WETLANDS OF CONNECTICUT

by Kenneth J. Metzler & Ralph W. Tiner

State Geological and Natural History Survey of Connecticut
in Cooperation with the U.S. Fish and Wildlife Service
National Wetlands Inventory

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CHAPTER 1.

Introduction

Since the 1950s, there has been particular concern about wetland losses and their impact on fish and wildlife populations. In 1954, the U.S. Fish & Wildlife Service conducted the first nationwide wetlands inventory. This inventory was published in a well-known report entitled, *Wetlands of the United States*, commonly referred to as "Circular 39" (Shaw and Fredine, 1956). Since the publication of Circular 39, wetlands have continued to change due to both natural processes and human activities, such as the conversion of wetlands for agriculture, residential and industrial developments and other uses.

During the 1960s, the general public in many states became more aware of wetland values and more concerned about wetland losses. People began to realize that wetlands not only provide significant fish and wildlife habitat, but that they also provide public benefits such as flood protection and water quality maintenance. Wetlands had been regarded by most people as wastelands whose best use could only be attained by draining for agriculture, dredging and filling for industrial and housing developments, or for use as sanitary landfills. However, scientific studies demonstrating wetland values were instrumental in increasing public awareness of wetland benefits and stimulating concern for wetland protection. Consequently, in the 1960s and 1970s, several states passed laws to protect coastal wetlands: Massachusetts (1963), Rhode Island (1965), Connecticut (1969), New Jersey (1970), Maryland (1970), Georgia (1970), New York (1972) and Delaware (1973). Shortly thereafter, several of these states adopted inland wetland protection legislation: Massachusetts, Rhode Island, Connecticut, and New York. Most other states with coastal wetlands subsequently followed the lead of these northeastern states, and in the mid to late 1980s, other northeastern states adopted freshwater wetland protection laws: Vermont, New Jersey, Maine, and Maryland.

During the 1970s, the U.S. Army Corps of Engineers assumed limited regulatory responsibility for wetland protection through Section 10 of the Rivers and Harbors Act and Section 404 of the Federal Water Pollution Control Act (later amended as the Clean Water Act of 1977). Federal permits from the U.S. Army Corps of Engineers are now required for many types of construction in wetlands, although normal agricultural and forestry practices are exempt.

The U.S. Fish and Wildlife Service has the primary responsibility for the protection and management of the nation's fish and wildlife and their habitats. Consequently, a need for ecological information was recognized for use in making knowledgeable decisions regarding policy, planning, and the management of the country's wetland resources. The National Wetlands Inventory Project was established in 1974 to generate and disseminate scientific information on the characteristics and extent of the nation's wetlands. The purpose of this information is to foster appropriate use of wetlands and to provide data for making accurate resource decisions. Two different kinds of information are generated by this project: (1) detailed maps; and, (2) status and trends reports.

Detailed wetland maps serve a purpose similar to that of the National Cooperative Soil Surveys, the National Oceanic and Atmospheric Administration's coastal geodetic survey maps, and the Geological Survey's topographic maps. Detailed wetland maps are used for many purposes including watershed management plans, environmental impact assessments, permit reviews, facility and corridor siting, oil spill contingency plans, natural resource inventories, wildlife surveys, and others. To date, over 10,000 maps have been produced, covering 61 percent of the lower 48 States, 18 percent of Alaska, and all of Hawaii. Present plans are to complete wetland mapping for the conterminous U.S. by 1998 and to accelerate the mapping of Alaska's wetlands thereafter.

By classifying wetland types and measuring acreages, it has also been possible to provide national estimates of the status and recent losses and gains of wetlands. Hence, the National Wetlands Inventory (NWI) provides information for reviewing the effectiveness of existing federal programs and policies and for increasing public awareness. Technical and popular reports about these trends have recently been published (Frayer, *et al.*, 1983; Tiner, 1984).

Need for a Wetlands Inventory in Connecticut

Although the state of Connecticut prepared coastal wetland maps in the early 1970's for regulatory purposes, no statewide acreage summaries of the extent of these wetlands were prepared. Similarly, Connecticut prepared maps for inland wetlands based upon soil types from the National Cooperative Soil Surveys for identification purposes only. Neither set of maps separates wetlands into vegetation types. Moreover, significant time has elapsed since the coastal and inland wetland maps were prepared and changes have undoubtedly occurred.

Consequently, the U.S. Fish and Wildlife Service and the Connecticut Department of Environmental Protection joined together in 1980 to conduct a wetlands inventory for Connecticut. This inventory was a part of the Service's National Wetlands Inventory Project, and produced detailed wetland maps that identify the status of Connecticut's wetlands and serve as a base for determining future changes.

Description of the Study Area

Connecticut's landscape is primarily hilly with a broad central lowland bisecting the state (Figure 1). Elevations range from sea level along the coast to over 2,000 feet in the northwest uplands. Most of the state is underlain by acidic schists and gneisses with sandstones, shales, and basalts in the Central Valley. Along the western border, a few narrow limestone valleys occur (Rodgers, 1985). A general description of the geology of Connecticut can be found in *The Face of Connecticut: People, Geology, and the Land* (Bell, 1985).

Connecticut has a temperate humid climate that is modified by its proximity to the Atlantic Ocean. In general, there is a large range in both diurnal and annual temperatures, ample precipitation evenly distributed throughout the year, great variation between the same season in different years, and considerable diversity from place to place (Brumbach, 1965). Annual precipitation is 44-48 inches, with an average snowfall accumulation ranging from 7 inches along the coast to 20 inches in the northwestern uplands. Average temperatures range from a mean maximum of 82.5^{O}F in July to a mean minimum of 18.4^{O}F in January. The length of the frost free season averages from 180 days along the coast to 150 days in the northwest corner of the state, with the first freeze occurring in late September or early October and the last in mid-April or early May.

Organization of this Report

This report includes discussions of wetland concept and classification (Chapter 2), National Wetlands Inventory techniques and results (Chapter 3), wetland formation and hydrology (Chapter 4), hydric soils (Chapter 5), wetland vegetation and plant communities (Chapter 6), wetland values (Chapter 7), wetland trends (Chapter 8), and wetland protection (Chapter 9). The Appendix contains a list of hydrophytic plants found in Connecticut's wetlands. Scientific names of plants follow the *Preliminary Checklist of the Vascular Flora of Connecticut* (Dowhan, 1979) with synonymy to the *National List of Scientific Plant Names* (U.S.D.A. Soil Conservation Service, 1982). A figure showing the general distribution of Connecticut's wetlands and deepwater habitats is provided as an enclosure at the back of this report.

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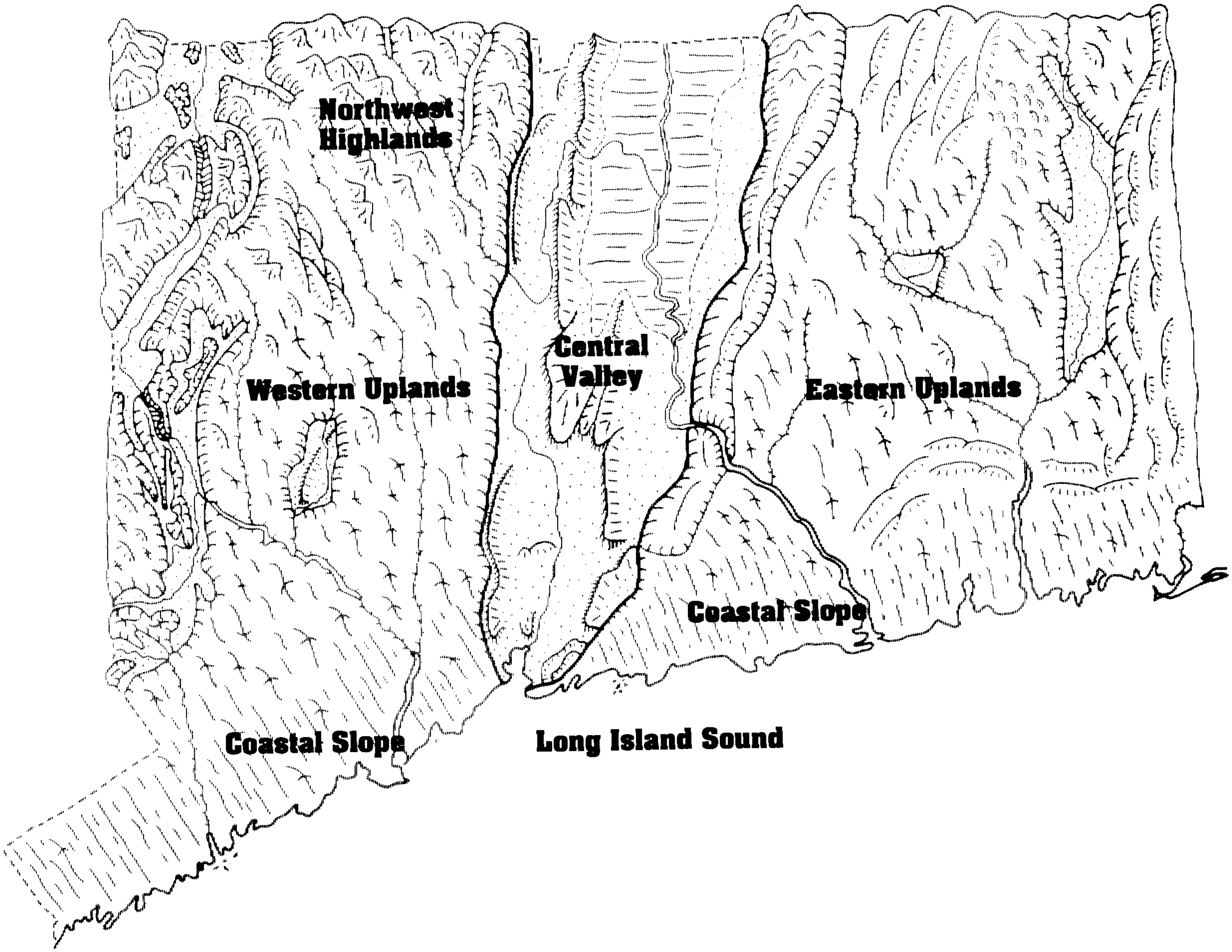

Figure 1. Physiographic regions of Connecticut (from Bell, 1985).

CHAPTER 2.

U.S. Fish and Wildlife Service's Wetland Definition and Classification System

Introduction

In January 1975, the U.S. Fish and Wildlife Service brought together 14 authors of regional wetland classifications and other prominent wetland scientists to help decide if any existing classification could be used or modified for a national inventory, or if a new system was needed. They recommended that the Service attempt to develop a new national wetland classification. In July 1975, the Service sponsored the National Wetlands Classification and Inventory Workshop, where more than 150 wetland scientists and mapping experts met to review a preliminary draft of the new wetland classification system. The consensus was that the system should be hierarchical in nature and built around the concept of ecosystems (Sather, 1976).

Four key objectives for the new system were established: (1) to develop ecologically similar habitat unit; (2) to arrange these units in a system that would facilitate resource management decisions; (3) to furnish units for inventory and mapping; and, (4) to provide uniformity in concept and terminology throughout the country (Cowardin, *et al.*, 1979).

The U.S. Fish and Wildlife Service wetland classification system was developed by Lewis M. Cowardin, U.S. Fish and Wildlife Service; Virginia Carter, U.S. Geological Survey; Francis C. Golet, University of Rhode Island; and Edward T. LaRoe, National Oceanic and Atmospheric Administration, with assistance from numerous federal and state agencies, university scientists, and other interested individuals. The classification system went through three major drafts and extensive field testing prior to its publication as *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin, *et al.*, 1979). Since its publication, this classification system has been widely used by federal, state and local agencies, university scientists, private industry, and nonprofit organizations for identifying and classifying wetlands.

The U.S. Fish and Wildlife Service's Definition of Wetlands

Wetlands generally lie between the better drained, rarely flooded uplands and the permanently flooded deep waters of lakes, rivers and coastal embayments (Figure 2). Wetlands include the variety of marshes, bogs, swamps, shallow ponds, and bottomland forests that occur throughout the country. They usually lie in upland depressions or along rivers, lakes and coastal waters where they are subject to periodic flooding or surface water ponding. Some wetlands, however, occur on slopes where they are associated with ground water seeps. To accurately inventory this resource, the point along the continuum of natural wetness where wetland ends and upland begins had to be determined. While many wetlands lie in distinct depressions or basins that are readily observable, the wetland-upland boundary is not always easy to identify. This is especially true along many flood plains, in glacial till deposits, on gently sloping terrain, and in areas with significant hydrologic modification. To help ensure accurate and consistent wetland determination, a multi-disciplinary and ecologically-based wetland definition was constructed.

The U.S. Fish and Wildlife Service first acknowledged "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). Secondly, no attempt was made to legally define "wetland," since each state or federal regulatory agency has defined wetland somewhat differently to suit its administrative purposes (Table 1). A wetland is whatever the law says it is. For example, Connecticut's Tidal Wetland Protection Act (Section 22a-28 through 35, inclusive of the Connecticut General Statutes) defines tidal wetlands by a combination of hydrologic and vegetative characteristics. In contrast, Connecticut's Inland Wetlands and Watercourses Act (Sections 22a-36 through 22a-45, inclusive of the Connecticut General Statutes) defines inland wetlands primarily by certain soil types ("poorly drained, very poorly drained, alluvial, and flood plain as defined by the U.S.D.A. National Cooperative Soil Survey"). Watercourses are defined differently as ". . . rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water, natural or artificial, which are contained within, flow through, or border upon the State." With this variation in the legal definitions of wetlands within Connecticut as well as differences on the federal and state levels, a wetland definition was needed that would standardize the identification of wetlands throughout the United States.

The U.S. Fish and Wildlife Service 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 the purposes of this classification, wetlands

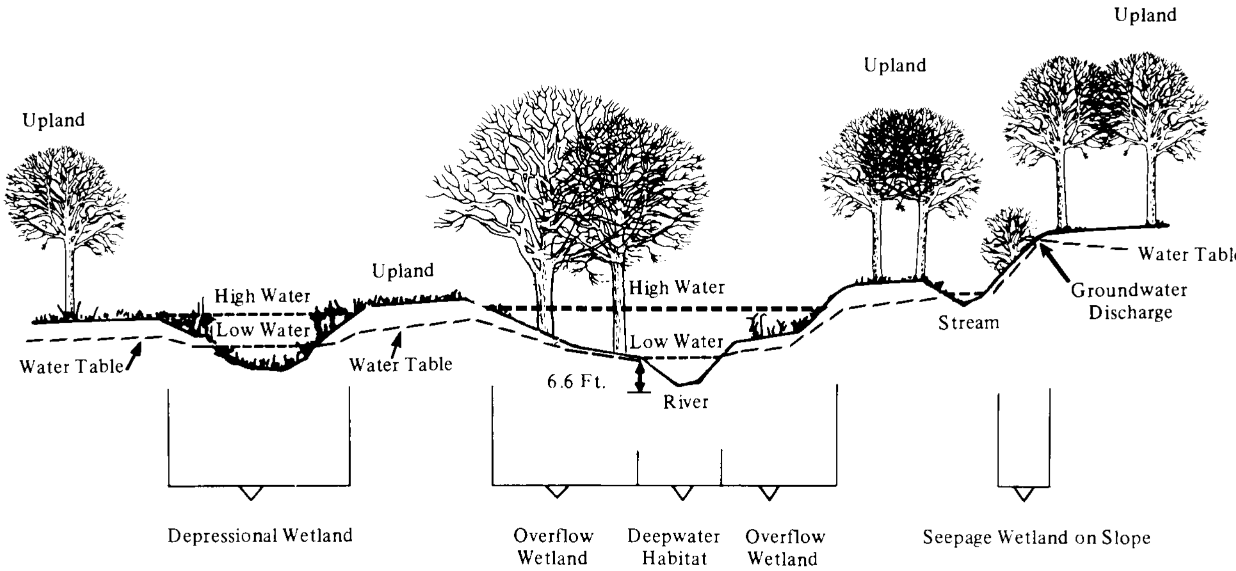

Figure 2. Schematic diagram showing wetland and deepwater habitats, and uplands on the landscape. Note differences in wetlands due to hydrology and topographic position.

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 and is saturated with water or covered by shallow water at some time during the growing season of each year." (Cowardin, *et al.*, 1979, see Tiner, 1989 for clarification).

In defining wetlands from an ecological standpoint three key attributes of wetlands are emphasized: (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. National and regional lists of wetland plants have been prepared by the U.S. Fish and Wildlife Service (Reed, 1988a; 1988b) and the Soil Conservation Service has developed a list of hydric soils (U.S.D.A. Soil Conservation Service, 1987) to help identify wetland.

Particular attention must be given to flooding or soil saturation during the growing season. 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 can have serious implications for the growth and survival of most plants. In wetlands, plants must be adapted to cope with these stressful conditions.

Using this definition, 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).

Completely drained hydric soils that are no longer capable of supporting hydrophytes due to a change in water regime are not considered wetlands under the U.S. Fish and Wildlife classification system. Areas with effectively drained hydric soils are, however, good indicators of historic wetlands which may be suitable for restoration through mitigation projects.

The U.S. Fish and Wildlife Service generally classifies shallow waters as wetlands. Deeper water bodies are defined as deepwater habitats, since water is the principal medium in which organisms live. In tidal areas, the deepwater habitat begins at the extreme spring low tide level. In nontidal freshwater areas, however, this habitat by definition starts at a depth of 6.6 feet (2 m) since shallow water areas are often vegetated with emergent wetland plants. Both "wetlands" and "deepwater habitats" are regulated by state and federal laws to protect wetland and water quality.

The U.S. Fish and Wildlife Service's Wetlands Classification System

The U.S. Fish and Wildlife Service wetlands classification system is hierarchical, proceeding from general to specific (Figure 3). In this approach, wetlands are first

Table 1. Definitions of "wetland" according to selected federal agencies and state statutes.

Organization (Reference)	Wetland Definition	Comments
U.S. Fish and Wildlife Service (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 the 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 and is saturated with water or covered by shallow water at some time during the growing season of each year."	This is the official U.S. Fish and Wildlife Service definition and is used for conducting an inventory of the wetlands in the United States. This definition emphasizes flooding and/or soil saturation, hydric soil saturation, hydric soils, and hydrophytic vegetation. Shallow lakes and ponds are also included as wetlands. Comprehensive lists of wetland plants and hydric soils are available to further clarify this definition.
U.S. Army Corps of Engineers (Federal Register, July 19, 1977; July 22, 1982; November 13, 1986)	"Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."	Federal regulatory definition in response to Section 404 of the Clean Water Act of 1977. Excludes similar areas lacking vegetation, such as tidal flats and does not define lakes, ponds, and rivers as wetlands.
U.S.D.A. Soil Conservation Service (National Food Security Act Manual, 1988)	"Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having high potential for agricultural development and a predominance of permafrost soils."	This is the Soil Conservation Service's definition for implementing the "Swampbuster" provision of the Food Security Act of 1985. Any area that meets hydric soil criteria is considered to have a predominance of hydric soils. Note the geographical exclusion for certain lands in Alaska.
State of Connecticut (CT General Statutes, Sections 22a-36 to 45, inclusive, 1972, 1987)	"Wetlands mean land, including submerged land, which consists of any of the soil types designated as poorly drained, very poorly drained, alluvial, and floodplain by the National Cooperative Soils Survey, as may be amended from time to time, of the Soil Conservation Service of the United States Department of Agriculture. Watercourses are defined as rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water, natural or artificial, public or private."	This is the State regulatory definition of inland wetlands and watercourses in Connecticut. The definition emphasizes soil drainage characteristics and hydrology and allows accurate determination of most wetland boundaries on-site by a certified soil scientist.
State of Connecticut (CT General Statutes, Sections 22a-28 to 35, inclusive 1969)	"Wetlands are those areas which border on or lie beneath tidal waters, such as, but not limited to banks, bogs, salt marshes, swamps, meadows, flats or other low lands subject to tidal action, including those areas now or formerly connected to tidal waters, and whose surface is at or below an elevation of one foot above local extreme high water."	This is the state regulatory definition for tidal wetlands in Connecticut. This definition includes a general list of plants capable of growing in these wetlands and the boundaries of such are plotted on official tidal wetland boundary maps based on detailed ground surveys.

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 (Figure 4). The Marine System generally consists of the open ocean and its associated coastline, while the Estuarine System encompasses salt and brackish marshes and brackish waters of coastal rivers and embayments. Freshwater wetlands and deepwater habitats fall into one of the other three systems: Riverine (rivers and streams), Lacustrine, (lakes, reservoirs, and large ponds) or Palustrine (marshes, bogs, swamps, and small shallow ponds).

Each system, with the exception of the Palustrine, is further subdivided into SUBSYSTEMS. The Marine and Estuarine Systems both have the same two subsystems: (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 subsystems, but the differences are based on water depth: (1) Littoral - extending from the lake shore to a depth of 6.6 feet (2 m) below low water, or to the extent of nonpersistent emergents (e.g., arrowheads, pickerel-weed, or spatterdock); and, (2) Limnetic - deepwater habitats beyond the 6.6 feet (2 m) at low water. The Riverine System has four subsystems: (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 waters with very little or no floodplain development; and, (4) Intermittent - channels containing nontidal flowing waters for only part of the year.

Wetland CLASS describes the general appearance of the wetland or deepwater habitat, its dominant vegetative life form, or the composition of the substrate where vegetative cover is less than 30% (Table 2). There are 11 classes, five of which refer to areas where vegetation covers

Table 2. 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 stone 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 completely 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 stone, boulders, and bedrock and less than 30% vegetative cover, except by pioneer plants. (NOTE: This class combines two classes of the 1977 operational draft system - Beach/Bar and Flat.)	Cobble-gravel; Sand; Mud; Organic; Vegetated
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 20 feet (6 m) tall.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead
Forested Wetland	Wetlands dominated by woody vegetation 20 feet (6 m) or taller.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead

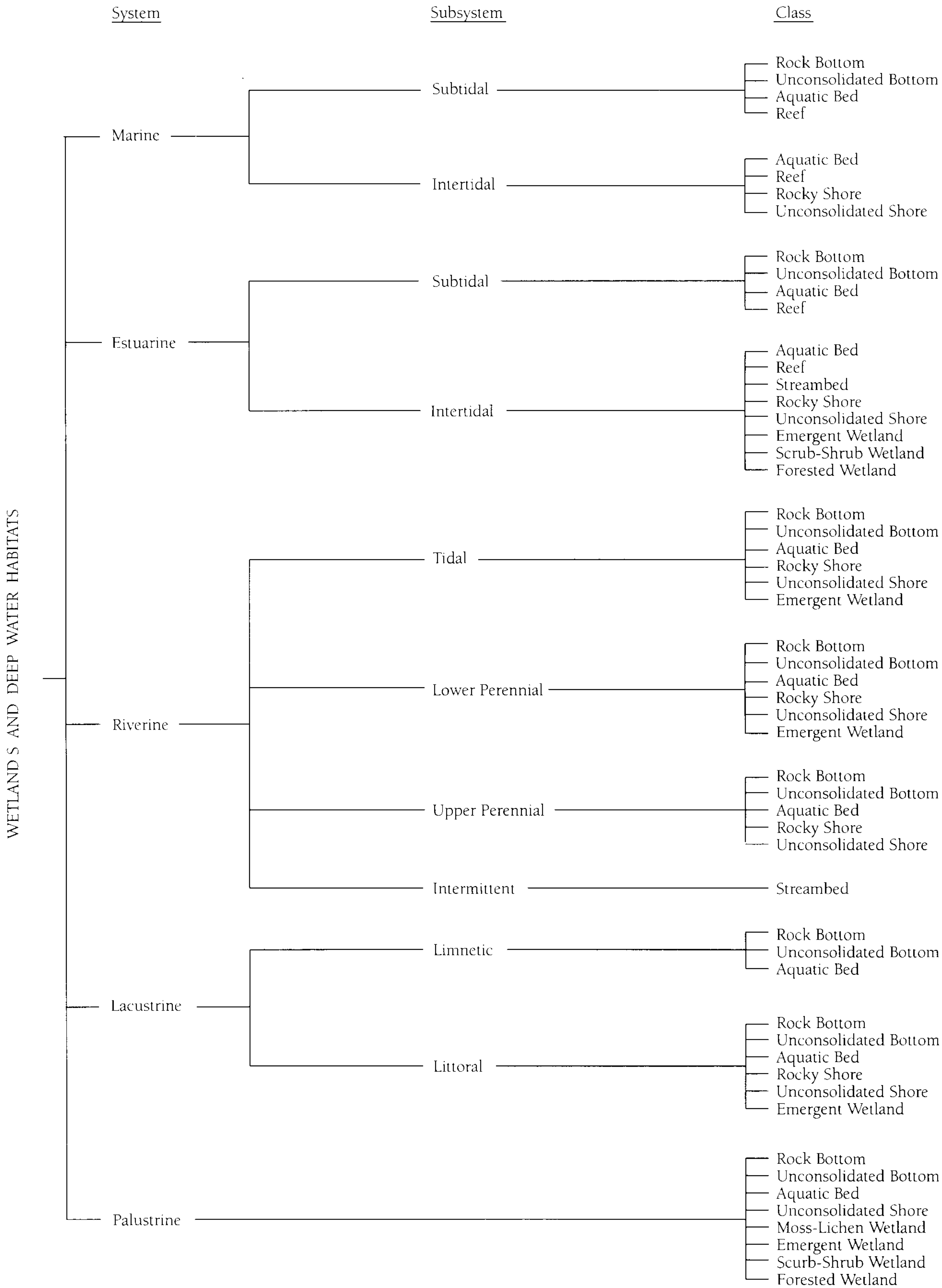

Figure 3. Classification hierarchy of wetlands and deepwater habitats showing systems, subsystems, and classes. The Palustrine System does not include deepwater habitats (Cowardin, *et al.*, 1979).

