATION

The following discussion is a simplified overview of the FWS's wetland classification system. Consequently, some of the more technical points have been omitted from this discussion. When actually classifying a wetland, the reader is advised to refer to the official classification document (Cowardin *et al.* 1979) and should not rely solely on this overview.

The FWS's wetland classification system is vertical in nature proceeding from general to specific. In this approach, wetlands are first defined at a rather broad level - the SYSTEM. The term SYSTEM represents "a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors." Five systems are defined: Marine, Estuarine, Riverine, Lacustrine and Palustrine. The Marine System generally consists of the open ocean and its associated coastline. Obviously, Pennsylvania does not have marine wetlands. The Estuarine System encompasses salt and brackish marshes and brackish waters of coastal rivers and embayments and in Pennsylvania this system is limited to the lower Delaware River. Freshwater wetlands and deepwater habitats fall into one of the other three systems: Riverine (e.g., rivers and streams), Lacustrine, (e.g., lakes, reservoirs and large deep ponds) or Palustrine (e.g., marshes, bogs, swamps and small shallow ponds). Thus,

TABLE 1

Classes and subclasses of wetlands and deepwater habitats (Cowardin et al. *1979).*

Class	Brief Description	Subclasses
Rock Bottom	Generally permanently flooded areas with bottom substrates consisting of at least 75% stones and boulders and less than 30% vegetative cover.	Bedrock; Rubble
Unconsolidated Bottom	Generally permanently flooded areas with bottom substrates consisting of at least 25% particles smaller than stones and less than 30% vegetative cover.	Cobble-Gravel; Sand; Mud; Organic
Aquatic Bed	Generally permanently flooded areas vegetated by plants growing principally on or below the water surface line.	Algal; Aquatic Moss; Rooted Vascular; Floating Vascular
Reef	Ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates.	Coral; Mollusk; Worm
Streambed	Channel whose bottom is completed dewatered at low water periods.	Bedrock; Rubble; Cobble-Gravel; Sand; Mud; Organic; Vegetated
Rocky Shore	Wetlands characterized by bedrock, stones or boulders with areal coverage of 75% or more and with less than 30% coverage by vegetation.	Bedrock; Rubble
Unconsolidated Shore*	Wetlands having unconsolidated substrates with less than 75% coverage by stones, boulders and bedrock and less than 30% vegetative cover, except by pioneer plants.	Cobble-Gravel; Sand; Mud; Organic; Vegetated
	(*NOTE: This class combines two classes of the 1977 operational draft system—Beach/Bar and Flat. Beach/Bar is a sloping landform, while Flat is a nearly level landform.)	
Moss-Lichen Wetland	Wetlands dominated by mosses or lichens where other plants have less than 30% coverage.	Moss; Lichen
Emergent Wetland	Wetlands dominated by erect, rooted, herbaceous hydrophytes.	Persistent; Nonpersistent
Scrub-Shrub Wetland	Wetlands dominated by woody vegetation less than 6 m (20 feet) tall.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead
Forested Wetland	Wetlands dominated by woody vegetation greater than 6 m (20 feet) tall.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead

at the most general level, wetlands can be defined as either Marine, Estuarine, Riverine, Lacustrine or Palustrine. Most of Pennsylvania's wetlands are associated with the Palustrine System.

Each system, with the exception of the Palustrine, is further subdivided in subsystems. The Marine and Estuarine Systems both have the same two subsystems, which are defined by tidal water levels: (1) Subtidal—continuously submerged areas and (2) Intertidal—areas alternately flooded by tides and exposed to air. Similarly, the Lacustrine System is separated into two systems based on water depth: (1) Littoral—wetlands extending from the lake shore to a depth of 2m (6.6 feet) below low water or to the extent of nonpersistent emergents (e.g., arrowheads, pickerelweed or spatterdock) if they grow beyond that depth, and (2) Limnetic—deepwater habitats lying beyond the 2m (6.6 feet) at low water. By contrast, the Riverine System is further defined by four subsystems which represent different reaches of a flowing freshwater or lotic system: (1) Tidal—water levels subject to tidal fluctuations, (2) Lower Perennial—permanent, slow-flowing waters with a well-developed floodplain, (3) Upper Perennial—permanent, fast-flowing water with very little or no floodplain development, and (4) Intermittent—channel containing nontidal flowing water for only part of the year.

Below the subsystem, the CLASS level describes the general appearance of the wetland or deepwater habitat in terms of the dominant vegetative life form or the composition of the substrate, where vegetative cover is less than 30 percent (Table 1). Of the 11 classes, five refer to areas where vegetation covers 30 percent or more of the surface: Aquatic Bed, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland and Forested Wetland. The remaining six classes represent areas generally lacking vegetation where the composition of the substrate and degree of flooding distinguish classes: Rock Bottom, Unconsolidated Bottom, Reef (sedentary invertebrate colony), Streambed, Rocky Shore, and Unconsolidated Shore. Permanently flooded unvegetated areas are classified as either Rock Bottom or Unconsolidated Bottom, while exposed areas are typed as Streambed, Rocky Shore or Unconsolidated Shore. Invertebrate reefs are found in both permanently flooded and exposed areas.