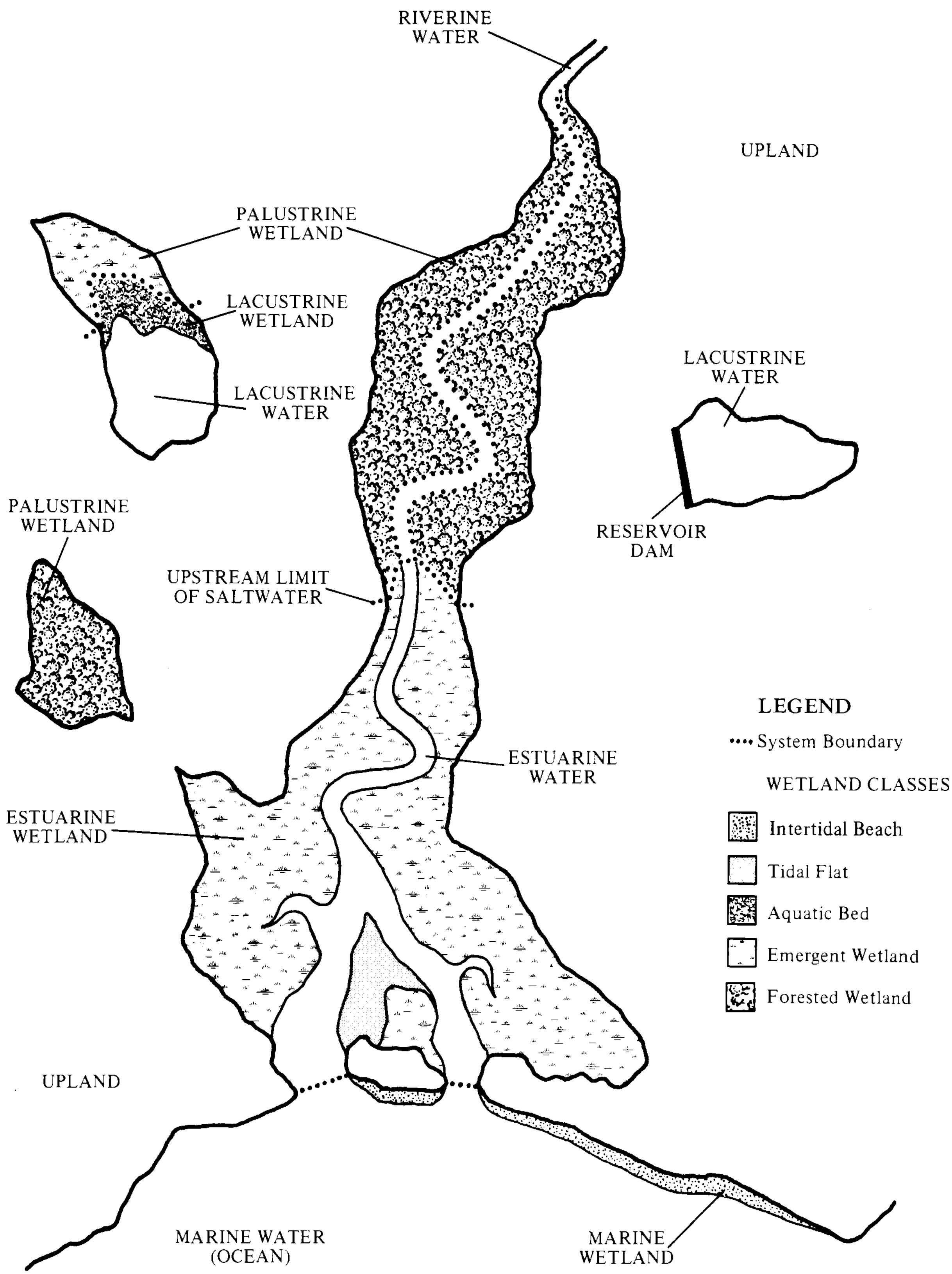

Figure 4. Diagram showing major wetland and deepwater habitat systems. Predominant wetland classes for each system are also designated. (*Note*: Tidal flat and beach classes are now considered unconsolidated shore.)

Table 3. Water regime modifiers, both tidal and nontidal groups (Cowardin, *et al.*, 1979).

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	Permanently flooded-tidal	Permanently flooded by tides and river or exposed irregularly by tides.
		Semipermanently flooded-tidal	Flooded for most of the growing season by river overflow but with tidal fluctuation in water levels.
		Regularly flooded	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 throughout the year in all years.
		Intermittently flooded	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.
		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 usualy exposed and only flooded for variable periods without detectable seasonal periodicity. (Not always wetlands: 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.

30% 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: Rock Bottom, Unconsolidated Bottom, Reef (sedentary invertebrate colony), Streambed, Rocky Shore, and Unconsolidated Shore. Permanently flooded nonvegetated 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 divided into SUBCLASSES which define the type of dominant vegetation or the type of substrate in nonvegetated areas. Below the subclass level, DOMINANCE type can be applied to specify the predominant plant or animal in the wetland community. MODIFERS allow better description of a given wetland or deepwater habitat in regard to hydrologic, chemical, and soil characteristics and to human impacts.

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 fluctuations are largely driven by oceanic tides. Tidal regimes can be subdivided into two general categories: one for salt and brackish tidal areas, and another for fresh 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. Both tidal and nontidal water regime modifiers are presented and briefly defined in Table 3.

Water chemistry is divided into two categories: (1) SALINITY MODIFIERS; and, (2) pH MODIFIERS. Like water regimes, salinity modifiers have been further subdivided into two groups: (1) halinity modifiers for tidal areas; and, (2) salinity modifiers for nontidal areas (Table 4). Estuarine and marine waters are dominated by sodium chloride, which is gradually diluted by the fresh water discharge of coastal rivers. In contrast, the salinity of inland waters is derived from a combination of four major cations (calcium, magnesium, sodium, and potassium) and three major anions (carbonate, sulfate, and chloride). Interactions between precipitation, surface runoff, groundwater flow, and evapotranspiration influence inland salts.

The pH modifiers are used to identify acid (pH < 5.5), circumneutral (pH 5.5-7.4) and alkaline (pH > 7.4) waters. Some studies have shown a good correlation between plant distribution and pH levels, especially in peat soils that isolate plant roots from the underlying mineral substrate (Sjors, 1950; Jeglum, 1971). Since pH can be used to distinguish between mineral-rich and mineral-poor wetlands and is relatively easy to determine, pH modifiers were instituted for freshwater wetlands.

SOIL MODIFIERS are used because 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% or more organic matter by weight in the upper 16 inches, it is considered organic, whereas if it has less than this amount, it is a mineral soil.

SPECIAL MODIFIERS describe the activities of people and/or animals such as beaver that affect wetlands and deepwater habitats. These modifiers include: (1) excavated; (2) impounded; (3) diked; (4) partly drained; (5) farmed; and, (6) artificial. A detailed definition of each level of the U.S. Fish and Wildlife Service's wetland classification system can be found in Cowardin, *et al.* (1979).

Table 4. Salinity modifiers for coastal and inland areas (Cowardin, *et al.*, 1979).

Coastal Modifiers[1]	Inland Modifiers[2]	Salinity (0/00)	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.

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CHAPTER 3.

National Wetlands Inventory Techniques and Results

Introduction

High-altitude aerial photography ranging in scale from 1:60,000 to 1:80,000 serves as the primary remote sensing imagery source for the National Wetlands Inventory. Once suitable high-altitude photography is obtained, there are seven steps in preparing wetland maps: (1) field investigations; (2) photo interpretation; (3) review of existing wetland information; (4) quality assurance; (5) draft map production; (6) interagency review of draft maps; and, (7) final map production. Steps 1, 2, and 3 encompass the basic data collection phase of the inventory. Steps 4 through 7 result in the production of 1:24,000 scale wetland maps.

After publication of final wetland maps for Connecticut, the U.S. Fish and Wildlife Service generated acreage summaries for wetlands and deepwater habitats for both the state and by counties. The procedures used to inventory Connecticut's wetlands and the results of this inventory are discussed in the following sections.

Wetlands Inventory Techniques

Review of Existing Wetlands Inventories

Prior to initiating the National Wetlands Inventory (NWI) in Connecticut in 1980, the U.S. Fish and Wildlife Service reviewed past wetland surveys to ensure that no duplication would occur. Major inventories included U.S. Fish and Wildlife Service surveys of important waterfowl wetlands in 1954, 1959, and 1965; Connecticut Department of Environmental Protection's coastal wetlands mapping in the early 1970s; and, National Cooperative Soil Survey maps for the State's inland wetlands (1962-1983). During this review, it was found that no comprehensive inventory on the ecological characteristics of Connecticut's wetlands and deepwater habitats existed. Information was lacking on the variety of wetlands based on vegetation types and hydrologic characteristics, and there were no current data on the acreage and distribution of different wetland types. In this respect, the NWI effort provides the first comprehensive statewide inventory of Connecticut's wetland resources. A summary of wetland inventories in Connecticut is presented in Table 5.

Mapping Photography

Black and white, 1:80,000 scale aerial photography was used for mapping Connecticut's wetlands (Figure 5). This imagery was taken mostly during the spring of 1980 with a portion of western Connecticut overflown during the spring of 1981. The user should pay particular attention to the date of the photography used for each map, since wetlands may have undergone changes, either natural or human-induced, since that time. In general, however, the effective date of this inventory can be considered 1980.

Field Investigations

Prior to performing the air photo interpretation, field investigations were conducted by Connecticut DEP staff to become familiar with the variety of wetlands throughout Connecticut. Many wetlands, whether typical or uncommon, were first identified on the imagery and then field checked to record the appropriate classification and to develop correlations between photo signatures displayed on the imagery and what was actually observed on the ground.

Throughout the survey, field trips were conducted to resolve significant interpretation questions. Detailed notes were taken at more than 200 sites throughout the state. In addition, observations were made of countless other wetlands for classification purposes. Approximately nine weeks were spent in the field from the fall of 1980 to the spring of 1982.

Photo Interpretation and Collateral Data

High-altitude aerial photographs were interpreted by specially-trained DEP biologists using mirror stereoscopes. Wetlands were identified and delineated and each wetland was classified using the mapping conventions as a guide (U.S. Fish and Wildlife Service, 1981). In accordance with these conventions, all agricultural lands, including historic wetlands and alluvial flood plains under agricultural use, were not designated as wetlands and, therefore, are not included in this report.

During photo interpretation, additional resource information was examined to insure the completeness of the wetlands inventory. Collateral data include the following:

(1) 1:12,000 black and white aerial photography (1980);
(2) U.S. Geological Survey topographic maps;
(3) U.S.D.A. National Cooperative Soil Surveys;
(4) State of Connecticut Coastal Area Management coastal resource maps; and,
(5) numerous published and unpublished manuscripts.

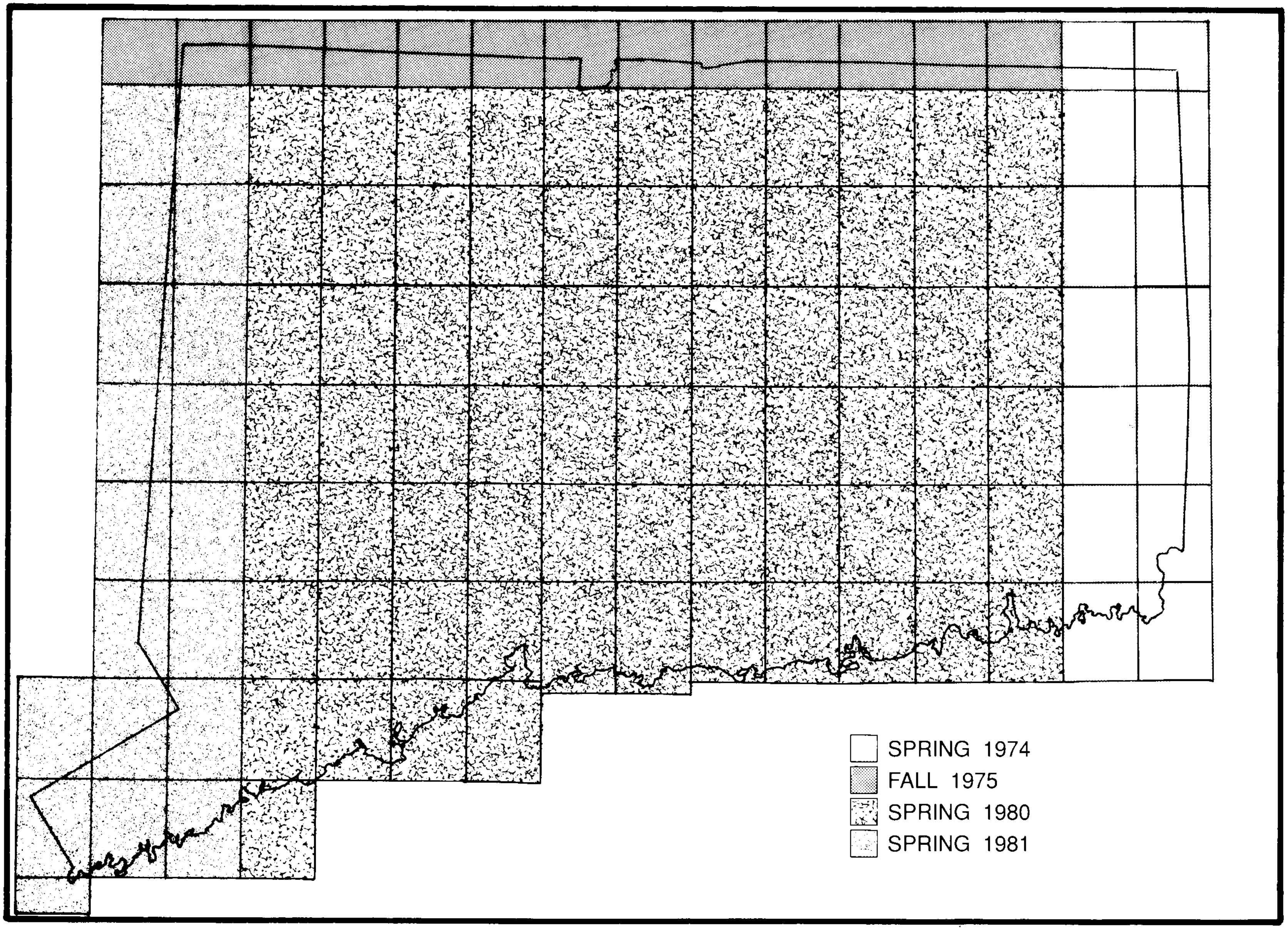

Figure 5. Index of aerial photography used for the National Wetlands Inventory in Connecticut.

Table 5. Wetland inventories conducted in Connecticut. This list represents the more comprehensive surveys and does not include local studies.

Date of Survey	Lead Agency	Wetlands Mapped	Comments
1980-1982	Connecticut Department of Environmental Protection with U.S. Fish and Wildlife Service	Coastal and Inland Wetlands	First comprehensive inventory of Connecticut's wetlands and deepwater habitats. Two sets of National Wetlands Inventory maps were produced; 1:24,000 and 1:100,000. Wetlands classified according to Cowardin, *et al.* (1979). Minimum mapping area = 1 acre. Mostly 1980 photography used; 1981 photos used for the western part of the state.
1973-1975	Connecticut Department of Environmental Protection with U.S.D.I. Bureau of Sports Fisheries and Wildlife	Coastal Wetlands	First ecological overview of essentially all the tidal marsh acreage in Connecticut. 127 marsh systems were surveyed for vegetation, associated fauna and environmental impacts. Ten systems had additional micro relief surveys. Published as Volume I and II; Niering and Warren (1975).
1972	Connecticut Department of Environmental Protection	Coastal Wetlands	Field mapping of tidal wetlands by biologists using the vegetation-hydrology definition of the Tidal Wetland Act. Approximately 15,000 acres of tidal wetland mapped on 1:2,400 aerial photo prints and approved by public hearing, with boundaries staked and flagged at straight line intervals. Report (Lefor and Tiner; 1972, 1974).

(Table 5 continued on facing page.)

Although efficient and accurate for inventorying wetlands, the techniques have limitations. Problems inherent with air photo interpretation often limit one's ability to delineate wetlands based upon the quality of the photography and the season and year in which it was taken. Since it was not always possible to make a reasonable determination of wetlands based upon the vegetation, hydrology, or topography visible on aerial photos, additional information was needed prior to the classification of certain areas. Although many problems were resolved by regular and/or additional field work, others required the use of available collateral information. Some of these problems and their resolution are discussed below:

1. Classification of Long Island Sound. Due to a low energy coastline and the magnitude of freshwater influence from Connecticut's rivers (Hardy, 1972), Long Island Sound was classified as part of the estuarine system rather than part of the marine system, based upon the definitions of Cowardin, *et al.* (1979).

2. Tidal flooding of wetlands. Since the photography used for this inventory was not tide-coordinated, some regularly flooded emergent tidal wetlands and tidal flats were obscured by flooding waters. U.S.G.S. topographic maps and collateral photography were used to identify locations of these wetlands.

3. Mapping of estuarine algal beds. These features were not interpretable from the source imagery and were only delineated when observed in the field.

4. Determination of water regime for intertidal flats. All intertidal flats were considered regularly flooded in this survey, although it is recognized that the lower portions of these flats are irregularly exposed.

5. Application of water chemistry modifiers in estuarine system. Problems arose in attempting to

Date of Survey	Lead Agency	Wetlands Mapped	Comments
1950-1983	U.S.D.A. Soil Conservation Service	Coastal and Inland Wetlands (based on soils)	County surveys mapping, soil series soil complexes, undifferentiated soil groups, and miscellaneous areas. Minimum mapping area is 3-5 acres. Soils were mapped on 1:15,840 aerial photo prints. Inland wetlands were defined by statute as "poorly drained, very poorly drained, floodplain and alluvial" as defined by U.S.D.A. Soil Conservation Service. Primary data source for implementing the Connecticut's Inland Wetland Act. Published county soil survey reports for all of Connecticut.
1964	U.S.D.I. Fish and Wildlife Service	Coastal Wetlands	A resurvey of the 1959 report. Identified 14,839 acres of coastal wetland, a loss of 2,179 acres since 1954. Report (USFWS, 1965)
1959	U.S.D.I. Fish and Wildlife Service	Inland Wetlands (>40 acres) and Coastal Wetlands (>10 acres)	A revision of the 1954 survey. Identified 66,034 acres of wetland, a loss of 1,332 acres since 1955 with 6,656 acres in imminent danger. Report (USFWS, 1959)
1953	U.S.D.I. Fish and Wildlife Service	Coastal Wetlands and Tidal and Fresh Areas Along the Three Major Rivers	Inventoried 90% of all wetlands with significance to waterfowl. Identified 23,397 acres of wetland of which 17,018 acres were coastal. Minimum mapping 75 acres. Report (USFWS, 1954)

separate salt marshes from brackish marshes and the brackish marshes from the slightly brackish (oligohaline) marshes upstream in tidal rivers. Field observations were made to address these problems throughout the coastal zone. Based upon this field review, brackish marshes dominated by common reed (*Phragmites australis*) and/or narrow-leaved cattail (*Typha angustifolia*) were mapped differently from slightly brackish marshes dominated by wild rice (*Zizania aquatica*).

6. Determination of the upper boundary of riverine tidal waters. Head of tide information was obtained from the state's coastal resource maps, except where readily observable impoundments abruptly ended tidal influence.

7. Identification of freshwater aquatic beds. Due to use of spring photography, aquatic beds in ponds and lakes were not interpretable. These wetlands were mapped only when observed in the field; otherwise they were included within the associated waterbodies.

8. Mapping of beaver-influenced wetlands. Where beaver had impounded or otherwise modified areas, the special modifier "b" was added to the wetland classification. This modifier was used only when beaver dams and/or lodges were clearly visible on the imagery or after confirmation through direct field investigations.

9. Identification of bogs. Bogs in Connecticut are primarily scrub-shrub wetlands dominated by ericaceous plants such as leatherleaf (*Cassandra calyculata*), and in most cases were easily photo interpreted. The acid modifier "a" was used to distinguish bogs from other palustrine scrub-shrub wetlands. All areas determined as bogs were field checked in this inventory.

10. Use of the circumneutral water chemistry modifier. Calcareous wetlands are present in the marble

valleys of western Connecticut. The modifier "t" was used to indicate these wetlands. Circumneutral wetlands in these areas were identified from published bedrock maps and unpublished field data.

11. Determination of the minimum mapping unit. Due to the availability of 1:12,000 aerial photography as collateral information, the minimum mapping unit used in this survey is approximately one acre.

12. Mapping and classification of linear wetlands. Linear wetlands consist mainly of shallow streams and contiguous vegetated wetlands too narrow to be mapped as polygons. These areas were classified by convention on the basis of the bordering vegetation and are treated as linear palustrine wetlands, although most of these linear wetlands contain a stream channel.

13. Inclusion of small upland areas within delineated wetlands. Small islands of higher elevation and better drained uplands naturally exist within many wetlands. Due to the minimum size of mapping units, small upland areas may be included within designated wetlands. Field inspections and/or use of larger-scale photography were used to refine wetland boundaries when necessary.

14. Forested wetlands on glacial till. These wetlands are difficult to identify in the field, let alone through air photo interpretation. Consequently, some of these wetlands were not detected and do not appear on the NWI maps.

Draft Map Production

Two levels of quality assurance were performed after the photo interpretation: (1) regional quality control; and, (2) national consistency quality assurance. The NWI Region 5 Office staff carefully reviewed each photo to ensure proper identification and classification of the wetlands, and the NWI Team at St. Petersburg, Florida spot checked photos to ensure consistency with national standards. Once approved by quality assurance workers, draft large-scale (1:24,000) wetland maps were produced by NWI's support service contractor using Bausch and Lomb zoom transfer scopes.

Draft Map Review

Draft maps were sent to the following agencies for review and comment:

(1) U.S. Fish and Wildlife Service, Concord Field Office;
(2) U.S. Army Corps of Engineers (New England Division);
(3) U.S.D.A. Soil Conservation Service, Connecticut Office;
(4) U.S. Environmental Protection Agency (Region I);
(5) National Marine Fisheries Service; and,
(6) Connecticut Department of Environmental Protection.

In addition to this multi-agency review, the U.S. Fish and Wildlife Service Region 5 Office's NWI staff also conducted field checks with the DEP biologists and thoroughly examined the draft maps to ensure proper and accurate use of the classification and mapping.

Final Map Production

All comments received on the draft maps were evaluated and incorporated into the final maps as appropriate. Two scales of final maps were published: (1) large-scale (1:24,000); and, (2) small-scale (1:100,000).

Wetland Acreage Compilation

The U.S. Fish and Wildlife Service initiated compilation of wetland acreage for Connecticut in early 1986. Area measurements of NWI map data were taken with a Numonics digital planimeter, at the University of Massachusetts Cooperative Wildlife Research Unit, in Amherst. Wetland and deepwater habitat acreage data were generated for the state and by county.

Wetlands Inventory Results

National Wetlands Inventory Maps

A total of 112 U.S. Geological Survey large-scale (1:24,000) wetland maps were published for Connecticut. These maps identify the size, shape and type of wetlands and deepwater habitats in the state. An evaluation of NWI maps in Massachusetts determined that these maps had accuracies exceeding 95 percent (Swartwout, *et al.*, 1982), and a more recent study by the Vermont Agency of Natural Resources found that 91 percent of the 261 wetlands examined were accurately mapped (Crowley, *et al.*, 1988). This high accuracy is possible because the inventory technique involves a combination of photo interpretation, field studies, use of existing information, and interagency review of draft maps. However, NWI maps cannot be used to determine the legal boundary of wetlands in Connecticut. Since soil drainage is the primary identifying criterion, most wetland boundaries in Connecticut are determined on-site by a certified soil scientist using the U.S.D.A. county soil surveys as a guide. This difference in determination led to disparity between the boundary of NWI wetlands and legal wetlands in Connecticut, although recent studies have indicated a

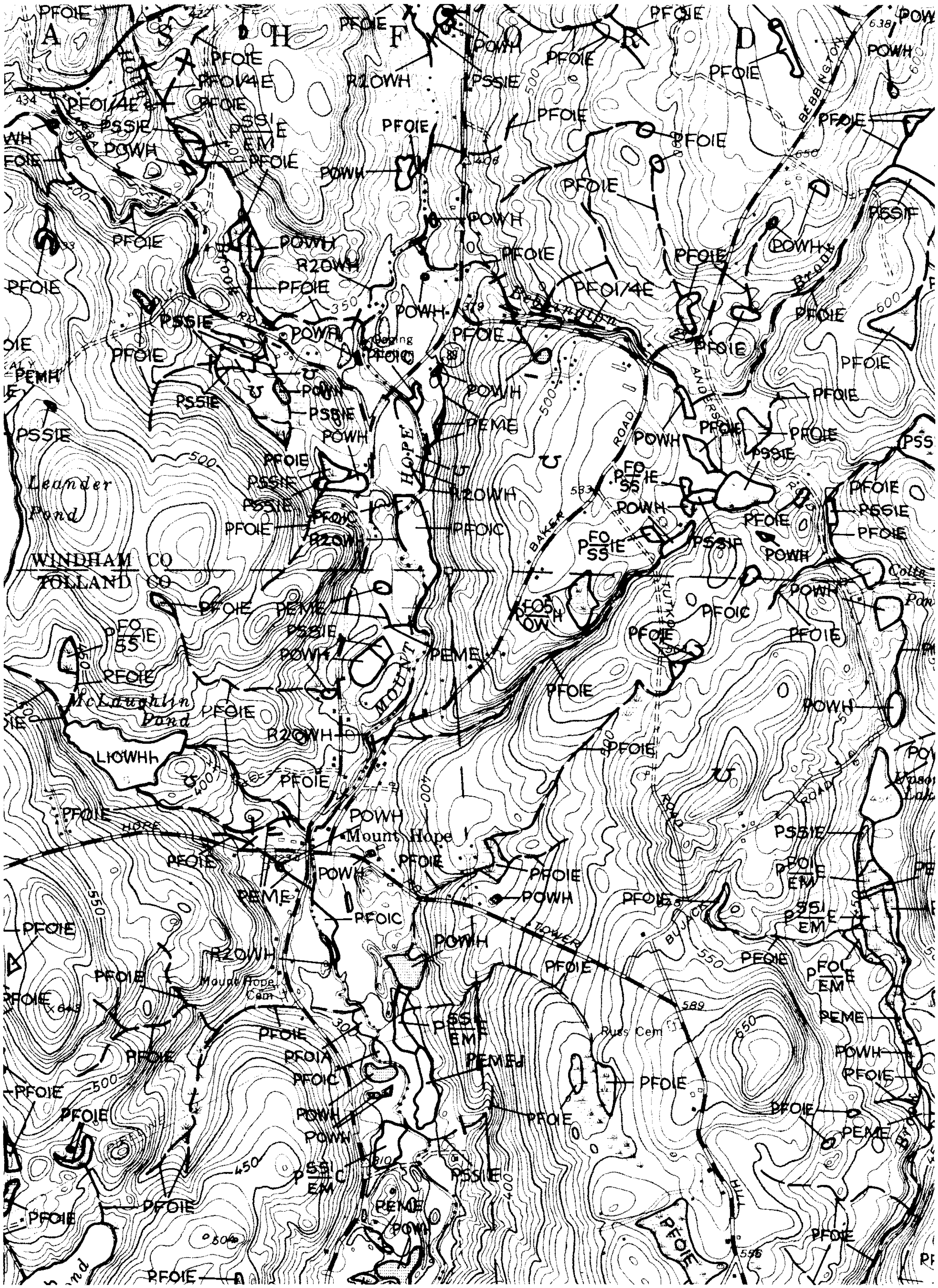

Figure 6. Example of a National Wetlands Inventory map. This is a portion of the 1:24,000 scale Spring Hill quadrangle, with the legend omitted.

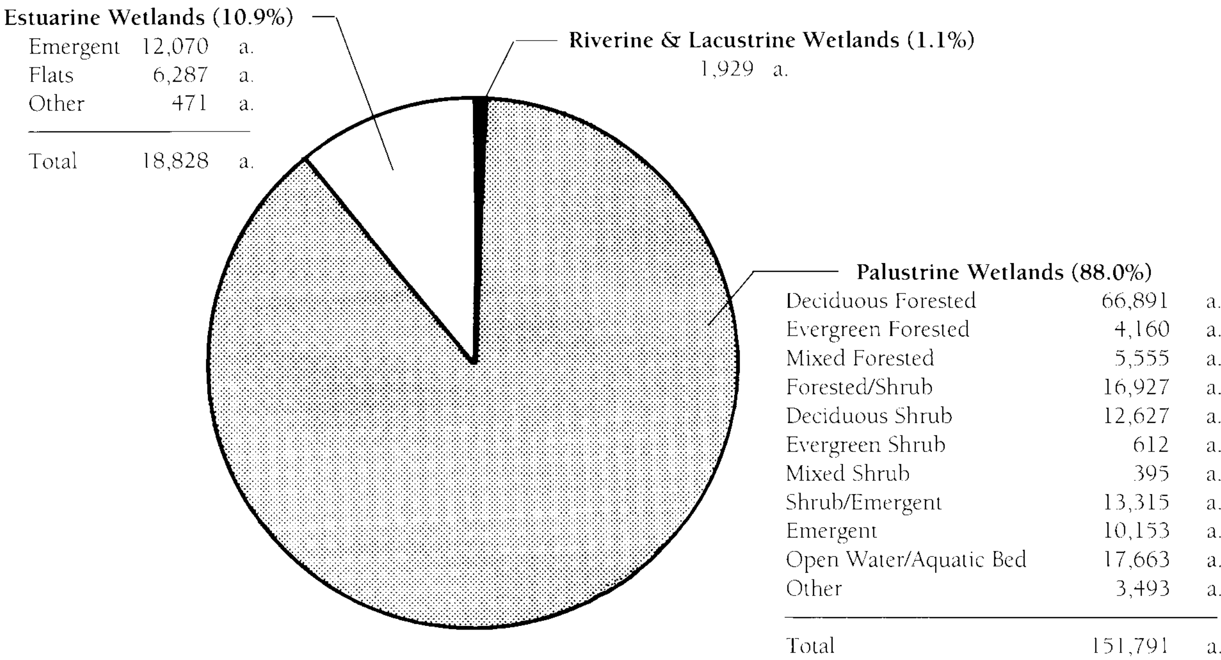

Figure 7. Relative abundance of Connecticut's wetlands.

one-to-one correspondence in most cases (Metzler, unpublished data).

Final maps have been available for Connecticut since 1982. Figure 6 shows an example of a 1:24,000 map. In addition, maps showing changes in wetlands in central Connecticut from 1980 to 1985/86 are available from Connecticut DEP or the U.S. Fish and Wildlife Service for review. NWI maps can be purchased from the Connecticut Department of Environmental Protection, Maps and Publications Office, Room 555, 165 Capitol Avenue, Hartford, CT 06106.

Wetland and Deepwater Habitat Acreage Summaries

State Totals

According to this inventory, Connecticut has approximately 172,548 acres of wetlands and 478,751 acres of deepwater habitats, excluding smaller rivers and streams that appear as linear features on wetland maps, and wetlands that were not identified due to their small size. Using the NWI definition, about five percent of the state's land surface is wetland.

The relative extent of major wetland types is shown in Figure 7. About 88 percent of the state's wetlands fall within two systems: Palustrine and Estuarine. The general distribution of Connecticut's wetlands by type is shown on the enclosed figure at the back of this report.

Of the 18,828 acres of estuarine wetlands inventoried, 64 percent are emergent wetlands. The vast majority of these are salt and brackish marshes (11,963 acres), with just 107 acres of slightly brackish or oligohaline marshes inventoried. Nearly 90 percent of the emergent wetlands are irregularly flooded with the remainder subject to daily tidal flooding. Nearly two-thirds of these wetlands have been mosquito ditched. About 6,300 acres of intertidal flats were mapped and less than 50 acres of estuarine scrub-shrub wetlands were identified.

Palustrine wetlands, covering 151,791 acres, are over eight times more abundant than estuarine wetlands. Almost all of this acreage is nontidal freshwater wetland, with 1,437 acres, or less than one percent, mapped as freshwater tidal marshes. Almost two-thirds of nontidal wetlands are forested, dominated primarily by red maple. Interestingly, evergreen and mixed evergreen forested wetlands total only 9,715 acres and occur primarily in Litchfield County (2,155 acres) where they are dominated by eastern hemlock, and New London (2,658 acres) and Windham (2,547) counties where Atlantic white cedar is more common.

Emergent wetlands (10,153 acres), deciduous scrub-shrub (12,627 acres), mixed emergent and scrub-shrub (13,315 acres), and shallow ponds/aquatic beds (17,663 acres) comprise the majority of the remaining freshwater nontidal wetlands. Other freshwater wetlands inventoried include evergreen scrub-shrub wetlands, which are primarily leatherleaf bogs. From a water regime stand-

Table 6. Wetland acreage of Connecticut counties based on National Wetland Inventory mapping. Percentage of each county represented by wetland and ranking based on wetland acreage is also indicated.

County	Land Area (sq. mi.)	Land Area (Acres)	Wetland Area (Acres)	% County Represented by Wetland	Ranking Order by Wetland Acreage
Fairfield	659	400,000	19,321	4.8	6
Hartford	751	473,600	21,166	4.5	4
Litchfield	949	600,320	22,761	3.8	3
Middlesex	388	235,160	15,402	6.5	7
New Haven	623	387,750	19,465	5.0	5
New London	701	424,520	34,819	8.2	1
Tolland	421	266,240	11,512	4.3	8
Windham	520	328,540	28,102	8.6	2
State Total	5,012	3,116,130	172,548	5.5	-

Table 7. Deepwater habitat acreage of Connecticut counties based on National Wetlands Inventory mapping.[1]

	Fairfield	Hartford	Litch-field	Middlesex	New Haven	New London	Tolland	Windham	State Totals
Estuarine Waters	3,799	—	—	3,323	1,960	10,651	—	—	19,733
Riverine Tidal Waters	99	2,640	—	3,854	284	256	—	—	7,133
Riverine Nontidal Waters[2]	411	2,302	2,380	40	874	651	366	1,212	8,236
Lacustrine Waters	10,479	3,991	13,137	3,129	6,000	7,401	3,616	3,641	51,394
Unmapped Waters of Long Island Sound[3]									392,255
TOTAL DEEPWATER HABITAT	14,788	8,933	15,517	10,346	9,118	18,959	3,982	4,853	478,751

[1]Estuarine deepwater habitat acreage figures are lower than actual due to the exclusion of Connecticut's portion of Long Island Sound from calculations.

[2]Riverine nontidal acreage figures are lower than actual due to the exclusion of linear wetlands delineated on the NWI maps.

[3]Includes saltwater of tidal rivers based on an estimate made by Connecticut Department of Environmental Protection, Coastal Area Management Unit (now, Office of Long Island Sound Programs).

point, nearly all of Connecticut's freshwater nontidal wetlands are classified as seasonally flooded/saturated, with seasonally and temporarily flooded regimes used for alluvial flood plains, and saturated regimes for bogs.

Riverine wetlands occur primarily along tidal rivers such as the Connecticut and Housatonic. Only 238 acres of riverine tidal flat, with and without nonpersistent emergent vegetation were mapped. Lacustrine wetlands are also limited in their distribution with the 1,691 acres mapped, perhaps reflecting the early spring timing of the photography, or simply a restricted occurrence.

Deepwater habitat acreage in Connecticut totals 86,496 acres including the brackish water of tidal rivers and bays. Nearly 70 percent of these areas are either

Table 8. Summary of National Wetlands Inventory wetland type acreage for each Connecticut county.

Wetland Type	Fairfield	Hartford	Litch-field	Middlesex	New Haven	New London	Tolland	Windham	State Totals
Estuarine Emergent Wetlands	1,462	—	—	2,310	5,234	3,064	—	—	12,070
Estuarine Intertidal Flat	2,938	—	—	875	1,675	799	—	—	6,287
Estuarine Other Wetlands	354	—	—	8	70	39	—	—	471
SUBTOTAL Estuarine Wetlands	4,754	—	—	3,193	6,979	3,902	—	—	18,828
Palustrine Open Water/ Aquatic Bed	3,325	2,405	2,794	1,459	2,117	2,022	1,401	2,140	17,663
Palustrine Emergent Wetlands	367	1,600	2,129	1,670	791	1,133	568	1,895	10,153
Palustrine Deciduous Forested Wetlands	6,161	10,746	6,203	4,013	4,790	17,617	4,216	13,145	66,891
Palustrine Evergreen Forested Wetlands	3	98	1,152	19	105	1,024	505	1,254	4,160
Palustrine Mixed Forested Wetlands	37	386	1,003	335	227	1,634	640	1,293	5,555
Palustrine Other Forested Wetlands	331	276	1,614	144	161	230	282	445	3,483
Palustrine Forested/ Scrub-shrub Wetlands	2,108	2,104	2,029	2,210	1,782	3,202	1,031	2,461	16,927
Palustrine Deciduous Scrub-shrub Wetlands	1,371	1,528	1,838	1,320	1,284	2,239	1,101	1,946	12,627
Palustrine Evergreen Scrub-shrub Wetlands	6	79	119	12	29	67	53	247	612
Palustrine Mixed Scrub-shrub Wetlands	13	63	124	15	34	56	83	7	395
Palustrine Scrub-shrub/ Emergent Wetlands	841	1,794	3,157	834	938	1,537	1,322	2,892	13,315

Wetland Type	Fairfield	Hartford	Litch-field	Middlesex	New Haven	New London	Tolland	Windham	State Totals
Palustrine Farmed Wetlands	—	—	—	—	—	9	—	1	10
SUBTOTAL Palustrine Wetlands	14,563	21,079	22,162	12,031	12,258	30,770	11,202	27,726	151,791
Riverine Wetlands (mostly tidal)	1	15	11	167	—	44	—	—	238
Lacustrine Wetlands	3	72	588	11	228	103	310	376	1,691
TOTAL WETLAND ACREAGE	19,321	21,166	22,761	15,402	19,465	34,819	11,512	28,102	172,548

NOTE: Forested wetland acreage figures are higher than actual due to inclusion of alluvial soils that are not flooded often or long enough to constitute wetland according to Cowardin, *et al.* (1979). These areas, however, are considered "wetland" according to state statutes.

freshwater lakes and reservoirs (51,394 acres) or freshwater nontidal rivers (8,236 acres). Riverine tidal waters total 7,133 acres, and 19,733 acres of brackish and salt tidal water are mapped in the lower portion of tidal rivers and in tidal creeks, coves, and bays.

County Totals

Acreages of wetlands and deepwater habitats for each county are found in Tables 6 and 7, respectively. In addition the relative abundance of the different types of wetland in each county is shown in Table 8, and Figures 8 and 9 show the relative abundance of estuarine and palustrine wetlands.

New London County has the largest extent of wetlands (34,819 acres) followed closely by Windham County (28,102 acres). Litchfield (22,761 acres), Hartford (21,166 acres), New Haven (19,465 acres), and Fairfield (19,321 acres) counties are close in acreage, whereas Middlesex (15,402 acres) and Tolland counties (11,512 acres) contain the least. Windham County has the largest percentage of land mapped as wetland (8.6%) and Tolland County has the least (4.3%).

New London County also has the most deepwater habitat (18,959 acres), much of which is estuarine waters (10,651 acres). Fairfield County has the largest acreage of freshwater lakes and reservoirs (10,479), much in water utility company ownership. The least amount of deepwater habitat occurs in Tolland County, with 3,982 acres of rivers, lakes and reservoirs.

Summary

The National Wetlands Inventory Project completed an inventory of Connecticut's wetland and deepwater habitats using aerial photo interpretation methods. Detailed wetland maps and acreage summaries were produced for the entire state. Nearly 173,000 acres of wetland and 86,500 acres of deepwater habitat were delineated in Connecticut. Thus, about five percent of the state was identified as wetland in this inventory. This is in contrast to the estimated 15 to 20 percent of the state subject to regulations pursuant to Connecticut's wetland laws.

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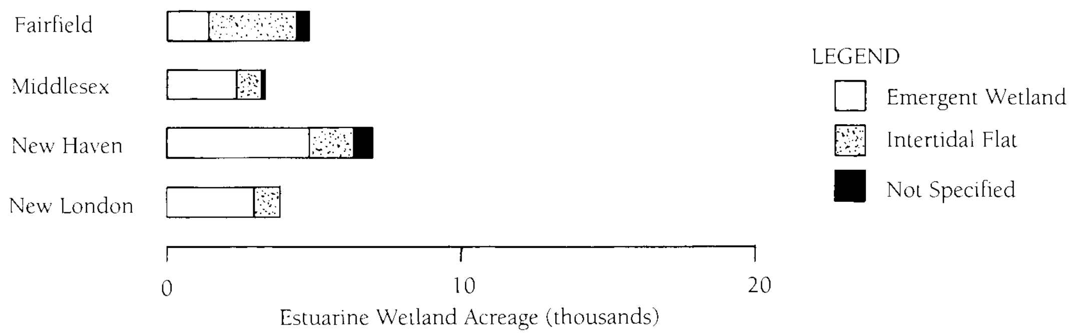

Figure 8. Relative distribution of estuarine wetlands in Connecticut.

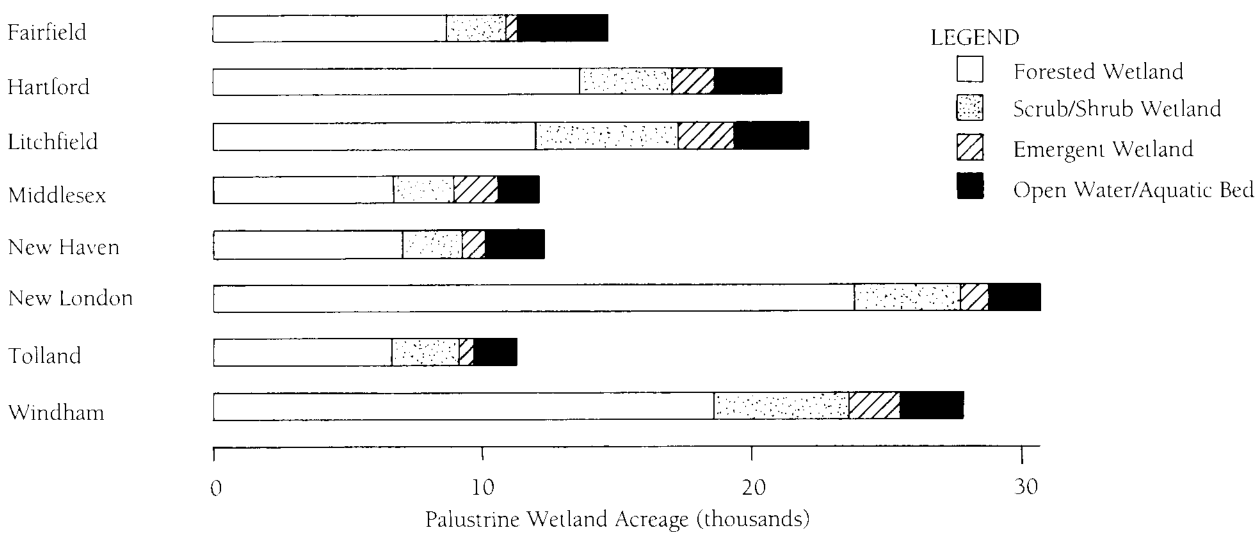

Figure 9. Relative distribution of palustrine wetlands in Connecticut.

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CHAPTER 4.

Wetland Formation and Hydrology

Introduction

Historical events and present hydrologic conditions have combined to create and maintain a diversity of wetlands in Connecticut. Human activities have also exerted broad influences on wetland formation and hydrology. The following subsections address general differences between Connecticut's inland and coastal wetlands in their formation and hydrology.

Wetland Formation

Inland Wetland Formation

Past glaciation has played an important role in the formation of many wetlands in Connecticut. From approximately 80,000 to 16,500 years ago, Connecticut and all of Long Island Sound were buried under glacial ice (Figure 10). This ice mass was the southern extension of the northeastern lobe of the Wisconsinan glacier, which terminated at present-day Long Island. During this Ice Age, roughly one third of the world's land surface was covered with ice compared to only 10 percent of the land surface today. In interior sections of Connecticut, the ice was upward of 2,000 feet thick (Flint, 1930).

As the climate warmed and the glacier retreated, the first wetlands appeared. Deglaciation proceeded northwestward by combined downwasting and backwasting, with nearly all of Connecticut cleared of glacial ice by 12,500 years ago (Black, 1973). Major rivers, streams, lakes, and numerous inland wetlands date back to these times.

Since deglaciation, the character of many wetlands in Connecticut has changed. Sedimentation and climatic change have influenced the hydrology and vegetation of many wetlands with changes recorded in the sediments. Sediments in selected wetlands and ponds in south-central Connecticut have been described by Deevy (1939) and Davis (1969) documenting natural changes in the vegetation and climate over the past 12,000 years. More recently, Thorson (1990) has analysed the sediments of five small wetlands in eastern Connecticut and has concluded that post-settlement changes have been far more significant than natural post-glacial succession in determining the character of many present-day wetlands.

Most of Connecticut's wetlands were formed as a result of four glacial processes: (1) glacial erosion of bedrock hollows and depressions; (2) melting of buried ice in deposits of sand and gravel forming troughs and

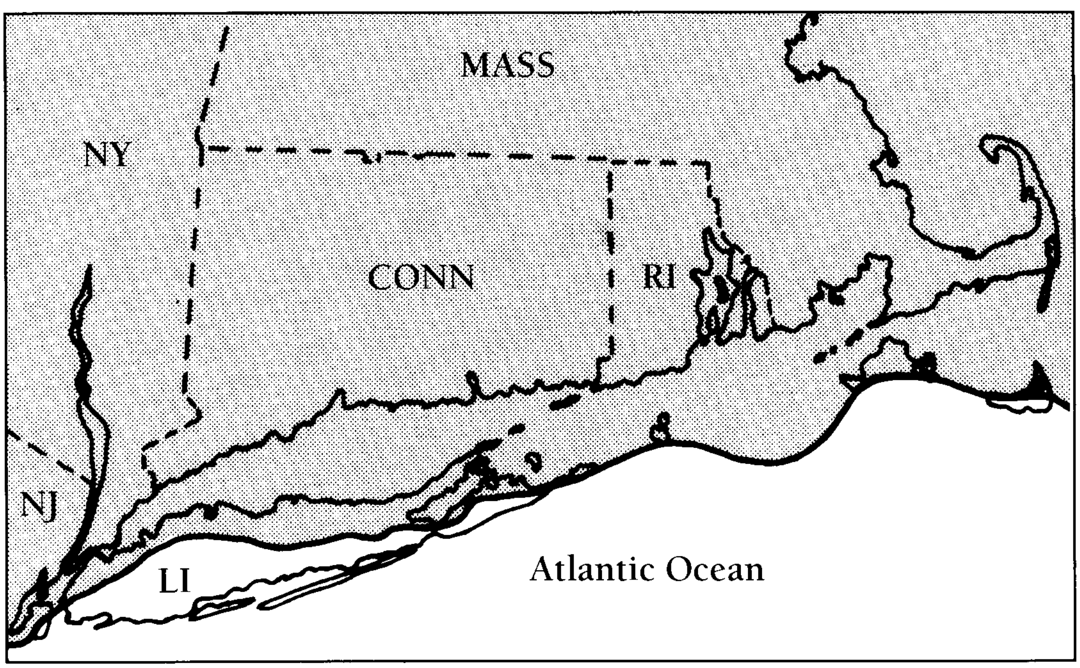

Figure 10. Extent of recent glaciation in southern New England (modified from Stone, *et al.*, 1985).

kettles; (3) formation of shallow depressions on the bottom of now-drained, former glacial lakes; and, (4) deposition of compact basal till and glaciolacustrine silts that impede drainage.

Wetlands in glacially scoured hollows and depressions are numerous throughout Connecticut. These wetlands are formed in either shallow soils over bedrock or over areas with compact basal till, both of which impede drainage. Wetlands on compact glacial till generally have a strongly fluctuating water table and surface flooding following periods of heavy rain.

Wetlands formed in glacial kettles and troughs are found in valleys with glacial deposits of sands and gravels. Assekonk Swamp in North Stonington and Sugar Brook Swamp in Plainfield are two of the larger examples found in the state. Smaller kettle wetlands can be found in McLean's Game Refuge in Granby and in the area surrounding Congamond Lake in Suffield. Congamond Lake is, in fact, a natural lake of glacial kettle origin, with the slow succession of wetland vegetation into the lake over time (Figure 11).

Wetlands formed in small depressions in glaciolacustrine deposits are most common in the towns of Suffield, Enfield, and East Windsor on the poorly drained sediments of Glacial Lake Hitchcock, the largest of Connecticut's now-extinct glacial lakes. This former lake at its greatest extent occupied much of the Connecticut Valley from Middletown north to the northern border of Massachusetts, a length of approximately 150 miles and a maximum width of 10 miles. This lake persisted until approximately 10,700 years ago (Flint, 1956; Stone, *et al.*, 1985) when the dam south of Rocky Hill was breached and the lake rapidly drained. Figure 12 illustrates the distribution of the larger glacial lakes once found in Connecticut. Some larger wetlands occupying low-lying depressions in former glacial lake beds include the Durham Meadows, the Cromwell Meadows, Robbins Swamp in Canaan, and the Susquetonscut Brook Swamp in Lebanon and Franklin.

Wetlands have also formed on flood plains along rivers and large streams throughout the state. Here, wetlands are found in the inner areas of mature flood plains behind the natural levees. The levees themselves are composed of coarse materials and are better drained than the inner flood plain, which is characterized by silts and clays and poor drainage. In addition, lateral river migration can form wetlands in the form of scroll bars (Wangunk Meadows, Portland) and oxbow lakes (Wethersfield Cove, Figure 13). The hydrology and vegetation of the Connecticut River flood plain has been described by Nichols (1915) and by Metzler and Damman (1985).

Beaver activity and human actions may also create wetlands by flooding former upland areas. In these situations, wetland plants quickly colonize the wetter habitats. Historically, beaver have played a prominent role in wetland formation by damming stream channels and flooding low-lying upland areas, but beaver largely disappeared due to trapping and agricultural practices. Today, however, beaver populations are increasing in abundance and range and are common in parts of Litchfield, Tolland, and Windham counties.

Beaver activity can also influence the hydrology and character of existing wetlands. Beaver dams can raise the water level in adjacent forested or scrub-shrub wetlands killing trees and creating areas of open water, emergent wetland, or a complexity of wetland habitats. Conversely, as beaver dams are removed from an area and the original hydrology is restored, previously created wetlands can be recolonized by upland vegetation, in effect reducing wetland acreage.