Each class is further divided into subclasses to better define the type of substrate in unvegetated areas (e.g., bedrock, rubble, cobble-grave, mud, sand, and organic) or the type of dominant vegetation (e.g., persistent or nonpersistent emergents; moss; lichen; or broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, needle-leaved evergreen and dead woody plants). Below the subclass level, dominance type can be applied to specify the predominant plant or animal in the wetland community.

To allow a better description of a given wetland or deepwater habitat in regard to hydrologic, chemical and soil characteristics and to human impacts, the classification system contains four types of specific modifiers: (1) Water Regime, (2) Water Chemistry, (3) Soil, and (4) Special. These modifiers may be applied

TABLE 2

Water regime modifiers, both tidal and nontidal groups (Cowardin et al. *1979). An asterisk(*) denotes a water regime developed by the National Wetlands Inventory Group for mapping purposes.*

Group	Type of Water	Water Regime	Definition
Tidal	Saltwater and brackish areas	Subtidal	Permanently flooded by tides.
		Irregularly exposed	Exposed less often than daily by tides.
		Regularly flooded	Daily tidal flooding and exposure to air.
		Irregularly flooded	Flooded less often than daily and typically exposed to air.
	Freshwater areas	Permanently flooded-tidal	Permanently flooded by tides or exposed less often than daily by tides.
		Semipermanently flooded-tidal	Flooded throughout growing season in most years by river overflow and with tidal fluctuation in water levels.
		Regularly flooded-tidal	Daily tidal flooding and exposure to air.
		Seasonally flooded-tidal	Flooded irregularly by tides and seasonally by river overflow.
		Temporarily flooded-tidal	Flooded irregularly by tides and for brief periods during growing season by river overflow.
Nontidal	Inland freshwater and saline areas	Permanently flooded	Flooded through the year in all years.
		Intermittently exposed	Flooded year-round except during extreme droughts.
		Semipermanently flooded	Flooded throughout the growing season in most years.
		Seasonally flooded	Flooded for extended periods in growing season, but surface water is usually absent by end of growing season.
		Saturated	Surface water is seldom present, but substrate is saturated to the surface for most of the season.
		*Seasonally flooded/saturated	Flooded for extended periods during growing season and when surface water is absent, water table remains at or very near the soil surface.
		Temporarily flooded	Flooded for only brief periods during growing season, with water table usually well below the soil surface for most of the season.
		Intermittently flooded	Substrate is usually exposed and only flooded for variable periods without detectable seasonal periodicity (not always wetland; may be upland in some situations).
		Artificially flooded	Duration and amount of flooding is controlled by means of pumps or siphons in combination with dikes or dams.

to class and lower levels of the classification hierarchy.

Water regime modifiers describe flooding or soil saturation conditions and are divided into two main groups: (1) tidal and (2) nontidal. Tidal water regimes are used where water level can be subdivided into two general categories, one for saltwater and brackish water tidal areas and another for freshwater tidal areas. This distinction is needed because of the special importance of seasonal river overflow in freshwater tidal areas. By contrast, nontidal modifiers define conditions where surface water runoff, ground-water discharge, and/or wind effects (i.e., lake seiches) cause water level changes. Tidal and nontidal water regime modifiers are briefly defined in Table 2.

Water chemistry modifiers are divided into two categories which describe the salinity and hydrogen ion concentration (pH): (1) salinity modifiers and (2) pH modifiers. Like water regimes, salinity modifiers are further subdivided into two groups: halinity modifiers for tidal areas and salinity modifiers for nontidal areas. Estuarine and marine waters are dominated by sodium chloride, which is gradually diluted by fresh water as one moves upstream in coastal rivers. On the other hand, the salinity of inland waters is dominated by four major cations (i.e., calcium, magnesium, sodium and potassium) and three major anions (i.e., carbonate, sulfate, and chloride). Interactions between precipitation, surface runoff, ground-water flow, evaporation, and sometimes plant evapotranspiration form inland salts. In Table 3, the ranges of halinity and salinity modifiers are defined as a modification of the Venice System (Remane and Schlieper 1971). The other set of water chemistry modifiers are pH modifiers for identifying acid ($pH < 5.5$), circumneutral (5.5-7.4) and alkaline ($pH > 7.4$) waters. Some studies have shown a good correlation between plant distribution and pH levels (Sjors 1950, Jeglum 1971). Moreover, pH can be used to distinguish between mineral-rich and mineral-poor wetlands.

The third group of modifiers—soil modifiers—are presented because the

TABLE 3

Salinity modifiers for coastal and inland areas (Cowardin et al. *1979).*

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

[1]Coastal modifiers are employed in the Marine and Estuarine Systems.
[2]Inland modifiers are employed in the Riverine, Lacustrine and Palustrine Systems.
[3]The term "brackish" should not be used for inland wetlands or deepwater habitats.