Farm ponds, artificial lakes, and reservoir construction may also create wetlands or have an effect on them. In many instances, natural vegetated wetlands are altered by water level changes in adjacent lakes, and by reservoir construction. In other cases, highly eutrophic shallow ponds and lakes may become completely overgrown with emergent, submergent, floating-leaved, and/or floating plants. Similarly, aquatic beds and emergent wetlands may become established along the shorelines of shallow lakes and reservoirs with active siltation. If siltation progresses, these accreted areas can eventually become shrub and forested wetlands.

Recently, wetlands have also been created in conjunction with government and private projects, such as highway construction, port expansion, and flood control impoundments. Some of these new wetlands were built to mitigate losses of natural wetlands, while most represent unintentional creations. The U.S. Army Corps of Engineers has successfully established wetlands, particularly in tidal areas at several locations across the country, but many wetland creation projects end in failure, for a host of reasons. For example, the Connecticut Department of Transportation has unsuccessfully attempted the creation of artificial wetlands along some of the highway corridors in the state (Reinold and Cobler, 1986). In most cases, these wetlands were created in conjunction with stormwater retention basins with the resultant design insufficient to ensure wetland success (Butts, 1988). Currently, the state-of-the-art in wetland creation is not advanced enough to ensure successful replacement of all values lost from the destroyed wetlands (Larson and Neill, 1987). Recently, a masters thesis has been conducted on the comparision of created and natural freshwater wetlands in Connecticut (Confer, 1990).

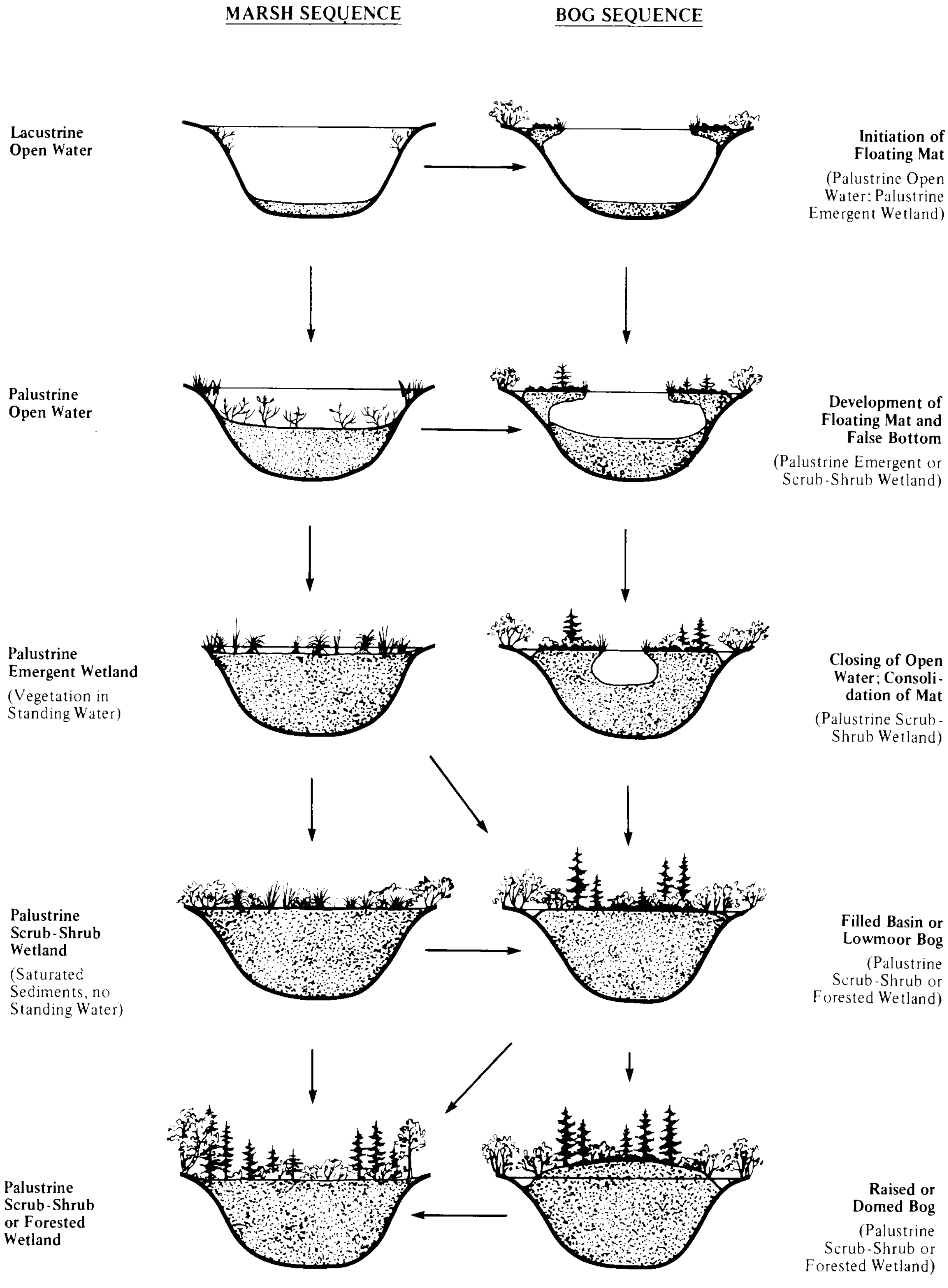

Figure 11. Marsh and bog successional patterns (adapted from Dansereau and Segadas-Vianna, 1952).

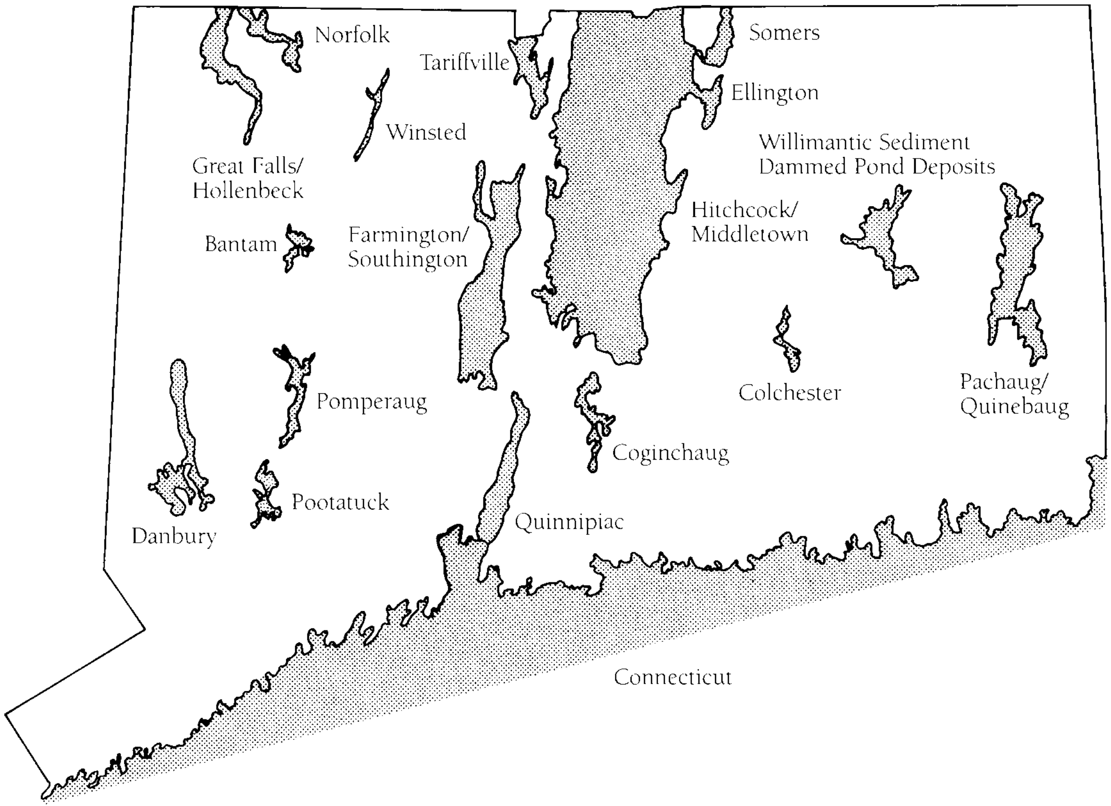

Figure 12. Extent of major glacial lakes in Connecticut (modified from Schaefer, J.P., U.S. Geological Survey, unpublished data). Glacial Lake Connecticut corresponds approximately to the present-day extent of Long Island Sound.

Restoration of previously drained or otherwise degraded wetlands offers better possibilities for success. On the Connecticut coast, historically degraded reed (*Phragmites*) marshes have been changed to salt marsh in a relatively short period of time with the opening or construction of culverts to increase or reintroduce tidal flooding (Rozsa, 1988; Steinke, 1988; Sinicrope, *et al.*, 1990). Wetland restoration has also been successfully accomplished by the U.S. Fish and Wildlife Service and other agencies in the Prairie Pothole Region of North and South Dakota and elsewhere. Similar opportunities exist in Connecticut for restoration of drained or otherwise degraded wetlands.

Coastal Wetland Formation

Nearly 18,000 years ago, much of the world's ocean water was stored as glacial ice. This lowered sea levels by approximately 325 feet from the present level (Oldale, 1986). The Connecticut shoreline was then far to the southeast, and Long Island Sound was buried under glacial ice. When the climate warmed and the glacier melted, the vast amount of water stored as ice was slowly released and sea level rose. As Long Island Sound became free from glacial ice, a freshwater lake was formed in the pre-existing basin and persisted in part for approximately 4,000 years. Marine waters may have entered the eastern portion of Long Island Sound as early as 13,000 years ago, with transgression into the central portion not before 10,200 radiocarbon years ago (Stone and Borns, 1986; Needell and Lewis, 1985). Sea level continued to rise relatively rapidly until approximately 4,000 years ago when rates showed a marked decrease (Bloom and Ellis, 1965; Redfield, 1972; Keene, 1971; Emery and Uchupi, 1972). As sea level rise slowed, the deposition of suspended materials was able to keep pace with submergence and the development of coastal marshes began. It is interesting to note, however, that at this time, sea level on the Connecticut coast was approximately 11 feet (3.5 m) lower than at present. Since then, the low relative rate of coastal submergence has allowed the development of the extensive salt marsh communities which have slowly migrated inland with rising sea level.

The development of coastal marshes in Connecticut has received considerable attention. Bloom and Ellis (1965) described the formation of three coastal marsh types based on morphology and radiocarbon dating of cored sediments: deep coastal marshes, shallow coastal marshes, and estuarine marshes. Using this system, Hill and Shearin (1970) classified and mapped the coastal marshes of Connecticut and Rhode Island. In general, they found the Connecticut marshes west of the Connecticut River "deep," with accumulated peat greater than nine feet and the marshes east of the Connecticut River "shallow" with peat accumulation less than nine feet. Estuarine

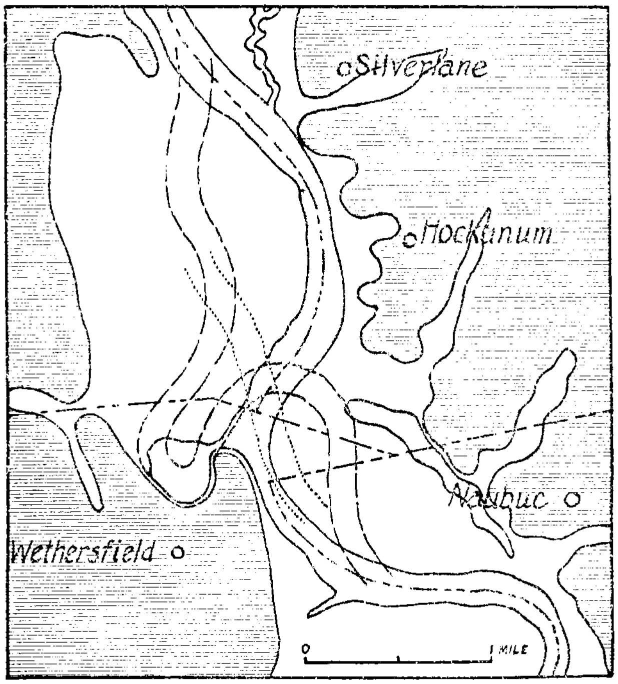

Figure 13. Recent changes in the Connecticut River flood plain south of Hartford (from Flint, 1930). Ruled area - glaciolacustrine terraces, stippled area - channel in 1893, dotted lines - channel about 1837, evenly dashed lines - approximate channel in the 1600's.

marshes were restricted to the major tidal rivers with variable depth and substantial mixing of freshwater sediments. The development history of Connecticut's coastal marshes (Bloom and Ellis, 1965) is as follows:

During the period of rapid submergence, the sea rose into coastal valleys and produced bays and lagoons. Sediments accumulated but did not approach sea level. When the rate of submergence slowed, mud flats developed and were soon colonized by low marsh vegetation. Then as sediments accumulated, the low marsh was colonized by high marsh vegetation. As sea level continued to rise, sedimentation kept pace with submergence and the marsh surface grew both inland and further out into the bay. Redfield (1972) describes a similar development of salt marshes in Massachusetts, while Orson (1982) describes the somewhat different development of a salt marsh in Niantic, Connecticut. A section through a "deep" marsh in Connecticut typically has a veneer of muddy salt marsh peat nine feet thick or less, overlying a thick wedge of mud. In many marshes, this mud overlies a thin layer of freshwater sedge peat, representing the fringe of freshwater marsh that grew at the transgressing shoreline.

In contrast, "shallow" marshes have developed primarily on submerged coastal lowlands with slight topographic relief. Many of these areas were freshwater marshes prior to submergence as evinced by their stratigraphy: salt marsh peat alternating with layers of sedge peat, overlying gravelly material. These layers represent the upland border of fresh or brackish marsh that was buried as sea level rose. Gross (1966) and Orson, *et al.* (1987) describe the formation of tidal marshes in drowned river valleys in eastern Connecticut. These salt marshes began forming about 3,500 years ago. Halophytic (salt-tolerant) plants replaced freshwater marsh plants as salinity increased due to rising sea level and replaced upland vegetation as low-lying uplands were submerged by estuarine waters.

Presently, coastal marshes continue to migrate landward as sea level rises. Recent measurements of sea level rise on the Atlantic coast between Cape Cod and Cape Hatteras have shown an estimated average increase of 0.13 inches/year (3.5 mm), a rate comparable to the more rapid rates 4,000 years ago (Emery and Uchupi, 1972; Redfield, 1967). In Connecticut, a high rate of 0.4 inches/year (10 mm) was recorded by Harrison and Bloom (1977) during the period 1964 to 1973, and an average rate of 0.1 inches/year (2.5 mm) was calculated for the last 100 years (McCaffrey, 1977). With this increased rate of submergence, the future of coastal marshes in Connecticut is uncertain at best, especially where urban development has taken place in contiguous low-lying areas that would have allowed natural inland transgression by salt marsh vegetation.

Wetland Hydrology

The presence of water from flooding, surface water runoff, ground water discharge, or tides is the driving force creating and maintaining wetlands. These hydrologic mechanisms in combination with soil characteristics and climate determine the nature and types of wetlands. An accurate assessment of hydrology, unfortunately, requires extensive knowledge of the local hydrologic cycle, the frequency and duration of flooding, water table fluctuations, and ground water relationships. This information can be gained only through intensive and long-term studies. There are ways, however, to recognize general differences in wetland hydrology or water regime. Major hydrologic characteristics of wetlands are apparent at certain times of the year, especially during spring floods or high tides. Yet, for most of the year, such obvious evidence is lacking in many wetlands. At these times, less conspicuous signs of flooding may be observed: (1) water marks on vegetation; (2) water-transported debris on plants or collected around their bases; (3) water-stained leaves on the ground; and, (4) a predominance of hummock-like vegetation throughout the area. These signs and knowledge of the water table and wetland vegetation help one recognize hydrologic differences between wetlands.

The U.S. Fish and Wildlife Service wetland classification (Cowardin, *et al.*, 1979) includes water regime modifiers to describe hydrologic characteristics. Two groups of water regimes are identified: (1) tidal and (2) nontidal. Tidal water regimes are driven by oceanic tides, while nontidal regimes are largely influenced by surface water runoff and groundwater discharge. The state of our knowledge in wetland hydrology has been summarized by Carter, *et al.*, (1979), and Leitch (1981).

Tidal Wetland Hydrology

Ocean-driven tides are the dominant hydrologic feature of wetlands in coastal areas. Within Long Island Sound, tides are semi-diurnal and symmetrical with a period of 12 hours and 25 minutes. In other words, there are roughly two high tides and two low tides each day. Since the tides are largely controlled by the position of the moon relative to the sun, the highest and lowest tide ("spring tides") usually occur during full and new moons. In Long Island Sound, mean tidal ranges vary from 2.7 feet (0.8 m) in Stonington to 7.4 feet (2.3 m) in Greenwich (Table 9). Coastal storms can also cause extreme high and low tides. Strong winds over a prolonged period have a great impact on the normal tidal range in Long Island Sound, substantially raising or lowering the normal high or low tides during coincidental events.

In coastal wetlands, differences in tidal flooding create two zones that can be readily identified: (1) a regularly flooded zone and (2) an irregularly flooded zone (Figure 14). The regularly flooded zone is alternately flooded and exposed at least once daily by the tides. It includes both the "low marsh" and the more seaward intertidal mud and sand flats. Above the regularly flooded zone, the marsh is less frequently flooded by the tides. This irregularly flooded zone, or "high marsh," is exposed to air for long periods and flooded only for periods of variable length. The high marsh is usually flooded during spring tides. The upper margins of the high marsh may be flooded only during storm tides which are more frequent in the winter.

Table 9. Ranges of spring and mean tides at selected locations in Connecticut (NOAA, 1991).

Location	Mean Tide Range (ft)	Spring Tide Range (ft)	Mean Tide Level (ft)
Stonington, Fishers Island Sound	2.7	3.2	1.5
Noank, Mystic River Entrance	2.3	2.7	1.4
Thames River,			
New London	2.6	3.0	1.5
Norwich	3.0	3.6	1.7
Millstone Point	2.7	3.2	1.5
Connecticut River,			
Saybrook Jetty	3.5	4.2	2.0
Essex	3.0	3.6	1.7
East Haddam	2.9	3.5	1.6
Portland	2.2	2.6	1.3
Hartford	1.9	2.3	1.1

Estuarine plants have adapted to these differences in inundation and certain plants are good indicators of different water regimes (Table 10).

Some strictly freshwater wetlands are also subjected to tidal flooding. They lie above the estuary where virtually no ocean-derived salts (less than 0.5 parts per thousand) are found, and where river flow and tidal flooding interact to create a rather complicated hydrology (e.g., along the Connecticut River north of Essex). Although freshwater areas flooded and exposed at least once daily by the tides are considered regularly flooded, as they

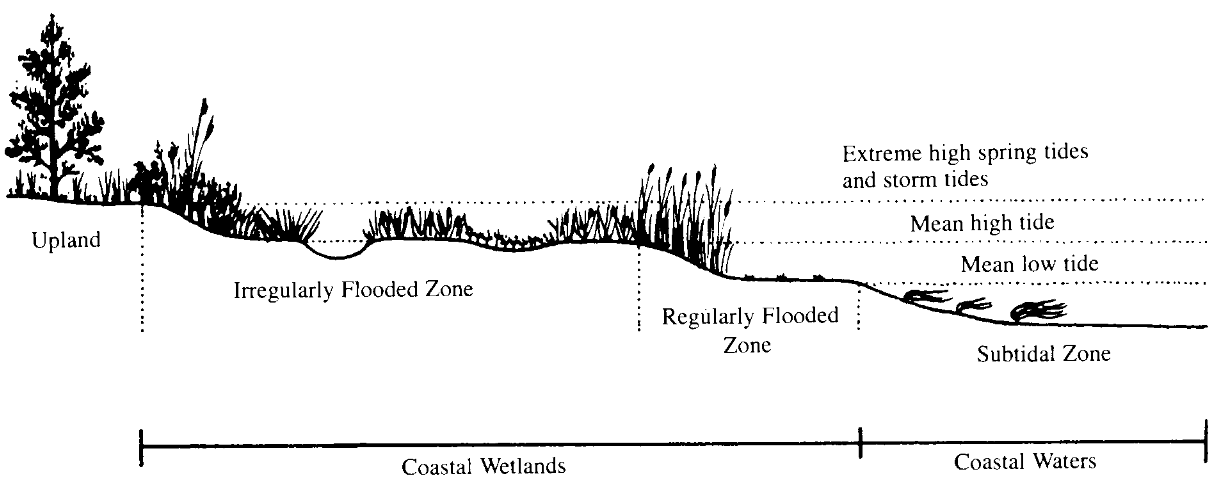

Figure 14. Hydrology of coastal wetlands showing different zones of flooding. The regularly flooded zone is flooded at least once daily by the tides, while the irregularly flooded zone is flooded less often (from Tiner, 1988).

are downstream in the estuary, wetlands that are not subject to daily tidal flooding are classified as seasonally flooded/tidal or temporarily flooded/tidal. These represent the more common water regimes in freshwater tidal areas, with the frequency and duration of flooding the main hydrologic differences between them. Seasonally flooded/tidal wetlands are often flooded by tides during periods of low flow, but flood waters may be present for rather long periods, especially during snow melt, heavy rains, or spring runoff. Temporarily flooded/tidal areas are flooded infrequently, and surface water does not persist for more than a few days. Temporarily flooded/tidal forested wetlands are quite similar in appearance to their nontidal counterparts and were not separated out in the current wetlands inventory.

Table 10. Examples of plant indicators of the predominant tidal water regimes for Connecticut's estuarine wetlands. These plants are generally good indicators of tidal flooding regimes.

Water Regime	Indicator Plants
Regularly Flooded	Smooth cordgrass - tall form (*Spartina alterniflora*)
	Eastern Lilaeopsis (*Lilaeopsis chinensis*)
	Water Hemp (*Amaranthus cannabinus*)
	Pickerelweed (*Pontederia cordata*)
	Wild Rice (*Zizania aquatica*)
Irregularly Flooded	Salt Hay Grass (*Spartina patens*)
	Spike Grass (*Distichlis spicata*)
	Smooth Cordgrass - short form (*Spartina alterniflora*)
	Black Grass (*Juncus gerardii*)
	Narrow-leaved Cattail (*Typha angustifolia*)
	Common Reed (*Phragmites australis*)

Nontidal Wetland Hydrology

Beyond the influence of the tides, two hydrologic forces regulate water levels or soil saturation in wetlands: (1) surface water runoff and (2) ground-water discharge. In certain cases, wind driven waves (e.g., seiches) across large freshwater lakes cause flooding of shoreline wetlands. Surface water runoff from the land either collects in depressional wetlands or overflows from rivers and lakes after snowmelt or periods of rainfall (Figure 15). Ground water will discharge into a depressional wetland, when it is directly connected to the water table, or into sloping wetlands in "seepage" areas (Figure 16). An individual wetland may exist due to surface water runoff, ground water discharge, or both. The role of hydrology in maintaining freshwater wetlands is discussed by Gosselink and Turner (1978).

Freshwater rivers and streams in Connecticut usually experience greatest flooding in winter and early spring (Hoyt and Langbein, 1955). Such flooding is associated with frozen soil, snowmelt, and/or heavy rains, although flooding can occur at any time during the year. In contrast,

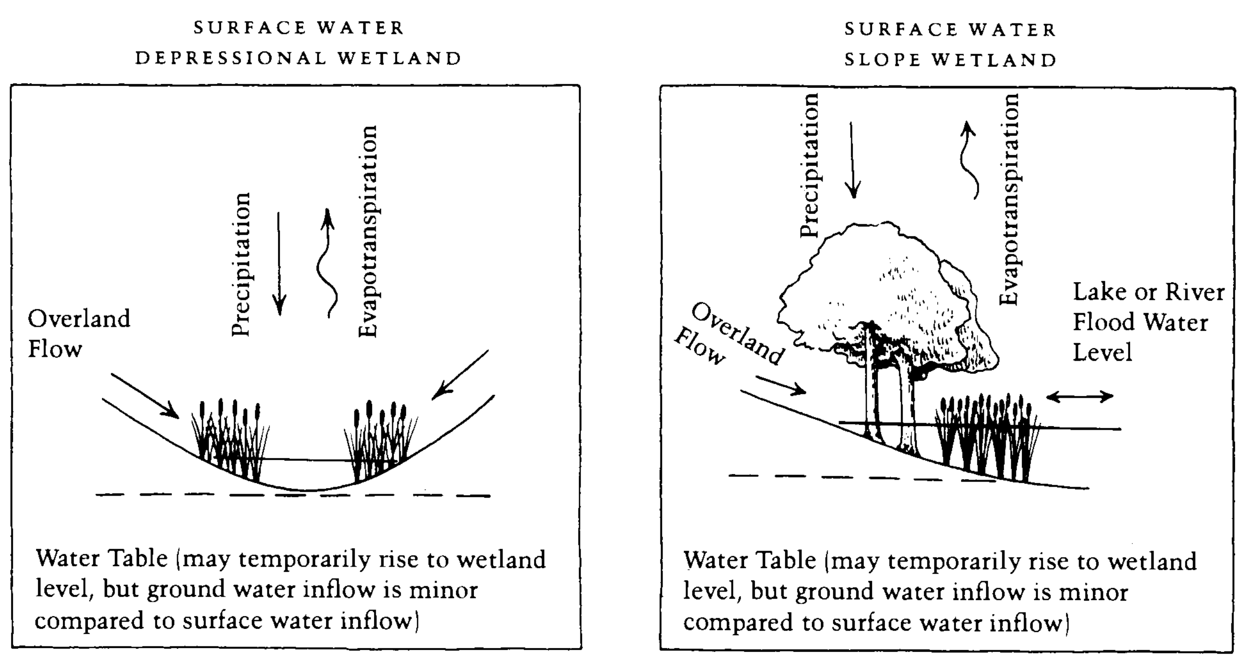

Figure 15. Hydrology of surface water wetlands (redrawn from Novitski, 1982).

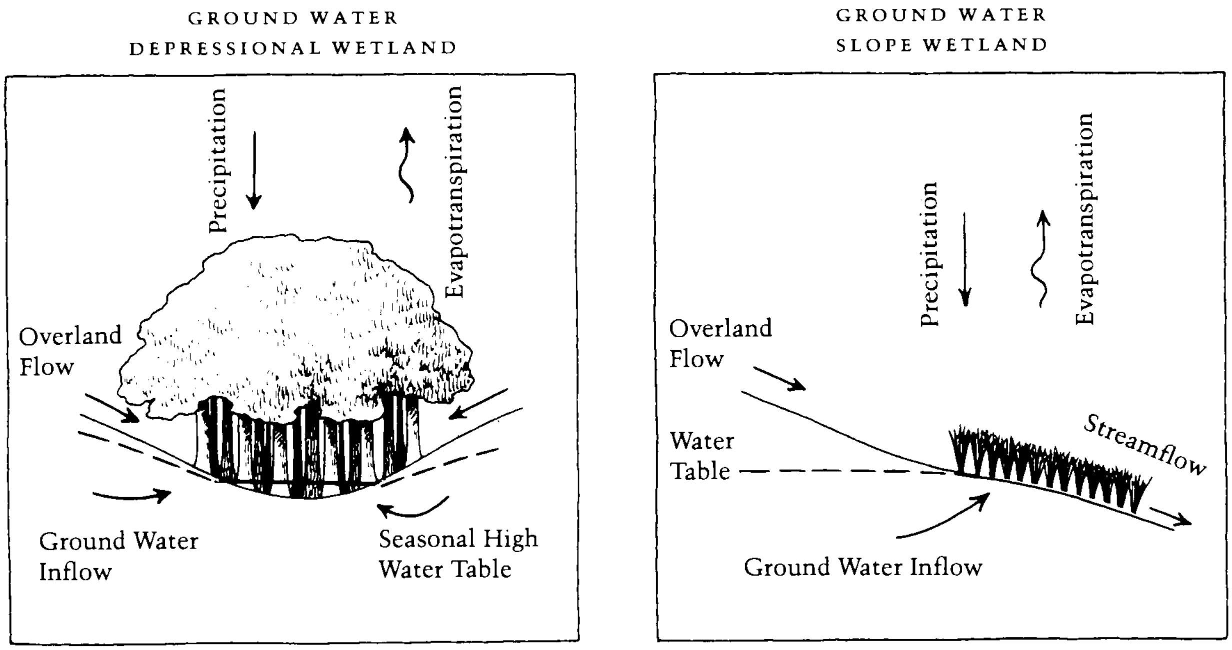

Figure 16. Hydrology of groundwater wetlands (redrawn from Novitski, 1982).

the hydrology of the Connecticut River is greatly affected by events in northern New England where snowmelt causes the river level to peak long after local rivers have receded. This has greatly influenced the development of the vegetation on the Connecticut River flood plain, with patterns of plant communities dependent on flood frequency and duration (Metzler and Damman, 1985). Summer floods have the most disastrous effect on the vegetation (Figure 17). In late summer and early fall, hurricanes can bring heavy rains which increase flood heights and duration.

Water table fluctuations follow a similar pattern (Figure 18). From winter to mid-spring or early summer, the water table is at or near the surface in most wetlands. During this time, water may pond on or flood the wetland surface for varying periods. The water table generally begins to markedly drop in early summer, and reaches its low point in September or October. Most of the fluctuation relates to increased day length, air temperatures, evapotranspiration, and other factors which help lower the water table from spring through summer.

Standing water may be present in depressional, streamside, or lakefront wetlands for variable periods during the growing season. When flooding or ponding is brief (usually two weeks or less), the wetland is considered temporarily flooded. During the summer, the water table may drop to three feet or more below the surface in these wetlands. This situation is prevalent along flood plains. Flooding for longer periods is described by three common water regimes: (1) seasonally flooded; (2) semi-permanently flooded; and, (3) permanently flooded. A seasonally flooded wetland typically has standing water visible for more than one month, but usually by late summer such water is absent. By contrast, a semi-permanently flooded wetland remains flooded throughout the growing season in most years. Only during dry spells does the surface of these wetlands become exposed to air. Even then, the

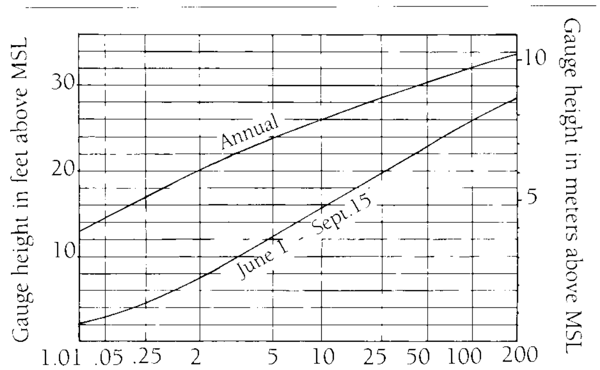

Figure 17. Recurrence interval of annual and summer flooding on the Connecticut River (from Metzler and Damman, 1985). A summer flood which can inundate the lower flood plain (approximately 12 ft.) has more than a ten percent chance of occurring annually near Hartford.

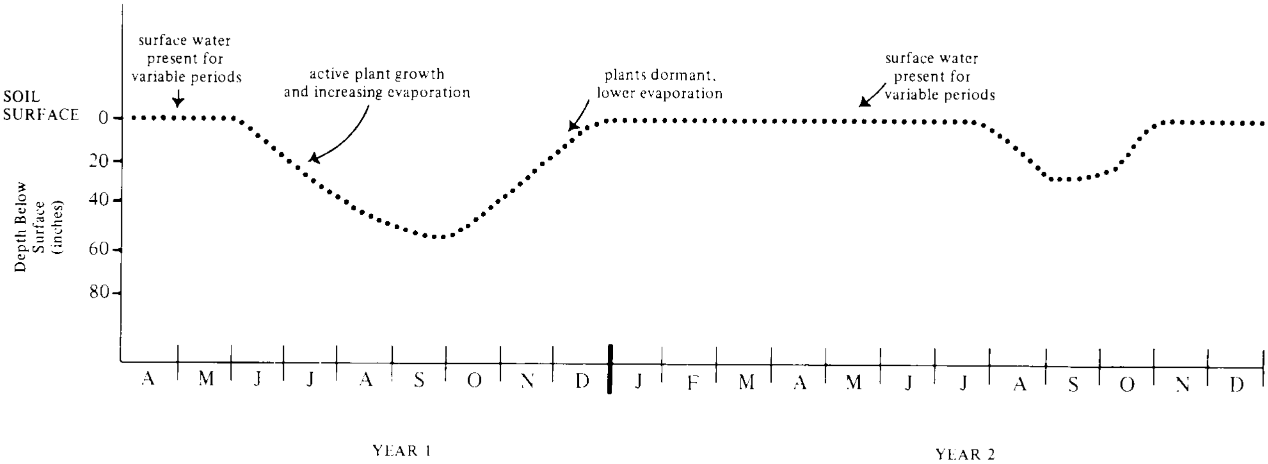

Figure 18. Water table fluctuation in a nontidal wetland (adapted from data by Lyford, 1964). In general, the water table is at or near the surface through the winter and spring, drops markedly in summer, and begins to rise in the fall. As shown, the water table fluctuates seasonally and annually.

water table lies at or very near the surface. Permanently flooded wetlands include areas exposed only during extreme drought (intermittently exposed). These wetlands include open water bodies where the depth is less than 6.6 feet (2 m), such as ponds and shallow parts of lakes, rivers, and streams.

Other wetlands are rarely flooded and are almost entirely influenced by ground-water discharge or surface water runoff. Some of these wetlands occur on slopes in association with springs or other points of active ground-water discharge commonly called "seeps." Here the soils are waterlogged to the surface for most of the growing season and the water regime is classified as saturated. Other saturated wetlands occur in glacial kettles and depressions. In these situations, soil saturation may come from both surface water runoff and ground-water discharge. Common indicator plants of nontidal water regimes are presented in Table 11.

Table 11. Examples of plant indicators of nontidal water regimes for Connecticut's palustrine wetlands.

Water Regime	Indicator Plants
Permanently Flooded	Fragrant White Water Lily (*Nymphaea odorata*) Pondweeds (*Potomogeton spp.*) Water shield (*Brasenia schreberi*) Small Yellow Pond-lily (*Nuphar microphyllum*)
Semipermanently Flooded	Buttonbush (*Cephalanthus occidentalis*) Water-willow (*Decodon verticillatus*) Bur-reeds (*Sparganium* spp.) Pickerelweed (*Pontederia cordata*) Cattail (*Typha* spp.)
Seasonally Flooded	Green Ash (*Fraxinus pennsylvanica*) Bog Hemp (*Boehmeria cylindrica*) Sensitive Fern (*Onoclea sensibilis*) Green Dragon (*Arisaema dracontium*)
Seasonally Flooded/ Saturated	Spicebush (*Lindera benzoin*) Highbush-blueberry (*Vaccinium corymbosum*) Swamp Azalea (*Rhododendron viscosum*) Tussock Sedge (*Carex stricta*) Skunk Cabbage (*Symplocarpus foetidus*)
Temporarily Flooded	Sycamore (*Platanus occidentalis*) Pin Oak (*Quercus palustris*) Ostrich Fern (*Matteuccia struthiopteris*) Joe-Pye-weeds (*Eupatorium* spp.) Avens (*Geum canadense*)
Saturated	Black Spruce (*Picea mariana*) Leatherleaf (*Cassandra calyculata*) Bog Laurel (*Kalmia polifolia*) Tawny Cotton Grass (*Eriophorum virginicum*)

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CHAPTER 5.

Hydric Soils of Connecticut

Introduction

The predominance of hydric soil is a key attribute for identifying wetlands (Cowardin, *et al.*, 1979), although natural or artificially created wetlands may exist on soils that were previously nonhydric. Hydric soils naturally develop in wet depressions, on flood plains, on seepage slopes, and along the margins of coastal and inland waters. Knowledge of hydric soils is particularly useful in distinguishing marginal wetlands from uplands, where the more typical wetland plants are less common or absent. This chapter focuses on the characteristics, distribution, and extent of Connecticut's hydric soils.

Definition of Hydric Soil

Hydric soils have been defined by the U.S.D.A. Soil Conservation Service (1987) as soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic (no oxygen) conditions in the upper part of the soil. These criteria can be used to identify soils that are sufficiently wet to support the growth and regeneration of hydrophytes. These soils are either saturated and/or flooded long enough to affect the reproduction, growth, and survival of plants. Plants growing in wetlands must adapt to anaerobic soil conditions and deal with the presence of reduced forms of manganese, iron, and possibly sulphur, which are more toxic than their oxidized forms (Patrick, 1983).

Soils that were formerly wet but that are now completely drained may not be hydric soils. These soils must be checked in the field to verify that drainage measures are still functional under normal or design conditions. Where drainage measures fail, soils can revert to hydric conditions. This condition, however, can only be determined on site.

Major Categories of Hydric Soils

Hydric soils are separated into two major categories on the basis of soil composition: (1) organic soils (Histosols) and (2) mineral soils. In general, soils having 20% or more organic material by weight in the upper 16 inches are considered organic soils. All Histosols, except Folists, are hydric soils. Soils with less organic content are mineral soils, and may or may not be hydric. Mineral soils are largely composed of various mixtures of sand, silt, and clays. For a technical definition of these soils, the reader is referred to Soil Taxonomy (U.S.D.A. Soil Conservation Service, 1975), and the pamphlet *Hydric Soil Map Units - Connecticut* (U.S.D.A. Soil Conservation Service, 1987).

A build-up of organic matter in developing organic soils in Connecticut results from prolonged anaerobic soil conditions associated with long periods of flooding and/or continuous soil saturation during the growing season. These saturated conditions impede aerobic decomposition (or oxidation) of the organic materials entering the water/soil system such as leaves, stems and roots, and encourage their accumulation as peat or muck over time. Like most organic soils, peats and mucks are very poorly drained, and water moves through them very slowly. Organic soils typically form in waterlogged depressions where peat or muck deposits range from one foot to more than 30 feet in depth. They also develop in low-lying areas along coastal waters where tidal flooding is frequent and the soil remains saturated nearly continuously.

Organic soils can be subdivided into three groups based on the percent of identifiable plant material in the soil: (1) muck (Saprist) where two-thirds or more of the material is decomposed and less than one-third is identifiable; (2) peat (Fibrist) with less than one-third decomposed and greater than two-thirds identifiable; and, (3) mucky peat or peaty muck (Hemist) where between one-third and two-thirds is both decomposed and identifiable. For more information on organic soils, the reader is referred to *Histosols: Their Characteristics, Classification, and Use* (Aandahl, *et al.*, 1974).

In other situations, organic matter does not accumulate in sufficient quantities to be considered peat or muck, and here mineral soils have developed. Some mineral soils do, however, have thick organic surface layers related to excess soil moisture for long periods from heavy seasonal rainfall and/or a high water table (Ponnamperuma, 1972). Mineral soils exhibit a wide range of properties related to differences in parent material, climate, topography, age and other factors. Hydric mineral soils have standing water for significant periods and/or are saturated within 10 inches (25 cm) of the surface for extended periods during the growing season. Soil saturation may result from low-lying topographic position, ground-water seepage, or the presence of a slowly permeable layer (i.e., clay, confining bed, fragipan, or hardpan). The duration and depth of soil saturation are essential criteria for identifying hydric soils and wetlands.

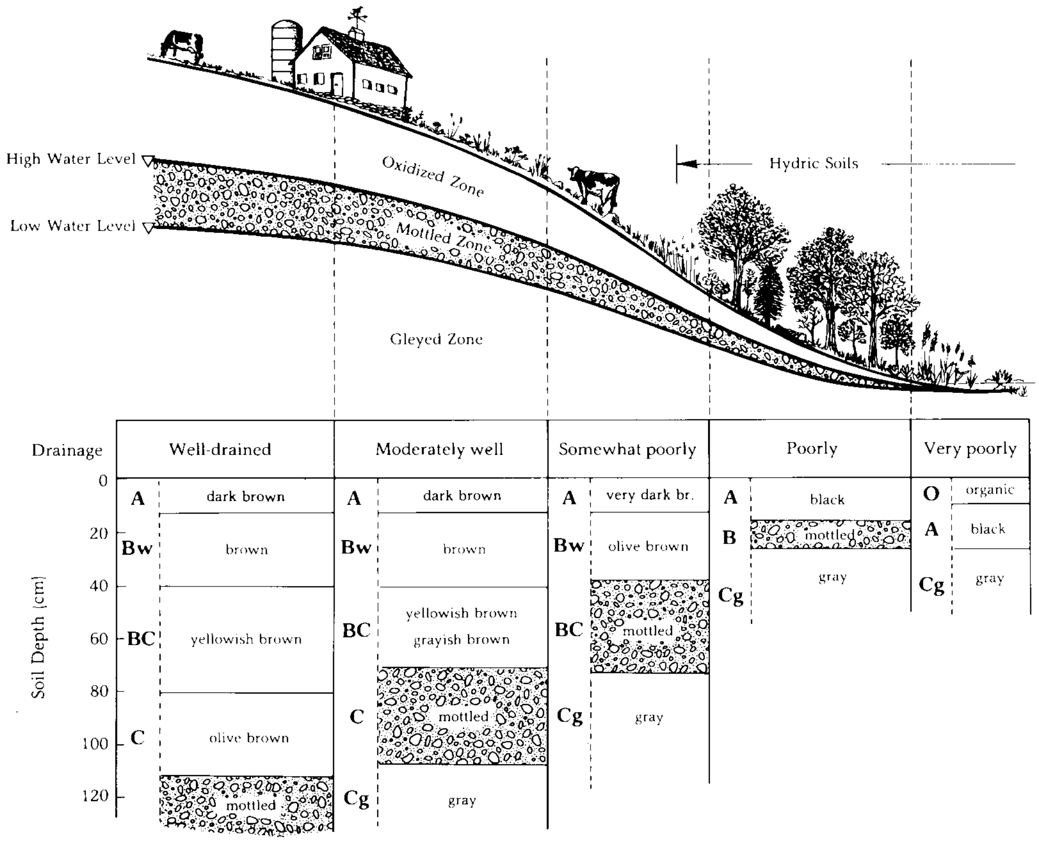

Figure 19. Schematic cross-section of a hydrosequence showing soil morphological changes with landscape position (from Tiner and Veneman, 1987).

Soil morphology features are widely used to indicate long term soil moisture (Bouma, 1983). The two most widely recognized features reflecting soil wetness are gleying and mottling. Gleyzation is the process of converting iron from its oxidized (ferric) form to its reduced (ferrous) state under prolonged periods of saturation (anaerobic conditions). Reduction and removal of reduced compounds result in gleying (Veneman, *et al.*, 1976). Gleyed soils are typically bluish, greenish, or grayish and soils gleyed to or near the surface are hydric soils.

Most soils that are alternately saturated and oxidized during the year are mottled (marked with spots or blotches of a different color or a different shade of the predominant soil matrix color) in the part of the soil that is wet. In most soils, depth and duration of saturation can be correlated to the quantity, nature, and pattern of soil mottling (Figure 19). It is important, however, to note that mottles will not form during saturation under two conditions: (1) when the water contains sufficient oxygen to service microbial needs for digesting organic matter; and, (2) when the soil or water temperatures are below biological zero (41^{o}F or 5^{o}C) during the time when the soil is saturated (Diers and Anderson, 1984). Abundance, size, and color of the mottles usually indicate the length of saturation. Mineral soils that are always saturated usually lack mottles and are uniformly gray throughout the saturated area. Mineral soils that are predominantly gray with brown or yellow mottles are usually saturated for long periods during the growing season, whereas soils that are predominantly brown or yellow with gray mottles are saturated for shorter periods, usually insufficient to be considered wetland. Soils that are never saturated are usually bright colored and are not mottled. In some hydric mineral soils, mottles may not be visible due to masking by organic matter (Parker, *et al.*, 1984).

While gleying and mottling are characteristic of nearly all hydric mineral soils, other soils with brighter colors may be saturated. This happens where the oxygen content of the soil remains high enough so that reduction of iron and manganese does not occur (Daniels, *et al.*, 1973). In a study of Texas soils, Vepraskas and Wilding (1983) found that periods of saturation and reduction do not coincide; some soils were saturated for longer periods than they were reduced, while for other soils the reverse was true. Differences were related to water table recharge. Soils with a slowly permeable surface layer were not saturated throughout the upper soil even when they were ponded, but high moisture levels persisted and maintained reduced conditions for more than six months. The authors have proposed technical criteria for identifying these soils as hydric.

National List of Hydric Soils

To help the U.S. Fish and Wildlife Service clarify its wetland definition, the U.S.D.A. Soil Conservation Service (SCS) agreed to develop a list of hydric soils in cooperation with the National Technical Committee for Hydric Soils. This list has gone through a number of reviews and revisions, and will continue to be revised as needs arise. The current list (1987) includes all soils that typically have properties that meet the criteria for hydric soils. Provisions for adding or deleting soils from this list, or changing the criteria, have been developed. Copies of the current list can be obtained from the SCS State Office in Storrs.

Connecticut Hydric Soils

A list of hydric soils occurring in Connecticut has been extracted from the national list. More than 25 soil series are identified as hydric (Table 12). In this list, all soils normally displaying hydric conditions in the field are considered hydric soils. In addition to this list, SCS has produced a list of hydric soil map units. Roughly 56 map units have been identified as hydric or as having high potential for containing hydric soils as inclusions. More information on hydric soils can be found in *Hydric Soils of New England* (Tiner and Veneman, 1987).

Six organic hydric soil series have been mapped in Connecticut, whereas, the majority of the hydric series are mineral soils. Organic hydric soils occupy 96,648 acres, while hydric mineral soils encompass 355,102 acres. In total, hydric soils cover approximately 14 percent of the State. However, these figures should be considered approximate only, since they do not account for alterations by draining, filling, and impoundment construction since mapping took place, nor do they include areas of hydric soils which were not identified during the mapping process.

County Acreage of Hydric Soils

A listing of the total acreage of hydric soils mapped within each county in Connecticut is presented in Table 13. Acreage totals are based on published National Cooperative Soil Surveys for Connecticut's eight counties, published between 1962 and 1983. Windham County has by far the largest percentage of its land surface classified as hydric soil, with Hartford and New London Counties close behind. Middlesex, Tolland, Fairfield, and New Haven Counties are near average for percentage of hydric soils found in Connecticut, whereas Litchfield County has the least. Unfortunately, these figures probably exaggerate today's actual extent of wetlands, since they do not account for recent alterations. A brief discussion of these hydric soils appears in the following section.

Table 12. List of hydric soils and qualifying land types mapped in Connecticut. (U.S.D.A. Soil Conservation Service, 1990) An asterisk (*) indicates series which may include non-hydric members and a plus sign (+) indicates series that are no longer used in Connecticut.

Soils Series or Land Type	Taxonomy
Adrian	Terric Medisaprists
Alden	Mollic Haplaquepts
Alluvial Land	N/A
+AuGres	Entic Haplaquods
*Bash	Fluvaquentic Dystrochrepts
+Biddeford	Histic Humaquepts
+Birdsall	Typic Humaquepts
+*Bowmansville	Aeric Fluvaquents
Carlisle	Typic Medisaprists
*Fredon	Aeric Haplaquepts
+Granby	Typic Haplaquolls
Halsey	Mollic Haplaquepts
Ipswich	Typic Sulfihemists
*Leicester	Aeric Haplaquepts
*Lim	Aeric Fluvaquents
Limerick	Typic Fluvaquents
+Lyons	Mollic Haplaquepts
*Massena	Aeric Haplaquepts
Maybid	Typic Humaquepts
Menlo	Histic Humaquepts
Muck, shallow	Terric Medisaprists
Palms	Terric Medisaprists
Pawcatuck	Terric Sulfihemists
Peat and Muck	Fibrists and Saprists
*Raynham	Aeric Haplaquepts
*Raypol	Aeric Haplaquepts
*Ridgebury	Aeric Fragiaquepts
*Rippowam	Aeric Fluvaquents
+*Rumney	Aeric Fluvaquents
Saco	Fluvaquentic Humaquepts
+Scantic	Typic Haplaquepts
Scarboro	Histic Humaquepts
Scitico	Typic Haplaquepts
Shaker	Aeric Haplaquepts
+*Swanton	Aeric Haplaquepts
*Walpole	Aeric Haplaquents
+*Wareham	Humaqueptic Psammaquents
Westbrook	Terric Sulfihemists
+Whately	Mollic Haplaquepts
Whitman	Typic Humaquepts
Wilbraham	Aquic Dystrochrepts

Description of Hydric Soils

This section briefly discusses key features of each hydric soil and map unit found in Connecticut. More detailed information about a particular soil series or map unit can be found in the published county soil survey or obtained directly from the U.S.D.A. Soil Conservation Service. Note: since a number of soil series concepts have been changed, many soil map unit names have been revised and current series names appear in parentheses in the subheadings. Each county soil survey should be consulted to determine the distribution of a particular soil. Acreage summaries for all hydric soil in each county are presented in Table 14. It should be noted that, for regulatory purposes, Connecticut's wetland laws include certain soils which are not hydric.

Table 13. Ranking of counties according to total acreage of hydric soils and percentage of each county represented by these soils (based on SCS County Soil Surveys). Note: County wetland acreage does not reflect recent changes due to drainage, filling, and other wetland attractions.

Rank	County	Date of Survey	Total Acreage Hydric Soils	Rank	County	% of County Represented by Hydric Soils
1	Hartford	1962	77,498	1	Windham	18.5
2	Litchfield	1970	68,290	2	Hartford	16.1
3	New London	1983	66,950	3	New London	15.5
4	Windham	1981	61,100	4	Middlesex	14.3
5	Fairfield	1981	54.530	5	Tolland	14.1
6	New Haven	1979	51,680	6	Fairfield	13.6
7	Tolland	1966	37,692	7	New Haven	13.6
8	Middlesex	1979	34,010	8	Litchfield	11.5
	CONNECTICUT TOTAL		451,750			

Adrian Series

The Adrian series consists of very deep, very poorly drained mucky soils, 16 to 51 inches thick overlying sandy deposits, formed in small glacial lake basins primarily within outwash plains or lake-plains. Adrian soils have been mapped in Fairfield and Middlesex Counties, in New Haven, New London, and Windham Counties as an undifferentiated unit with the Palms series, and in Hartford, Tolland, and Litchfield Counties as Peats and Mucks or as Muck, shallow.

Biddeford Series (Maybid Series)

The Biddeford series consists of very deep, very poorly drained silty soils formed in depressions within glacial lake deposits. Biddeford soils have been mapped only in a small part of Hartford County.

Birdsall Series (Halsey Series)

The Birdsall series consists of very deep, very poorly drained loamy soils formed in depressions and drainageways within glacial outwash terraces and till-covered uplands. This soil has been mapped in Fairfield and Litchfield Counties.