TABLE 4

Comparison of wetland types described in the original FWS classification system (Shaw and Fredine 1956) with major components of the new FWS wetland classification system (Cowardin et al. *1979).*

Original FWS Wetland Type	—New Wetland Classification— Systems	Classes	Water Regimes	Water Chemistry
Type 1—Seasonally flooded basins or flats	Palustrine	Emergent Wetland Forested Wetland	Temporarily Flooded Intermittently Flooded	Fresh Mixosaline
Type 2—Inland fresh meadows	Palustrine	Emergent Wetland	Saturated	Fresh Mixosaline
Type 3—Inland shallow fresh marshes	Palustrine, Lacustrine* or Riverine*	Emergent Wetland	Semipermanently Flooded Seasonally Flooded	Fresh Mixosaline
Type 4—Inland deep fresh marshes	Palustrine, Lacustrine*, or Riverine*	Emergent Wetland Aquatic Bed	Permanently Flooded Intermittently Exposed Semipermanently Flooded	Fresh Mixosaline
Type 5—Inland open fresh water	Palustrine or Lacustrine	Aquatic Bed Unconsolidated Bottom	Permanently Flooded Intermittently Exposed	Fresh Mixosaline
Type 6—Shrub swamps	Palustrine	Scrub-Shrub Wetland	All nontidal regimes except Permanently Flooded	Fresh
Type 7—Wooded swamps	Palustrine	Forested Wetland	All nontidal regimes except Permanently Flooded	Fresh
Type 8—Bogs	Palustrine	Scrub-Shrub Wetland Forested Wetland Moss-Lichen Wetland	Saturated	Fresh (Acid only)
Type 9—Inland saline flats	Palustrine or Lacustrine	Unconsolidated Shore	Seasonally Flooded Intermittently Flooded Temporarily Flooded	Eusaline Hypersaline
Type 10—Inland saline marshes	Palustrine or Lacustrine*	Emergent Wetland	Seasonally Flooded Semipermanently Flooded	Eusaline
Type 11—Inland open saline water	Palustrine or Lacustrine	Unconsolidated Bottom	Permanently Flooded Intermittently Flooded	Eusaline
Type 12—Coastal shallow fresh marshes	Estuarine or Palustrine	Emergent Wetland	Regularly Flooded Irregularly Flooded Semipermanently Flooded-Tidal Seasonally Flooded-Tidal	Oligohaline Fresh
Type 13—Coastal deep fresh marshes	Estuarine or Palustrine	Emergent Wetland	Regularly Flooded Semipermanently Flooded-Tidal	Oligohaline Fresh
Type 14—Coastal open fresh water	Estuarine or Riverine (Tidal)	Aquatic Bed Unconsolidated Bottom	Subtidal Permanently Flooded-Tidal	Oligohaline Fresh
Type 15—Coastal salt flats	Estuarine	Unconsolidated Shore	Regularly Flooded Irregularly Flooded	Hypersaline Euhaline Polyhaline
Type 16—Coastal salt meadows	Estuarine	Emergent Wetland	Irregularly Flooded	Euhaline Polyhaline Mesohaline
Type 17—Irregularly flooded salt marshes	Estuarine	Emergent Wetland	Irregularly Flooded	Euhaline Polyhaline Mesohaline
Type 18—Regularly flooded salt marshes	Estuarine	Emergent Wetland	Regularly Flooded	Euhaline Polyhaline Mesohaline
Type 19—Sounds and bays	Estuarine or Marine	Unconsolidated Bottom Aquatic Bed Flat	Subtidal Irregularly Exposed Regularly Flooded	Euhaline Mixohaline
Type 20—Mangrove swamps	Estuarine or Palustrine	Scrub-Shrub Wetland Forested Wetland	Irregularly Exposed Regularly Flooded Irregularly Flooded	Hyperhaline Euhaline Mixohaline Fresh

*Lacustrine and riverine emergent wetlands are characterized by nonpersistent plants; emergent wetlands dominated by persistent plants are classified as palustrine.

nature of the soil exerts strong influences on plant growth and reproduction as well as on the animals living in it. Two soil modifiers are given: (1) mineral and (2) organic. In general, if a soil has 20 percent or more organic matter by weight in the upper 40 cm (16 inches), it is considered an organic soil, whereas if it has less than this amount, it is a mineral soil. For specific definitions refer to Appendix D of the FWS's classification system (Cowardin *et al.* 1979) or to *Soil Taxonomy* (U.S.D.A. Soil Conservation Service 1975).

The final set of modifiers—special modifiers—were established to describe the activities of people or beaver affecting wetlands and deepwater habitats. These modifiers include: excavated, impounded (i.e., to obstruct outflow of water), diked (i.e., to obstruct inflow of water), partly drained, farmed, and artificial (i.e., materials deposited to create or modify a wetland or deepwater habitat).

Since the FWS's newer wetland classification replaces its older and widely used classification, Table 4 was developed to assist the reader in comparing the major features of the new system with the earlier system.

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