Carlisle Series

The Carlisle series consists of very poorly drained mucky soils more than 51 inches thick formed in depressions within glacial lake plains, outwash plains, till plains and moraines. Carlisle soils have been mapped in New Haven, New London, Fairfield, Windham, and Middlesex counties. In Hartford, Tolland, and Litchfield Counties, these soils have been mapped as Peat and Muck.

Fredon Series

The Fredon series consists of deep, poorly and somewhat poorly drained loamy soils, formed on glacial outwash plains and terraces. They occur in depressions and drainageways. Fredon soils have been partially derived from materials containing limestone. These soils have been mapped only in Litchfield County.

Granby Series (Scarboro Series)

The Granby series consists of deep, poorly, and very poorly drained sandy soils formed on nearly level outwash and glacial lake plains, and in drainageways. Derived from materials containing limestone, Granby soils have been mapped only in Litchfield County. The Granby series has been included in correlation with the Scarboro series.

Table 14. Acreage and percent of area of hydric soils within each county in Connecticut (based on U.S.D.A. Soil Conservation Service soil surveys). Soils are listed by soil series, soil series complexes, or by undifferentiated soil groups (tidal marsh, muck, alluvial land). The percentage coverage by each hydric soil is indicated for each county. Total land acreage for each county is also shown. Mapping units preceded by an asterisk (*) include some non-hydric soil.

County (Total Land Acreage)	Hydric Soil Type	Acreage of Soil Type in County	% of County Covered by Soil Type
Fairfield (400,000)	Adrian	5,280	1.3
	Carlisle	5,910	1.5
	Leicester	1,980	0.5
	Raypol	2,230	0.6
	*Ridgebury	3,180	0.8
	*Ridgebury, Leicester Whitman	25,650	6.4
	Rippowam	2,530	0.6
	Saco	3,380	0.8
	Scarboro	1,880	0.5
	Walpole	1,050	0.3
	Westbrook	870	0.2
	Westbrook (low salt)	590	0.1
	Fairfield Total	54,530	13.6
Hartford (473,600)	Alluvial Land	1,990	0.4
	Biddeford	1,706	0.4
	Leicester	848	0.2
	Leicester, Whitman, *Ridgebury	7,870	1.7
	Limerick	4,773	1.0
	Menlo	1,203	0.3
	Mucks, shallow	1,120	0.2
	Peats and Mucks	3,801	0.8
	*Ridgebury	171	0.04
	Riverwash	677	0.1
	Rumney	1,778	0.4
	Saco	9,932	2.1
	Scantic	6,891	1.4
	Scarboro	5,532	1.2
	Swanton	4,773	0.9
	Wallington	914	0.2
	Walpole	12,289	2.5
	Whately	990	0.2
	Whitman	278	0.1
	Wilbraham	4,938	1.0
	Wilbraham & Menlo	5,034	1.0
	Hartford Total	77,498	16.4
Litchfield (600,320)	Alluvial Land	1,701	0.3
	Birdsall	2,390	0.4
	Fredon	821	0.1
	Granby	650	0.1
	*Kendaia & Lyons	1,113	0.2
	Leicester	2,318	0.4

County (Total Land Acreage)	Hydric Soil Type	Acreage of Soil Type in County	% of County Covered by Soil Type
	Leicester, *Ridgebury Whitman	26,524	4.4
	Limerick	2,856	0.5
	Lyons	553	0.1
	Muck, shallow	1,287	0.2
	Peat & Muck	12,154	2.0
	Raynham	1,369	0.2
	*Ridgebury	3,786	0.6
	Riverwash	310	0.1
	Rumney	1,782	0.3
	Saco	3,399	0.6
	Scarboro	2,119	0.4
	Walpole & Raynham	1,657	0.3
	Wareham	457	0.1
	Whitman	1,044	0.2
	Litchfield Total	68,290	11.4
Middlesex (235,160)	Adrian	3,280	1.4
	Carlisle	2,460	1.0
	Leicester, *Ridgebury, Whitman	13,600	5.7
	Raypol	1,390	0.6
	Rumney	3,270	1.3
	Saco	1,670	0.7
	Scarboro	1,100	0.5
	Walpole	1,820	0.8
	Westbrook	1,640	0.7
	Westbrook (low salt)	1,650	0.7
	Wilbraham	2,130	0.9
	Middlesex Total	34,010	14.5
New Haven (387,750)	Adrian & Palms	3,440	0.9
	Carlisle	3,780	1.0
	Leicester	820	0.2
	Raynham	1,390	0.4
	Raypol	2,380	0.6
	*Ridgebury	580	0.1
	*Ridgebury, Leicester, Whitman	16,600	4.3
	Rumney	4,440	1.4
	Saco	1,420	0.4
	Scarboro	590	0.2
	Walpole	2,530	0.6
	Westbrook	4,960	1.3
	Westbrook (low salt)	510	0.1
	Wilbraham	3,970	1.0
	Wilbraham & Menlo	4,270	1.1
	New Haven Total	51,680	13.3

County (Total Land Acreage)	Hydric Soil Type	Acreage of Soil Type in County	% of County Covered by Soil Type
New London (424,520)	Adrian & Palms	11,260	2.6
	Carlisle	7,040	1.6
	Ipswich	430	0.1
	Limerick	740	0.2
	Pawcatuck	1,170	0.3
	Raypol	1,730	0.4
	*Ridgebury	1,430	0.3
	*Ridgebury, Leicester, Whitman	28,490	6.6
	Rippowan	4,550	1.1
	Scarboro	4,870	1.1
	Walpole	3,160	0.7
	Westbrook	580	0.1
	Westbrook (low salt)	1,500	0.4
	New London Total	66,950	15.8
Tolland (266,240)	Alluvial Land	1,737	0.6
	Leicester	1,197	0.5
	Leicester, *Ridgebury, Whitman	19,386	7.2
	Limerick	293	0.1
	Peat & Muck	5,919	2.2
	Peat & Muck, shallow	2,317	0.9
	Raynham	365	0.1
	*Ridgebury	484	0.2
	Rumney	576	0.2
	Saco	1,456	0.5
	Scarboro	860	0.3
	Walpole	2,258	0.9
	Whitman	182	0.1
	Wilbraham	662	0.3
	Tolland Total	37,692	14.2
Windham (328,540)	Adrian & Palms	4,350	1.3
	Carlisle	9,350	2.8
	*Ridgebury	1,700	0.5
	*Ridgebury, Leicester, Whitman	34,000	10.3
	Rippowam	3,500	1.1
	Saco	4,850	1.5
	Scarboro	2,400	0.7
	Walpole	950	0.3
	Windham Total	61,100	18.6

Ipswich Series

The Ipswich series consists of very deep, very poorly drained peaty soils formed in tidal marshes subject to daily inundation by salt water. The upper surfaces are typically fibrous, overlying well decomposed organic materials. Ipswich soils have been mapped only in New London County.

Leicester Series

The Leicester series consists of very deep, poorly drained loamy soils formed in friable glacial till. They are nearly level or gently sloping soils in drainageways and low-lying positions of till-covered uplands. Leicester soils have been mapped in all counties primarily as an undifferentiated unit with Ridgebury and Whitman soils.

Limerick Series

The Limerick series consists of deep, poorly drained loamy soils formed on floodplains. Most areas of Limerick soil are flooded for periods of several days each year, usually in late winter or early spring. Limerick soils have been mapped along major rivers and streams in Hartford, Litchfield, Tolland, and New London Counties. Where the silts are underlain by sand and gravel, the soils are currently classified as the Lim series.

Lyons Series (Alden Series)

The Lyons series consists of very deep, very poorly drained loamy soils formed in local alluvium and glacial till derived partially from calcareous rocks. They are nearly level to gently sloping soils in depressions within undulating to rolling till plains. Lyons soils have been mapped only in the limestone valleys of Litchfield County. In some areas, Lyons soils have been mapped in an undifferentiated unit with Kendaia soil.

Menlo Series

The Menlo series consists of very deep, very poorly drained loamy soils formed in compact glacial till. Menlo soils have developed in drainageways and in low depressions within glaciated uplands. Since Menlo soils are derived mainly from reddish sandstones and basalt, these soils are restricted to the Connecticut Central Valley in Hartford and New Haven Counties. Menlo soils have also been mapped as an undifferentiated unit with the Wilbraham series.

Palms Series

The Palms series consists of very deep, very poorly drained mucky soils, 16 to 51 inches thick overlying loamy materials, formed in depressions within lake plains, till plains, and moraines. Palms soils have been mapped as an undifferentiated unit with Adrian soils in New Haven, New London, and Windham Counties, and as Peats and Mucks in Hartford, Tolland, and Litchfield Counties.

Pawcatuck Series

The Pawcatuck series consist of very deep, very poorly drained peaty soils, 16 to 51 inches deep overlying sandy materials, formed in tidal marshes that are flooded twice daily by salt water. Pawcatuck soils have been mapped only in New London County.

Raynham Series

The Raynham series consists of very deep, poorly drained silty soils that have formed on glacial lake plains. These soils have formed on nearly level to gently sloping areas and in depressions. Raynham soils and an undifferentiated unit of Raynham and Walpole soils have been mapped only in Litchfield County. Areas mapped as the Wallington series in Hartford County are now classified as the Raynam series.

Raypol Series

The Raypol series consists of very deep, poorly drained loamy soils formed in silty deposits overlying sand and gravel. These soils occur on low-lying, nearly level to gently sloping areas on outwash terraces. Raypol soils have been mapped in New Haven, New London, Fairfield and Middlesex Counties. Areas of the Walpole series mapped as the Walpole loam map unit in Hartford County have been included in correlation with the Raypol series.

Ridgebury Series

The Ridgebury series consists of very deep, poorly and somewhat poorly drained loamy soils formed in compact glacial till. They are nearly level to sloping soils in shallow drainageways in uplands. Ridgebury soils and an undifferentiated unit of Ridgebury, Whitman, and Leicester soils have been mapped in all counties in Connecticut.

Rumney Series (Rippowam Series)

The Rumney series consists of very deep, poorly drained loamy soils formed in alluvial deposits. These soils occur on nearly level areas subject to frequent flooding, usually during the winter and early spring. Rumney and Rippowam soils have been mapped along rivers in all counties in Connecticut.

Saco Series

The Saco series consists of very deep, very poorly drained silty soils formed in alluvial deposits. These soils occur as low-lying, nearly level, backwater areas on floodplains subject to frequent flooding. Saco soils have been mapped along the major rivers and streams in all counties but New London County.

Scarboro Series

The Scarboro series consists of very deep, very poorly drained sandy soils formed in outwash plains, glacial lake deltas, and terraces. Scarboro soils have been mapped in all counties in Connecticut.

Scantic Series (Scitico Series)

The Scantic series consists of very deep, poorly drained silty and clayey soils, formed in glacial lake sediments. They occur on nearly level and gently sloping lowlands on glacial lake plains. Scantic soils have a limited distribution in Hartford County.

Swanton Series (Shaker Series)

The Swanton series consists of very deep, poorly drained loamy soils formed in sandy materials overlying glacial lake deposits. They occur on nearly level to gently sloping glacial lake terraces. Swanton soils have a limited distribution in Hartford County.

Walpole Series

The Walpole series consists of very deep, poorly drained soils formed in sandy and gravely deposits of glacial outwash. These soils occur in level to gently sloping, low-lying areas on terraces and outwash plains. Walpole soils have been mapped throughout Connecticut. Areas in Litchfield County mapped as Au Gres soils have been included in correlation with the Walpole series.

Wareham Series (Scarboro Series)

The Wareham series consists of very deep, poorly and somewhat poorly drained sandy soils formed on outwash plains, glacial lake deltas, and stream terraces. These soils occur on nearly level to gently sloping areas and in depressions. Wareham soils have a limited distribution in Litchfield County.

Westbrook Series

The Westbrook series consists of very deep, very poorly drained mucky soils, 16 to 51 inches deep overlying loamy materials, formed in tidal marshes subject to twice daily inundation by salt water. Westbrook soils have been mapped in Fairfield, New Haven, Middlesex, and New London Counties, with a low salt variant mapped in brackish areas along the major rivers.

Whately Series (Maybid Series)

The Whately series consists of very deep, very poorly drained loamy soils formed in a thin mantle of loamy materials overlying silty and clayey glacial lake sediments. These soils occur in nearly level depressions on glacial lake plains, outwash plains or glacial lake deltas. Areas mapped as Whately soil have a small distribution in Hartford County.

Whitman Series

The Whitman series consists of very deep, very poorly drained loamy soils formed in compact glacial till. These soils occur on nearly level to gently sloping depressions and drainageways on till-covered uplands. Whitman soils have been mapped throughout Connecticut, mostly as an undifferentiated unit with the Leicester and Ridgebury series.

Wilbraham Series

The Wilbraham series consists of very deep, poorly drained loamy soils formed in compact glacial till. They occur in nearly level to gently sloping low depressions and in drainageways on till-covered uplands. Since Wilbraham soils are derived from reddish sandstones and basalts, these soils are restricted to the Connecticut Central Valley in Hartford, Tolland, Middlesex, and New Haven counties and have been mapped as an undifferented unit with the Menlo series.

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CHAPTER 6.

Vegetation and Plant Communities of Connecticut's Wetlands

Introduction

The vast majority of Connecticut's wetlands are characterized by dense growths of plants adapted to existing hydrologic, water chemistry, and soil conditions, but some wetlands have little or no apparent vegetation. Although most wetland definitions rely heavily on dominant vegetation for identification and classification purposes, vegetation is a relatively minor attribute in the legal definition of inland wetlands in Connecticut. The presence of "hydrophytes" or wetland plants, however, is one of the three key attributes of the U.S. Fish and Wildlife Service's and other federal wetland definition (Cowardin, *et al.*, 1979; Federal Interagency Committee for Wetland Definition, 1989). Vegetation is often the most conspicuous feature of wetlands and one that can usually be identified in the field. Other wetland characteristics, such as hydric soil and hydrology, may not be as easily recognized and may require considerable scientific expertise or long-term study for accurate identification. In this chapter, after discussing the concept of "hydrophyte," attention will focus on the major plant communities of Connecticut's wetlands. In addition, rare and endangered wetland plants will be briefly covered in the last section.

Hydrophyte Definition and Concept

Wetland plants are technically referred to as *hydrophytes*. A hydrophyte is defined as "any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content" (Cowardin *et al.*, 1979). Thus, hydrophytes are not restricted to true aquatic plants growing in water, but also include plants morphologically and/or physiologically adapted to periodic flooding or the saturated soil conditions of marshes, swamps, bogs, and bottomland forests. Today's concept of hydrophyte is an individualistic one that recognizes each plant's ability to adapt to wetland environments. A hydrophyte can, therefore, be defined as "an individual plant adapted for life in water or in periodically flooded and/or saturated soil (hydric soil) and growing in wetlands or deepwater habitats; may represent the entire population of a species or only a subset of individuals so adapted (Tiner, 1988, 1991).

A national list of wetland plants has been prepared by the U.S. Fish and Wildlife Service with cooperation from the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, and the U.S.D.A. Soil Conservation Service (Reed, 1988a). This list has been subdivided into regional lists, including one for the Northeast (Reed, 1988b). In this list, four types of hydrophytes are recognized: (1) obligate; (2) facultative wetland; (3) facultative; and, (4) facultative upland. Obligate hydrophytes are those plants which nearly always occur in wetlands (at least 99 percent of the time). They are the best vegetative indicators of wetlands. The facultative types can be found in both wetlands and uplands to varying degrees. Facultative wetland plants are usually associated with wetlands (from 67 to 99 percent of the time) and are generally good indicators of wetland, while purely facultative plants essentially show no affinity to wetlands or uplands and are found in wetlands with a frequency of occurrence between 34 and 66 percent. By contrast, facultative upland plants are more typical of uplands, but do, on occasion (from 1 to 33 percent of the time), occur in wetlands. When present in wetlands, they are usually in the drier ones, or occur at higher elevations in wetter areas. In addition to these four types, the U.S. Fish and Wildlife Service's list of wetland plants also identifies drawdown plants which invade normally nonvegetated wetlands, such as exposed shores, during extreme dry periods. These plants are often pioneer species with upland affinities. Examples of different types of hydrophytes for Connecticut are presented in Table 15.

Connecticut Hydrophytes

A list of Connecticut's hydrophytes that are the better vegetative indicators of wetlands was compiled for this report using the *National List of Plant Species that Occur in Wetlands: Connecticut* (Reed, 1988c) and the *Preliminary Checklist of the Vascular Flora of Connecticut* (Dowhan, 1979). This list contains all obligate and facultative wetland plants that occur in Connecticut. In preparing this list, information from wetland field surveys and scientific publications on Connecticut's wetland vegetation were reviewed, including a list of wetland plants reported by Lefor (1986). Scientific names of vascular plants referred to in this report follow Dowhan (1979) and U.S.D.A. Soil Conservation Service (1982) for vascular plants, Crum and Anderson (1981) for mosses, Schuster (1953) for liverworts, and Schneider, *et al.* (1979) for marine algae. Popular field guides to common wetland plants have been prepared by Magee (1981) and Tiner (1987, 1988). The list of Connecticut hydrophytes is included as an appendix. It should be noted that "watercourse" as defined under the Connecticut Inland Wetlands Act includes swamps, marshes, and bogs. In the absence of a hydric soil, the dominance of hydrophytes may be a critical factor to accurately determine the regulatory boundary of wetlands in Connecticut.

Table 15. Examples of wetland plant types occurring in Connecticut. Obligate plants are nearly always found in wetlands (at least 99% of the time); Facultative Wetland plants are usually associated with wetlands (66-99% of the time); Facultative plants have no affinity to wetlands or uplands and are found in wetlands between 34-67% of the time; Facultative Upland plants are occasionally present in wetlands (33.1% of the time).

Hydrophyte Type	Plant Common Name	Scientific Name
Obligate	Royal Fern	*Osmunda regalis*
	Pondweeds	*Potomogeton* spp.
	Smooth Cordgrass	*Spartina alterniflora*
	Common Three-square	*Scirpus pungens*
	Cattails	*Typha* spp.
	Skunk Cabbage	*Symplocarpus foetidus*
	Waterwillow	*Decodon verticillatus*
	Large Cranberry	*Vaccinium macrocarpon*
	Buttonbush	*Cephalanthus occidentalis*
	Atlantic White Cedar	*Chamaecyparis thyoides*
Facultative Wetland	Cinnamon Fern	*Osmunda cinnamomea*
	Salt Hay Grass	*Spartina patens*
	Bluejoint Grass	*Calamagrostis canadensis*
	Boneset	*Eupatorium perfoliatum*
	Spotted Jewelweed	*Impatiens capensis*
	Steeplebush	*Spiraea tomentosa*
	High-tide Bush	*Iva frutescens*
	High-bush Blueberry	*Vaccinium corymbosum*
	Sweet Pepperbush	*Clethra alnifolia*
	Silver Maple	*Acer saccharinum*
	Pin Oak	*Quercus palustris*
	Black Spruce	*Picea mariana*
Facultative	Switch Grass	*Panicum virgatum*
	Field Horsetail	*Equisetum arvense*
	Wrinked Goldenrod	*Solidago rugosa*
	Poison Ivy	*Toxicodendron radicans*
	Sheep Laurel	*Kalmia angustifolia*
	Gray Birch	*Betula populifolia*
	Red Maple	*Acer rubrum*
	Black Gum	*Nyssa sylvatica*
Facultative Upland	Bracken Fern	*Pteridium aquilinum*
	Partridgeberry	*Mitchella repens*
	Zig-zag Goldenrod	*Solidago flexicaulis*
	Black Huckleberry	*Gaylussacia baccata*
	Mountain Laurel	*Kalmia latifolia*
	American Beech	*Fagus grandiflora*
	White Ash	*Fraxinus americana*
	Pitch Pine	*Pinus rigida*

Factors Influencing Wetland Vegetation

Many factors influence wetland vegetation and community structure, including climate, hydrology, water chemistry, and human activities. Penfound (1952) identified the most important physical factors as: (1) water depth; (2) fluctuation of water levels; (3) soil moisture; and, (4) salinity. Other important physical factors included soil type, aeration, nutrients, acidity, temperature, and light. Penfound also recognized the role of biotic factors, such as plant competition, animal actions (e.g., grazing and beaver dam construction), and human activities. Many construction projects alter the hydrology of wetlands through channelization and drainage or by changing surface water runoff patterns. These activities often have a profound effect on plant composition. This is particularly evident in coastal marshes where mosquito ditching has increased the abundance of high-tide bush (*Iva frutescens*), especially on spoil berms adjacent to ditches (Bourn and Cottam, 1950).

Even though Connecticut is a small state, its location along the Atlantic coast gives rise to high plant and landscape diversity. Four physiographic regions can be identified: (1) the Central Valley; (2) the Eastern and Western Uplands; (3) the Coastal Slope; and, (4) the Northwest Highlands (Figure 1). Physical and biotic factors have interacted within each physiographic region to create a wealth of plant communities in Connecticut. Nichols (1913, 1915a, 1915b, 1920a, 1920b) reported on the predominant influences on the state's vegetation and on the variety of vegetation types, including wetlands.

Wetland Plant Communities

In Connecticut, wetlands occur in four of the five ecological systems recognized by the U.S. Fish & Wildlife Service's wetlands classification system: Estuarine, Riverine, Lacustrine and Palustrine. The Marine System is not represented in Connecticut since Long Island Sound is classified as an estuary. In coastal areas, the estuarine marshes, which include salt and brackish tidal marshes and flats, are most abundant, with intertidal beaches and shores occurring as a narrow fringe along parts of the shoreline. Overall, however, palustrine wetlands predominate, comprising about 90 percent of the state's wetlands. Palustrine wetlands include the overwhelming majority of freshwater marshes, swamps, bogs, and ponds. Riverine and lacustrine wetlands are largely represented by aquatic beds and nonpersistent emergent wetlands along the shores of rivers and in the shallow portions of lakes. The following sections discuss major wetland types in each ecological system as defined by Cowardin, *et al.* (1979). Descriptions are based on field observations, unpublished data, and a review of scientific literature. Unfortunately, nearly all of the Connecticut literature relates to estuarine wetlands, with little attention focused on the more abundant palustrine wetlands.

Estuarine Wetlands

The Estuarine System consists of tidal brackish waters and contiguous wetlands where ocean water is diluted by freshwater runoff from the land. It extends upstream in coastal rivers to freshwater where no measurable ocean-derived salts can be detected. The Estuarine System has a salinity range of 0.5 to 18 parts per thousand (ppt).

From a salinity standpoint, Connecticut's estuaries can be divided into three reaches: (1) polyhaline - strongly saline areas (18-30 ppt); (2) mesohaline (5-18 ppt); and, (3) oligohaline - slightly brackish areas (0.5-5 ppt). Long Island Sound and the lower reaches of major rivers such as the Connecticut and Housatonic are polyhaline, with salinities decreasing further upstream. A variety of wetland types develop in estuaries due to differences in salinity and the duration and frequency of flooding. Major wetland types include: (1) submerged aquatic beds; (2) intertidal beaches and rocky shores; (3) intertidal flats; and, (4) emergent wetlands.

Estuarine Aquatic Beds

Macroalgae and vascular plants form extensive aquatic beds in shallow waters and on irregularly exposed tidal flats in bays, coves, and inlets which are protected from the eroding force of waves and storm events. Here, common algae include sea lettuce (*Ulva lactuca*), Mermaid's hair (*Cladophora* spp.) and "green threads" (*Enteromorpha* spp.). Vascular plants such as widgeon grass (*Ruppia maritima*), horned pondweed (*Zannichellia palustris*) and sago pondweed (*Potamogeton pectinatus*) are also common in intertidal creeks and in irregularly flooded pools and brackish water ponds.

In waters several feet deep at low tide, kelp (*Laminaria agardhii*) and another brown alga (*Chorda filum*) form extensive beds. These two algae can be quite large, reaching six and two feet in length, respectively. Often these subtidal algal beds are intermixed with the red alga *Palmaria palmata*. In deeper waters, finely branched red algae such as *Spermothamnion repens*, *Antithamnion curciatum*, and *Callithamnion corymbosum* replace the large macrophytes found in shallow waters (Taylor and Villalard, 1979). Schneider, *et. al.* (1979) provide an up-to-date annotated checklist of algae from Connecticut's estuaries.

In protected bays and coves, another plant may form extensive aquatic beds. Eelgrass (*Zostera marina*) grows on muddy sediments rarely exposed by the tides to a depth determined by light availability. In Connecticut, the most extensive beds are found along the southeast coast in protected coves such as the Niantic River, Mumford Cove, the Mystic River, and Little Narragansett Bay. The infection of a mold, referred to as Wasting Disease, occurs periodically and severely reduces the size and vitality of eelgrass beds. The last severe infestation in Long Island Sound occurred during the 1930's with a slow recovery to present-day populations.

In the portions of tidal rivers and creeks with lower salinities, aquatic beds are dominated by other plants. In brackish portions of the lower Connecticut River, Barrett (1989) reported an abundance of widgeon grass, tape grass, horned pondweed, and sage pondweed intermixed with sea lettuce and *Enteromorpha intestinalis*. In oligohaline waters and freshwater areas, other pondweeds (*Potamogeton perfoliatus*, *P. crispus*, *P. epihydrus*, *P. nodosus*, and *P. spirillus*) were common, intermixed with hornwort (*Ceratophyllum demersum*), tape grass (*Vallisneria americana*), water stargrass (*Heteranthera dubia*), parrot feather (*Myriophyllum exalbescens*), and ditch moss (*Elodea canadensis* and/or *E. nuttallii*) (Barrett, 1989).

Estuarine Intertidal Beaches and Rocky Shores

Estuarine beaches and rocky shores occur along much of Connecticut's coast, except in areas modified by seawalls or revetments. The vegetation of intertidal beaches is generally sparse. On the upper zones of the beach, vascular plants such as sea rocket (*Cakile edentula*), saltwort (*Salsola kali*), sea beach orach (*Atriplex patula*), seabeach goosefoot (*Chenopodium macrocalycium*), coast blite (*Chenopodium rubrum*), seaside spurge (*Euphorbia polygonifolia*), and seabeach sandwort (*Arenaria peploides*) can be found. The vegetation of rocky shores is dominated exclusively by macrophytic algae including rockweeds

(*Fucus* spp. and *Ascophyllum nodosum*), Irish moss (*Chondrus* crispus), and others (*Porphyra* spp., *Petalonia fascia*, *Gigartina stellata*).

Estuarine Intertidal Flats

Estuarine mud and/or sand flats are common along the shores of Long Island Sound and in the lower reaches of tidal rivers, particularly between intertidal marshes and protected deep water bays and coves. These areas are flooded by tides and exposed to air twice daily. These flats are generally devoid of macrophytes, although smooth cordgrass (*Spartina alterniflora*) may occur in scattered clumps. Microscopic plants, especially diatoms, euglenoids, dinoflagellates, and blue-green algae are often abundant, although usually inconspicuous (Whitlatch, 1982). Nichols (1920a) reported sea lettuce and *Enteromorpha* spp. as common macroscopic algae on some mudflats.

Estuarine Emergent Wetlands

Differences in salinity and tidal flooding within estuaries have a profound and visible effect on the distribution of the vegetation in estuarine emergent wetlands. Plant composition is markedly different in the marshes contiguous to Long Island Sound and in the marshes upstream in the major tidal rivers. Even within areas of similar salinity, vegetation differs largely due to the frequency and duration of tidal flooding. Major plant species occurring in estuarine wetland plant communities are listed (Table 16).

Table 16. Representative estuarine wetland plant communities in Connecticut.

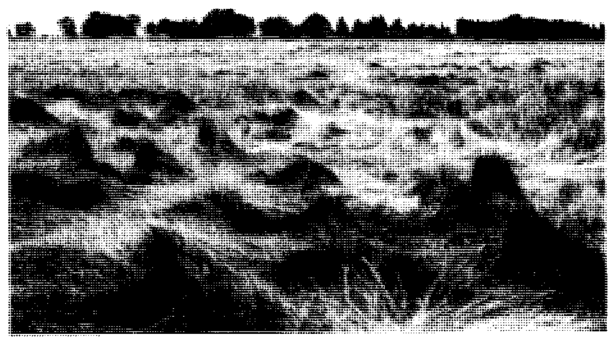
Wetland Type (Halinity)	Dominance Type	Common Associates	Less Common Plants	Water Regime
Emergent (Polyhaline)	Smooth Cordgrass (tall form)	None	None	Regularly Flooded
Emergent (Polyhaline)	Smooth Cordgrass (short form)	None	Glasswort, Sea Lavender, Salt Hay, Spike Grass, Salt Marsh Aster	Irregularly Flooded
Emergent (Polyhaline)	Salt Hay/ Spike Grass	Black Grass	Glasswort, Marsh Orach, Seaside Goldenrod	Irregularly Flooded
Emergent (Polyhaline)	Black Grass	Salt Hay, High-tide Bush, Salt Marsh Aster, Marsh Orach, Sea Lavender	Seaside Gerardia Glasswort, Sea-blite, Seaside Plantain, Arrow-grass	Irregularly Flooded
Emergent (Polyhaline)	Seaside Plantain/ Spike Grass/ Seaside Gerardia	Arrow-grass, Smooth Cordgrass (short form), Glasswort, Sea Lavender, Seaside Gerardia	Salt Marsh Aster, Black Grass, Salt Hay	Irregularly Flooded
Scrub-Shrub (Polyhaline)	High-tide Bush	Salt Hay, Spike Grass, Black Grass	Salt Marsh Aster, Seaside Goldenrod, Marsh Orach	Irregularly Flooded
Emergent (Mesohaline)	Smooth Cordgrass	Water Hemp, Spike Rush, Big Cordgrass	Eastern Lileopsis, Mudwort	Regularly Flooded
Emergent (Mesohaline)	Common Three-square/ Smooth Cordgrass	Spike Rush, Salt Marsh Bulrush	Water Smartweed, Smooth Bur-marigold, Soft Rush, Water Parsnip, Freshwater Cordgrass	Regularly Flooded
Emergent (Mesohaline)	Narrow-leaved Cattail	Rose Mallow, Climbing Hempweed	Big Cordgrass, Common Reed, Water Smartweed, Water Hemp	Irregularly Flooded
Emergent (Mesohaline)	Common Reed	None	None	Irregularly Flooded
Emergent (Mesohaline)	Salt Hay	Creeping Bent, Seaside Goldenrod, Black Grass	Common Reed, Narrow-leaved Cattail, Common Three-square, Arrow-grass	Irregularly Flooded
Emergent (Oligohaline)	Common Three-square/ Water Hemp	Arrowheads	None	Regularly Flooded

Salt marshes occur in protected coves and embayments along Long Island Sound and in the lower reaches of tidal rivers (Figure 20). A broad zonal pattern exists within salt marshes due to tidal flooding and local salinity levels. Three general zones are identified (Miller and Egler, 1950, Niering and Warren, 1980): (1) regularly flooded low marsh; (2) irregularly flooded high marsh; and, (3) the upper border or transition zone (Figure 21).

The low marsh is flooded at least once daily by the tides. Smooth cordgrass (*Spartina alterniflora*) dominates this zone from approximately mean sea level to the mean high water mark. This marsh type typically occurs as a thin fringe along bluff-like bay fronts or as a wider band along shallow aggrading areas with regular tidal flooding (Miller and Egler, 1950). Smooth cordgrass marshes are more abundant in southwestern Connecticut where they can occupy large areas. Recent studies indicate that the average height of smooth cordgrass increases westward into Long Island Sound with increased heights of tidal fluctuation (Shea, 1972) and that the distribution of the tall form of smooth cordgrass is an accurate indicator of the landward extent of mean high tide (Kennard, *et al.*, 1983).

Above the tall form smooth cordgrass zone is the high marsh, an area flooded less often and exposed to air for much greater periods. Here the vegetation often forms a mosaic rather than a distinct zone. Plant diversity is much greater than in the low marsh with several abundant species: salt hay (*Spartina patens*), spike grass (*Distichlis spicata*), a stunted form of smooth cordgrass, and black grass (*Juncus gerardii*), intermixed with glassworts (*Salicornia* spp.), sea lavender (*Limonium nashii*), sea beach orach (*Atriplex patula*), salt marsh aster (*Aster tenuifolius*), and seaside gerardia (*Agalinis maritima*).

A Metzler



B Mehrhoff

Figure 20. Examples of estuarine emergent wetlands on the Connecticut shoreline: (A) intertidal rocky shore covered with rockweed; and, (B) high marsh dominated by salt hay.

In unditched areas, or in marshes with restricted drainage, salt pannes (shallow depressions) and/or pools punctuate the marsh surface. The pools and tidal creeks may be vegetated with submerged widgeon grass, sea lettuce, and other algae. The more shallow pannes are subjected to extremes in temperature and salinity. Sum-

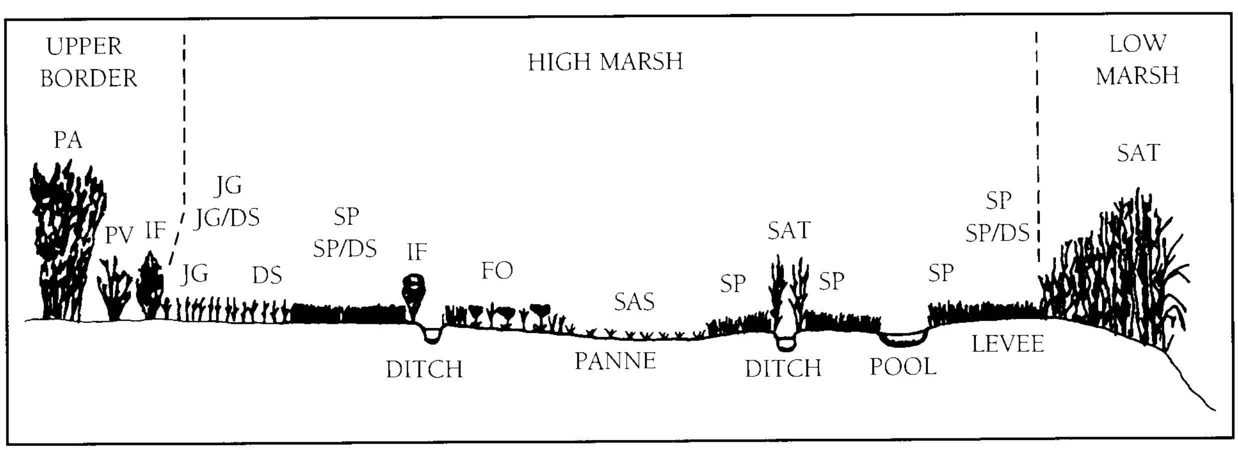


Figure 21. Generalized zonation of vegetation types in southern New England salt marshes (redrawn from Niering and Warren, 1980). SAT = *Spartina alterniflora*, tall; SP = *Spartina patens*; DS = *Distichlis spicata*; SAS = *Spartina alterniflora*, short; IF = *Iva frutescens*; JG = *Juncus gerardi*; PV = *Panicum virgatum*; PA = *Phragmites australis*.

mer salinities may exceed 40 parts per thousand (Martin, 1959). Although they may be devoid of plants, many pannes show concentric zonation with: (1) a central zone of blue-green algae and a salt crust, or water and widgeon grass;(2) an intermediate zone of stunted smooth cordgrass; and, (3) an outer zone composed of herbaceous plants such as sea lavender, glassworts, arrow-grass (*Triglochin maritima*), and seaside plantain (*Plantago juncoides*), intermixed with stunted smooth cordgrass and spike grass. Prior to extensive salt marsh ditching in the 1930's, these pannes may have occupied up to 20 percent of the total marsh area (Miller and Egler, 1950). Ditches throughout the high marsh are immediately bordered by smooth cordgrass, while old spoil berms adjacent to these mosquito ditches are usually vegetated by high-tide bush (*Iva frutescens*).

At the upland edge of salt marshes, switch grass (*Panicum virgatum*), common reed (*Phragmites australis*), sea myrtle (*Baccharis halimifolia*), high-tide bush, seaside goldenrod (*Solidago sempervirens*), and other species form the upper marsh border. Generally, the upper border is a distinct narrow belt between the tidal marsh and the upland. The vegetation can be characterized as a tall tussock grassland of switchgrass with the other plants occurring between the hummocks or as a dense border of common reed. Where freshwater runoff from the upland influences the vegetation, additional species are often present: common three-square (*Scirpus pungens*), poison ivy (*Toxicodendron radicans*), freshwater cordgrass (*Spartina pectinata*), red fescue (*Festuca rubra*), and marsh fern (*Thelypteris palustris*).

Numerous scientific studies have been undertaken in Connecticut's salt marshes, with general information provided by Nichols (1920a, 1920b); plant community descriptions by Coleman (1978), Gross (1966), Miller and Egler (1950), Niering and Warren (1974, 1975); and ecological relationships by Britton *et al.* (1915), Deane (1915), Niering, *et al.* (1977), Niering and Warren (1980), Roman (1978), Shea (1972), Shea, *et al.* (1975), and Steever, *et al.* (1976). Detailed U.S. Fish and Wildlife Service reports on New England high salt marshes (Nixon, 1982) and regularly flooded low marshes (Teal, 1986) serve as useful references on the ecology of salt marshes.

Brackish Tidal Marshes

Brackish tidal marshes occur in the middle (mesohaline) reaches of estuaries and are exposed to the widest ranges in salinity (5 to 18 ppt) which can vary considerably between seasons. In spring, these marshes are mildly brackish, even fresh at times, due to heavy river discharge, while in late summer during low flows salinity approaches that of the more saline marshes. In the Connecticut River, for example, during low summer flows salt in dilute concentrations has been detected at the East Haddam bridge, 16 miles (25 km) upstream. During spring flood the entire river is virtually free from salt (Meade, 1966).

From a vegetation standpoint, the middle reach of estuaries begins a large zone of transition where some of the common salt marsh plants like smooth cordgrass, salt hay, spike grass, and saltmarsh bulrush (*Scirpus maritimus*) begin to occur mixed with freshwater species such as common three-square, water smartweed (*Polygonum punctatum*), water parsnip (*Sium suave*), soft-stemmed bulrush (*Scirpus validus*), and wild rice (*Zizania aquatica*). Salt marsh plants are more common at downstream locations, while freshwater plants are more abundant upstream. For example, in the regularly flooded zone, smooth cordgrass is more important at higher salinities, whereas common three-square and wild rice dominate at lower salinities (Metzler and Rozsa, 1982; Barrett, 1989).

In Connecticut, two fairly well-defined types of brackish marshes have been described: (1) brackish meadows; and, (2) reed marshes (Nichols, 1920b). Brackish meadows have typically developed along the landward portion of salt marshes where ground-water discharge or surface water runoff occurs. Here the vegetation is transitional to the salt marsh with salt hay, spike grass, and black grass intermixed with plants such as salt marsh fleabane (*Pluchea purpurascens*), creeping bent (*Agrostis stolonifera*), spike-rush (*Eleocharis rostellata* and *E. parvula*), silverweed (*Potentilla anserina*), and water-pimpernel (*Samolus parviflorus*). In some areas, arrow-grass, seaside plantain (*Plantago* spp.), salt marsh sand-spurrey (*Spergularia marina*), bulrushes (*Scirpus pungens, S. americanus, S. robustus*), and seaside goldenrod are abundant.

Reed marshes, although frequently forming borders along the landward edge of salt marshes and covering large areas in marshes with tidal restriction, are best developed in the lower portions of tidal rivers and streams. Here, narrow-leaved cattail (*Typha angustifolia*) and common reed reach their maximum abundance. Along the Connecticut River much of the brackish marsh is dominated by narrow-leaved cattail with various mixtures of common reed, rose-mallow (*Hibiscus palustris*), salt marsh hemp (*Amaranthus cannabinus*), salt marsh bulrush (*Scirpus robustus*), and smooth bur-marigold (*Bidens laevis*). Zonation is clearly visible with a distinct low marsh border of smooth cordgrass and big cordgrass (*Spartina cynosuroides*), underlain by lilaeopsis (*Lilaeopsis chinensis*) on the creek's edge (Figure 22).

Reed marshes also occur on the lower Housatonic River, the lower Quinnipiac River, in coves of the Thames River, and in smaller rivers such as the East and Branford Rivers in Branford and the West River in New Haven. In the Quinnipiac River marshes extensive brackish cattail and reed marshes have developed relatively recently due

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Figure 22. Brackish tidal marsh on the lower Connecticut River. Narrow-leaved cattail predominates.

to tidal restriction by filling for railroad yards and highway construction (Smith and Jordan, 1976; Figure 23). In other marshes, Roman (1978) and Roman, *et al.* (1984) described the change from salt marsh vegetation to common reed following the restriction of tidal flow by tide gates.

Only traces of ocean-derived salts characterize the uppermost estuarine marshes. Here, the tidal marshes are flooded predominantly by fresh water, with salt water only influencing the vegetation submerged most frequently, especially during low-flow conditions in late summer. These slightly brackish, or oligohaline, marshes occur upstream of brackish tidal marshes and are mostly restricted to the lower intertidal zone. Here, the lower layer of mildly brackish water floods the marsh surface with the rise and fall of the tide. Characteristic plants include common three square, wild rice, salt marsh hemp, arrowheads (*Sagittaria subulata, S. latifolia,* and *S. rigida*), bur-marigolds (*Bidens comosa, B. laevis*), and tide-water arrow-head (*Sagittaria montevidensis*), intermixed with clumps of smooth cordgrass. The upper zones of these marshes are scarcely distinguishable from freshwater tidal marshes. At the upper limits of oligohaline influence these marshes grade imperceptibly into a strictly freshwater low marsh dominated by wild rice and pickerelweed (*Pontederia cordata*).

Riverine Wetlands

The Riverine System encompasses all of Connecticut's freshwater rivers and their tributaries, including the freshwater tidal segments of the Connecticut River (Figure 24), and other large coastal rivers where salinity is less than 0.5 parts per thousand. This system is largely dominated by deepwater habitats, with wetlands occurring between the river banks and deep water (6.6 feet and greater in depth). By definition, riverine wetlands are nonpersistent emer-

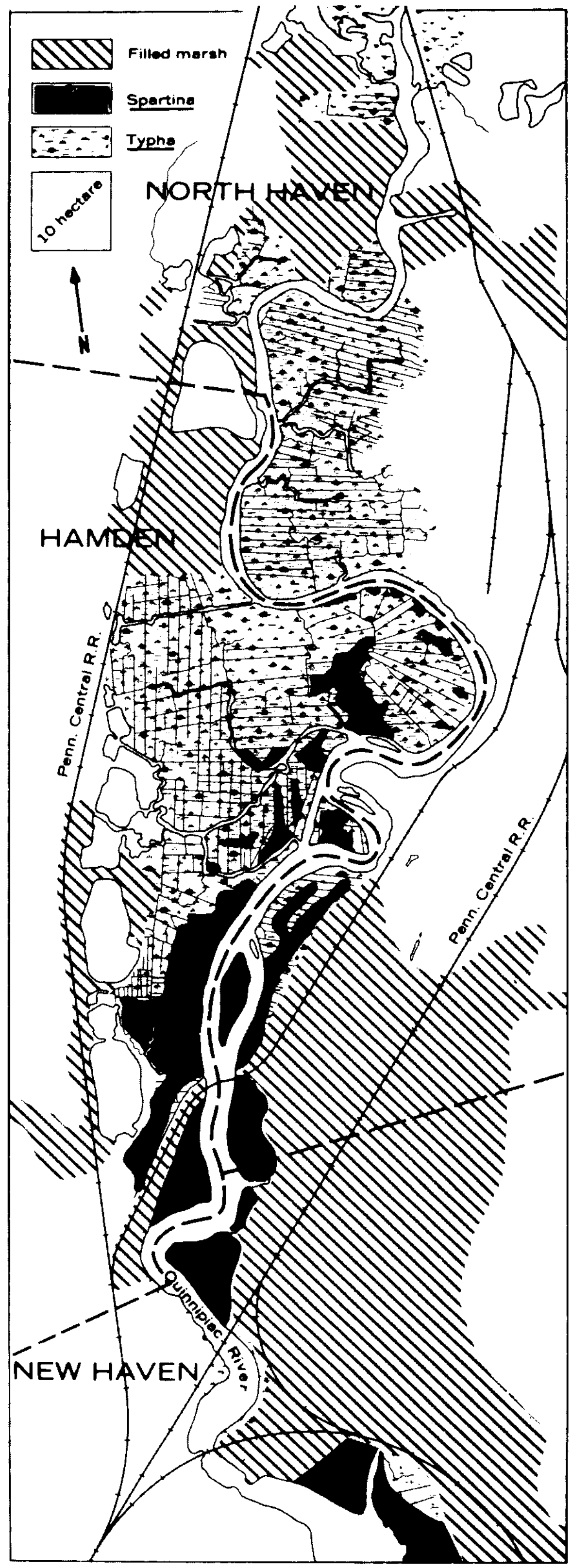

Figure 23. Map of the Quinnipiac River brackish tidal marshes (from Smith and Jordan, 1976).

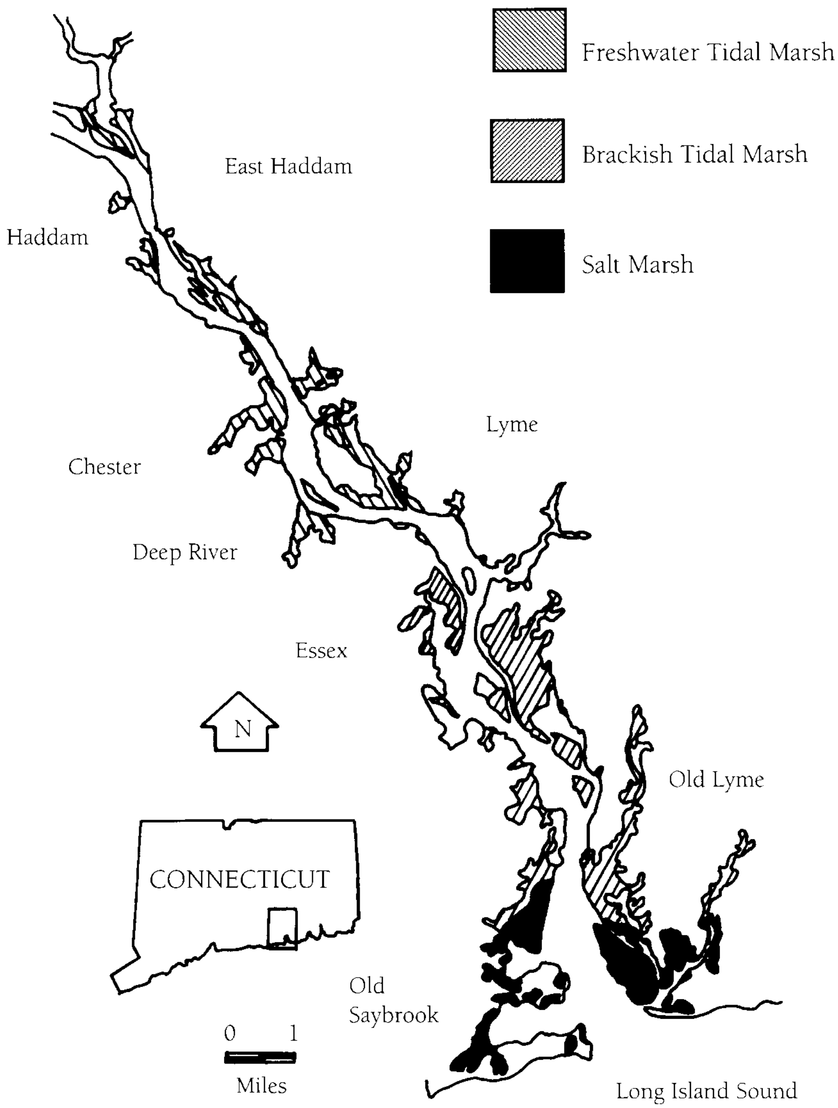

Figure 24. Distribution of the major tidal wetlands on the Connecticut River (modified from Barrett, 1989).

gent wetlands, aquatic beds, and unvegetated flats and shallow water. These wetlands are most extensive in freshwater tidal areas due to exposure of mudflats at low tide. The Connecticut River contains the bulk of the state's riverine tidal marshes. These marshes have been studied by Metzler and Rozsa (1982) and Senerchia-Nardone and Holland (1985), and Barrett (1989).

Riverine Tidal Wetlands

Freshwater tidal marshes exhibit a zonation pattern similar to their estuarine counterparts (Figure 25). Two major zones based on elevation and frequency of flooding are recognized: (1) low marsh; and, (2) high marsh. Low marsh areas are considered riverine tidal wetlands and include the upper part of intertidal mud flats. The low

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Figure 25. Freshwater tidal marsh on the lower Connecticut River.

marsh is generally flooded twice daily by the tides. High marsh areas are flooded less often and are classified as palustrine wetlands due to the predominance of persistent vegetation (Cowardin, *et al.*, 1979). The U.S. Fish and Wildlife Service has recently published a community profile on the ecology of eastern tidal freshwater marshes (Odum, *et al.*, 1984).

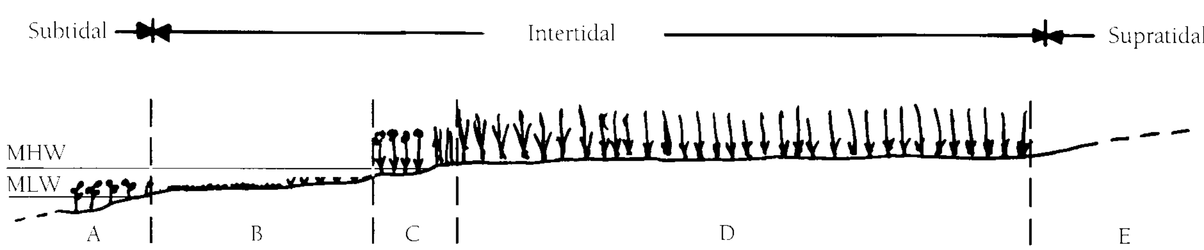
The dominant low marsh plants are nonpersistent emergents, including wild rice, pickerelweed, common three-square, soft rush, bullhead-lily (*Nuphar variegatum*) and arrow-arum (*Peltandra virginica*) intermixed with arrowheads, bur-marigolds (*Bidens laevis*, *B. comosa*, and *B. cernua*), and other low-growing species. These plants generally dominate the regularly flooded zones and intermix with persistent emergents at higher elevations to form large areas of palustrine tidal wetland (Figure 26). Wild rice is widespread in the low marsh because it can germinate under a wide range of hydrologic regimes (Whigham and Simpson, 1977). Pure and mixed stands of wild rice generally characterize the majority of riverine tidal marshes (Metzler and Rozsa, 1982), although nearly pure stands of common three-square and/or arrowheads are common along the river's edge. Major riverine tidal emergent wetland communities for the lower Connecticut River are listed in Table 17.

Vegetation is not always evident in riverine tidal marshes due to the predominance of nonpersistent emergents. By definition, these plants readily decompose after the growing season and their remains are not found standing in the marshes the following spring. These wetlands therefore appear as mudflats during low tide in the winter and early spring. During the growing season, however, the visual character of these wetlands can change dramatically. In early spring, when the river level has receded, seedlings of annual species cover the exposed muds. By late spring and early summer, broad-leaved emergents such as arrow-arum, pickerelweed, and arrowheads dominate, since their leaves are among the first to emerge. As the season progresses, wild rice overtops the other plants and becomes visually dominant, and in the late summer and early fall the yellow flowers of bur-marigold add conspicuous color to these marshes.

Riverine Nontidal Wetlands

Although a large portion of Connecticut's wetlands lie along nontidal rivers and streams, only a fraction of these are considered riverine wetlands (Cowardin, *et al.*, 1979). Riverine wetlands, by definition, largely occur as fringes of nonpersistent emergent plants growing on riverbanks or in shallow water, or as aquatic beds within the river channels. Contiguous wetlands dominated by persistent vegetation (trees, shrubs, and robust emergents) are classified as palustrine wetlands (see following section for discussion).

Nontidal riverine wetlands are most visible along slow-flowing, meandering lower perennial rivers. Nonpersistent emergent plants like bur-reeds (*Sparganium* spp.), pickerelweed, arrowheads, arrow-arum, rice cutgrass



ZONE	DESCRIPTION	SPECIES
A	Subtidal	Pondweeds, Ditchmoss, Tapegrass
B	Lower Intertidal	Arrowheads, Marsh-purslane, Bulrushes
C	Mid-tidal Marsh Border	Bulrushes, Water Hemp, Water Parsnip, Sneezeweed, Smooth Bur-marigold, Wild Rice, Pickerelweed, Arrowheads
D	High Marsh	Sweetflag, Cattail, Swamp Rose, Creeping Bent
E	Upland	Red Maple, Green Ash, Arrow-wood

Figure 26. Generalized plant zonation in a freshwater tidal wetland (modified from Metzler and Rozsa, 1982).

Table 17. Major freshwater tidal wetland communities on the lower Connecticut River (Barrett, 1989). Communities have been arranged according to ecological system. Riverine communities are flooded daily by the tides; palustrine communities are flooded less often, except permanently flooded ponds.

System	Dominance Types	Associated Vegetation	Wetland Location
Riverine	Wild Rice/Pickerelweed	Arrowheads, Common Three-square, Golden Club	Intertidal Flats
	Common Three-square	Arrowheads, Soft Rush, Water Purslane, False Pimpernel	River Shores
Palustrine	Sweet Flag/ Rice Cut-grass	River Bulrush, Spike Rush, Pickerelweed, Wildrice, Tussock Sedge, Three-way Sedge, Pickerelweed	Mid-marsh
	Arrow Arum/Cattails/ River Bulrush	Rice Cutgrass, Water Horsetail, Tussock Sedge, Common Reed	Regularly Flooded Marsh
	Common Reed	None	Regularly/Irregularly Flooded Marsh
	Sensitive Fern/ Marsh Fern	Halberd-leaved Tearthumb, Tussock Sedge, River Bulrush	Irregularly Flooded Marsh
	Common Cattail	Marsh Fern, Halberd-leaved Tearthumb, Water Horsetail, Purple Loosestrife	Irregularly Flooded Marsh
	River Bulrush	Marsh Fern, Halberd-leaved Tearthumb, Water Horsetail, Tussock Sedge, Bedstraw, Sensitive Fern	Irregularly Flooded Marsh
	Lake-bank Sedge	Sensitive Fern, Marsh Fern, Ground Nut, Halberd-leaved Tearthumb, Blujoint Grass	Creek Levees
	Arrow Arum	Rice Cutgrass, Wildrice, Sweet Flag	Back Marsh
	Sensitive Fern	False Nettle, Royal Fern	Flood Plain Border
	Speckled Alder	Silky Dogwood, Northern Arrowwood, Swamp Rose, Sensitive Fern, False Nettle, Royal Fern	Tidal Shrub Swamp

(*Leersia oryzoides*) and smartweeds (*Polygonum* spp.) colonize exposed banks or very shallow waters (Figure 27). Aquatic beds may also form in slightly deeper waters of clear rivers and streams. Important aquatic bed plants include submerged forms of bur-reeds and arrowheads, riverweeds and pondweeds (*Potamogeton* spp.), spatterdock, white water-lily (*Nymphaea odorata*), and numerous mosses. Along the Connecticut River, a zone of nonpersistent vegetation develops on low riverbanks and shores above the influence of summer river levels (Metzler and Damman, 1985). Here, annuals predominate, including barnyard grass (*Echinochloa pungens*, *E. crusgalli*), fall panicum (*Panicum dichotomiflorum*), smartweeds, bur-reeds, pony grass (*Eragrostis hypnoides*), and carpet-weed (*Mollugo verticillata*) (Figure 28).

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Figure 27. Aquatic vegetation is present in many Connecticut ponds and streams.

Metzler

Figure 28. Annual beach vegetation is formed along river channels that have large fluctuations in water level.

Palustrine Wetlands

The majority of Connecticut's wetlands, e.g., freshwater marshes, bogs, swamps, and bottomland forests, are classified as palustrine wetlands. The Palustrine System includes the most floristically diverse group of wetlands in the state. Considerable floristic changes can be observed in palustrine wetlands from northwestern Connecticut to the southeast coast due to differences in climate, hydrology, water chemistry (pH), soils, and human or natural disturbance. This collection of wetlands is subjected to a wider range of water regimes than wetlands of other systems. The more common water regimes include permanently flooded, semipermanently flooded, seasonally flooded, and temporarily flooded. Many tidally influenced freshwater areas are also considered palustrine wetlands.

Many plants in the Palustrine System may be restricted to one or two sets of hydrologic regimes, but a great many woody plants like red maple (*Acer rubrum*) and poison ivy (*Toxicodendron radicans*) tolerate a wide range of flooding and soil saturation conditions. Although their tolerances may be high, many wetland plants are usually more prevalent under particular water regimes and may, therefore, be used as reliable indicators of flooding duration and soil saturation. Examples of plant-water regime relationships are presented in Table 18.

Palustrine Aquatic Beds

Natural and man-made ponds are common throughout the state. These permanently flooded water bodies comprise the "wettest" palustrine wetlands. Many shallow ponds have aquatic beds covering all or part of their surfaces or bottoms. The aquatic beds are similar to those associated with the shallow water margins of lakes, reser-

Table 18. Examples of hydrophyte-water regime relationships in Connecticut's nontidal wetlands.

Water Regime	Scientific Name	Common Name	Plant Life Form
Permanently Flooded	*Vallisneria americana*	Tapegrass	Submergent
	Nymphaea odorata	Fragrant White Water Lily	Floating-leaved
	Lemna minor	Duckweed	Floating
	Pontederia cordata	Pickerelweed	Emergent
Semipermanently Flooded	*Sparganium americanum*	Bur-reed	Emergent
	Typha latafolia	Common Cattail	Emergent
	Decadon verticillatus	Water Willow	Shrubby Emergent
	Cephalanthus occidentalis	Buttonbush	Shrub
Seasonally Flooded	*Carex stricta*	Tussock Sedge	Emergent
	Symplocarpus foetidus	Skunk Cabbage	Emergent
	Calamagrostis canadensis	Bluejoint Grass	Emergent
	Vaccinium corymbosum	Highbush-blueberry	Shrub
	Ulmus americana	American Elm	Tree
	Fraxinus pennsylvanica	Green Ash	Tree
Temporarily Flooded	*Eupatorium* spp.	Joe-Pye-weeds	Emergent
	Solidago spp.	Goldenrods	Emergent
	Lilium canadense	Canada Lily	Emergent
	Quercus palustris	Pin Oak	Tree
	Nyssa sylvatica	Black Gum	Tree
	Carya ovata	Shagbark Hickory	Tree

voirs, and rivers. Common dominance types include floating species like duckweeds, rooted vascular plants such as bullhead-lily, white water-lily, water-shield (*Brasenia schreberi*) and pondweeds, and green algae. For additional information, refer to the discussions of Riverine and Lacustrine wetlands.

Palustrine Emergent Wetlands

Palustrine emergent wetlands are freshwater marshes and wet meadows dominated by persistent and nonpersistent grasses, rushes, sedges, and other herbaceous or grass-like plants. In general, they can be divided into two groups based on hydrology: (1) tidal emergent wetlands; and, (2) nontidal emergent wetlands. Examples of emergent nontidal wetlands are shown in Figure 29.

Palustrine Tidal Emergent Wetlands

Palustrine tidal emergent wetlands occur along the lower portions of freshwater rivers above the mean high tide mark. These wetlands fall within the Palustrine System since they have a predominance of persistent vegetation. Adjacent streamside marshes of nonpersistent emergents are, however, included in the Riverine System for classification purposes. In Connecticut freshwater tidal wetlands are most abundant along the Connecticut River. Plant diversity is greater in palustrine tidal emergent wetlands than in contiguous riverine tidal marshes. A mixed plant community usually predominates, and includes cattails, bur-marigold, water smartweed, halberd-leaved tearthumb (*Polygonum arifolium*), arrow-leaved tearthumb (*Polygonum sagittatum*), sensitive fern (*Onoclea sensibilis*), common arrowhead (*Sagittaria latifolia*), river bulrush (*Scirpus fluviatilis*), salt marsh hemp, sweet flag (*Acorus calamus*), and arrow-arum. Common reed is especially abundant in disturbed areas such as dredged material disposal sites and landfills. Other common plants which may be locally dominant are pickerelweed, rose mallow, purple loosestrife (*Lythrum salicaria*), water millet (*Echinochloa walteri*), reed canary grass (*Phalaris arundinacea*), bluejoint grass (*Calamogrostis canadensis*), soft stem bulrush, various sedges (*Carex lacustris* and *C. stricta*), and broad-leaved cattail (Barrett, 1989; Metzler

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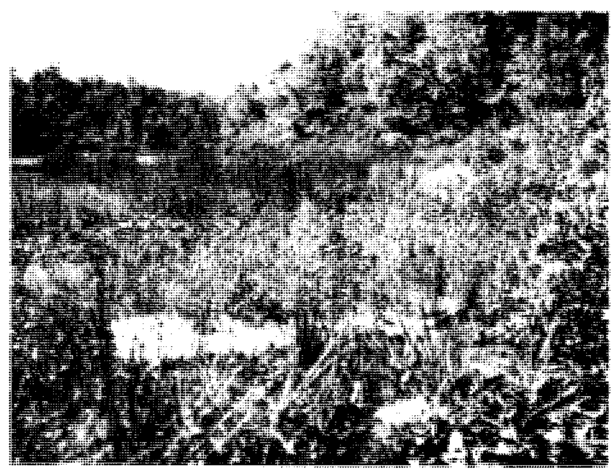

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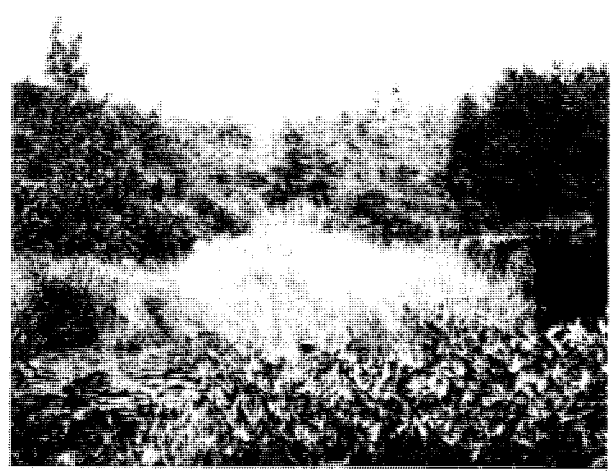

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Figure 29. Examples of palustrine emergent nontidal wetlands in Connecticut: (A) tussock sedge meadow (Hampton); (B) emergent pond shore (Salem); (C) cattail marsh (Mansfield); and, (D) emergent streambank (Voluntown).

and Rozsa, 1982; Simpson, *et al.*, 1983). In the high marsh, bullhead lily and pickerelweed are dominants in ponds and pond-like areas which may be flooded from 9 to 12 hours during each tidal cycle (Simpson *et al.*, 1983). Scattered shrubs and trees, such as buttonbush (*Cephalanthus occidentalis*), willows (*Salix* spp.), northern arrow-wood (*Viburnum recognitum*), swamp rose (*Rosa palustris*), and red maple are often associated with palustrine tidal wetlands. For additional information on the ecology of these wetlands, see Odum *et al.* (1984).

Palustrine Nontidal Emergent Wetlands

In Connecticut, many wet meadows are a product of man-induced disturbance such as mowing or grazing, while long term flooding excludes trees and other woody plants, thereby creating marshes. Natural marshes occur in semipermanently flooded shallow ponds and on the margins of shallow lakes. Here, species such as cattails, bur-reeds, and numerous rushes, sedges, and grasses persist. Table 19 presents a list of the predominant plants found in Connecticut's palustrine emergent wetlands.

Palustrine wetlands show a variety of vegetation cover types based upon hydrology, soil conditions, and disturbance history. Although most wetlands in Connecticut are affected by water seeping through acidic bedrock and soils, wetlands in parts of western Connecticut are alkaline due to the underlying carbonate bedrock (limestone). The vegetation of these calcareous wetlands is different from the majority of the wetlands in the state and will be discussed separately below.

Hydrology is the most significant factor which affects the vegetation of wetlands in Connecticut. Water willow (*Decodon verticillata*), pickerelweed, arrowheads, bur-reeds, cattails, and soft stem bulrush are common in semipermanently flooded wetlands. Seasonally flooded meadows support tussock sedge (*Carex stricta*), bluejoint grass, reed canary grass (*Phalaris arundinacea*), smartweeds, woolgrass (*Scirpus cyperinus*), and other bulrushes. Goldenrod (*Solidago* spp.) and Joe-Pye-weed (*Eupatorium* spp.) often reflect the drier situations of temporarily flooded emergent wetlands. Other plants are more widespread in their tolerance, including spotted jewelweed (*Impatiens capensis*), blue flag (*Iris versicolor*), skunk-cabbage (*Symplocarpus foetidus*), water-horehound (*Lycopus* spp.), marsh fern, crowfoot (*Ranunculus* spp.), sensitive fern (*Onoclea sensibilis*), swamp milkweed (*Asclepias incarnata*), boneset (*Eupatorium perfoliatum*), asters (*Aster novae-angliae*, *A. novi-belgii*, *A. puniceus*, *Aster* spp.), blue vervain (*Verbena hastata*), New York ironweed (*Vernonia noveboracensis*), and bog hemp (*Boehmeria cylindrica*). Shrubs may be scattered in clumps throughout marshes, but are usually found along the upland border. Highbush blackberry (*Rubus allegheniensis*) and poison ivy occur in temporarily flooded situations, while swamp rose (*Rosa palustris*), buttonbush (*Cephalanthus occidentalis*), winterberry (*Ilex verticillata*), poison sumac (*Toxicodendron vernix*), highbush-blueberry (*Vaccinium corymbosum*), alders (*Alnus* spp.), willows, and red maple (*Acer rubrum*) saplings are found in seasonally flooded marshes. More wide-ranging shrubs are meadow-sweet (*Spiraea latifolia*), steeplebush (*Spiraea tomentosa*), silky dogwood (*Cornus amomum*), and northern arrow-wood.

Emergent wetlands in the calcareous valleys in western Connecticut are quite different from marshes in the rest of the state. Alkaline waters rich in carbonates dissolved from the underlying rock create conditions that favor colonization by certain plants. Here, a number of plants adapted to the calciphilic conditions occur, including species with restricted distribution within the state and the region. In gently sloping areas with ground water seepage species such as Muhlenbergia (*Muhlenbergia glomerata*), bulrush (*Scirpus pendulus*), capillary beak-rush (*Rhynchospora capillacea*), golden sedge (*Carex aurea*), other sedges (*Carex castanea*, *C. sterilis*, *C. leptalea*), broad-leaved ladies-tresses (*Spiranthes lucida*), water-avens (*Geum rivale*), spreading globe-flower (*Trollius laxus*), and fringed gentian (*Gentiana crinata*) occur.

Table 19. Common dominance types of Connecticut's palustrine emergent wetlands.

Common Name	Scientific Name	Common Name	Scientific Name
Cattails	*Typha* spp.	Purple Loosestrite	*Lythrum salicaria*
Arrow Arum	*Peltandra virginica*	Smartweeds	*Polygonum* spp.
Tussock Sedge	*Carex stricta*	Arrowheads	*Sagitarria* spp.
Rice Cutgrass	*Leersia oryzoides*	Bulrushes	*Scirpus* spp.
Waterwillow	*Decodon verticillatus*	Goldenrod	*Solidago* spp.
Reed Canary Grass	*Phalaris arundinacea*	Three-way Sedge	*Dulichium arundinaceum*
Spike-rushes	*Eleocharis* spp.	Canada Rush	*Juncus canadensis*
Bluejoint Grass	*Calamagrostis canadensis*	Sensitive Fern	*Onoclea sensibilis*
Woolgrass	*Scirpus cyperinus*	Virginia Chain Fern	*Woodwardia virginica*
Sedges	*Carex* spp.	Bur-reeds	*Sparganium* spp.
Common Reed	*Phragmites australis*	Pickerelweed	*Pontederia cordata*
Soft Rush	*Juncus effusus*	Sweet Flag	*Acorus calamus*

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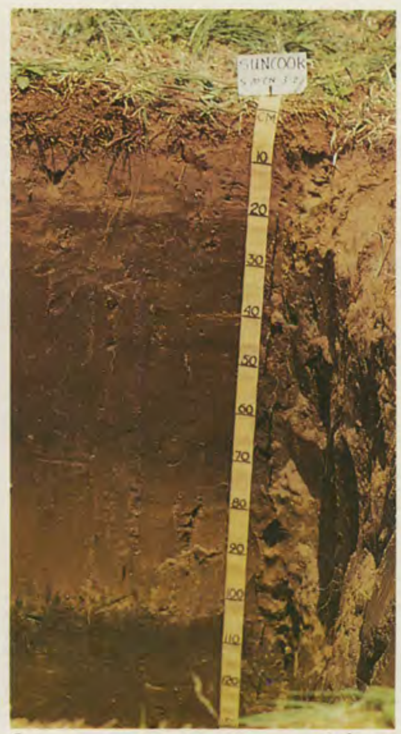


6 Roberts

Plates 1-6. Examples of five hydric soils and one nonhydric soil regulated as wetlands in Connecticut: (1) Carlisle muck; (2) Whitman fine sandy loam; (3) Ridgebury fine sandy loam; (4) Pawcatuck mucky peat; (5) Saco silt loam; and ,(6) Suncook loamy sand. Compare the very poorly drained Saco and the excessively drained Suncook soils. In spite of the sharply contrasting appearance, they are both considered wetland in Connecticut due to their location and formation on flood plains.

Metzler

Plate 7. Intertidal beach along the eastern Connecticut shore. Notice the accumulation of algae, eelgrass, and other debris at the high water mark (wrack line).

Metzler

Plate 8. Intertidal rocky shore/aquatic bed in Mystic. Rockweed is the dominant alga at this site.

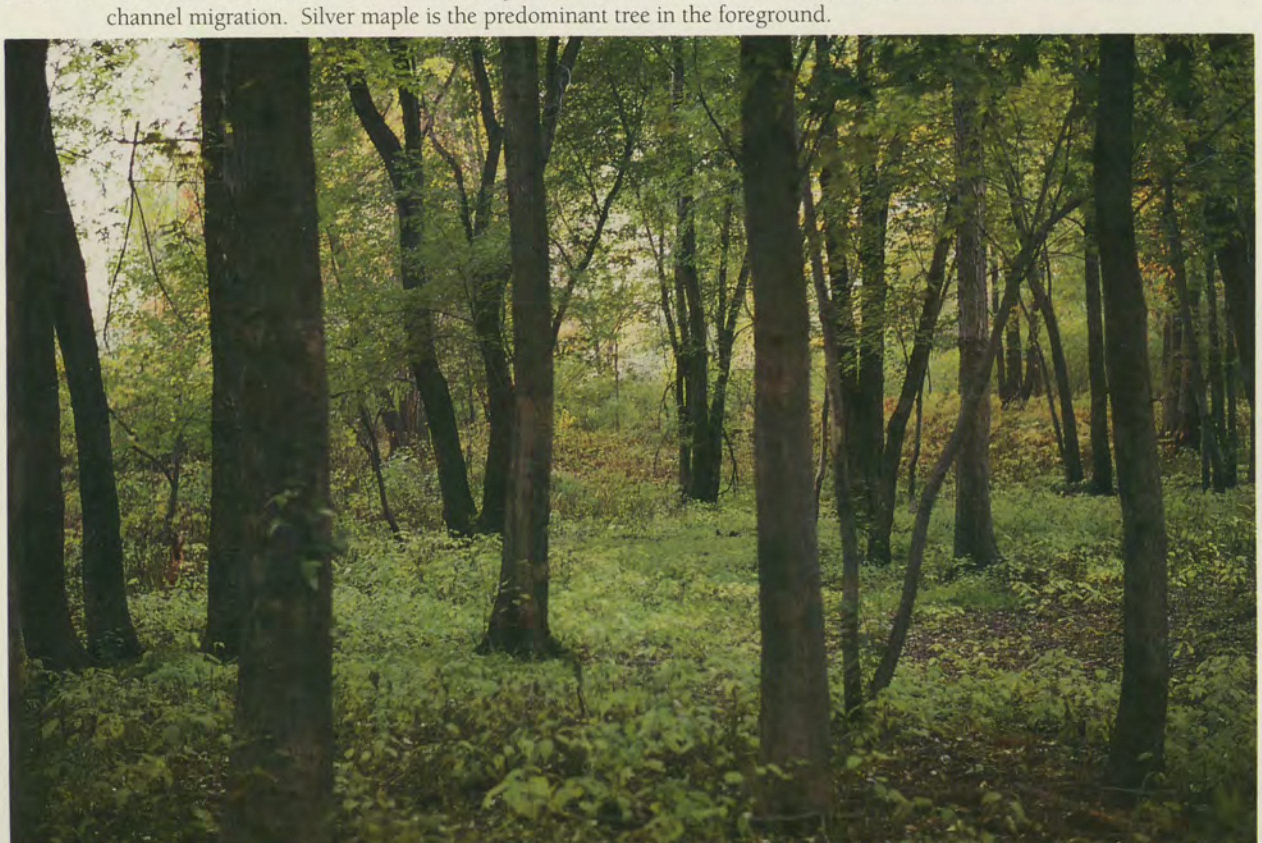
Plate 9. Intertidal flat in a cove in eastern Connecticut. This area is completely flooded during high tide and is an important feeding area for migratory shore birds and wading birds.

Metzler

Plate 10. Salt marsh on the central Connecticut shore. Note the large expanse of high marsh in the background with salt hay, spike grass, black grass, and sea lavender predominating and the mosquito ditches with smooth cordgrass in the foreground.

Metzler

Plate 11. Overview of the Connecticut River flood plain in Portland. Note the alternating pattern of ridges and swales formed by channel migration. Silver maple is the predominant tree in the foreground.



Hyde

Plate 12. Silver maple flood plain forested wetland in Windsor. Note the water line on the trees indicating the extreme fluctuation of water levels during periods of floods.

Metzler

Plate 13. Freshwater tidal emergent wetland in a small cove along the Connecticut River just south of Hartford. The Connecticut River has tidal influence to the rapids at Windsor Locks with a 0.5 foot fluctuation in Hartford during periods of low flow.

Mehrhoff

Plate 14. Red maple forested wetland in Canaan. Skunk cabbage is a conspicuous plant in the spring and early summer with only remnants found later in the year.

Metzler

Plate 15. Northern white cedar forested wetland in Canaan. Northern white cedar is an Endangered Species in Connecticut occurring only in a few calcareous wetlands in the northern marble valley in western Connecticut.

Metzler

Plate 16. A scrub-shrub wetland in Mansfield. Leatherleaf, highbush blueberry, and other ericaceous shrubs are predominated in this habitat reflecting the highly acidic nature of the water.

Metzler

Plate 17. A black spruce scrub-shrub bog in Burlington. Hare-tail, an endangered sedge, is conspicuous in the foreground. Black spruce bogs are critical habitat in Connecticut for a number of Endangered, Threatened and Special Concern plant species.

Mehrhoff

Plate 18. A beaver impounded wetland in Salisbury. Beaver impoundments create a diversity of wetland habitats including open water, emergent wetlands, and scrub-shrub wetland types.

Metzler

Plate 19. A non-persistant emergent wetland on a pond shore in Glastonbury. This particular pond has an extreme fluctuation in water level, often totally dry during the summer months.

Metzler

Plate 20. A cattail emergent wetland in Griswold during a drought year. This wetland generally has standing water throughout the year, with the soil exposed only during extreme droughts.

In more level areas, or where organic materials have accumulated, other sedges (*Carex aquatilis*, *C. lacustris*, *C. diandra*, *C. prairea*, *C. pseudo-cyperus*), hardstem bulrush (*Scirpus acutus*), cotton-grass (*Eriophorum viridi-carinatum*), grass-of-Parnassus (*Parnassia glauca*), large lady's-slipper (*Cypripedium calceolus*), showy lady's-slipper (*Cypripedium reginae*), buckbean (*Menyanthes trifoliata*), pitcher-plant (*Sarracenia purpurea*), and twig-rush (*Cladium mariscoides*) are intermixed with shrubs such as red-osier dogwood (*Cornus stolonifera*), swamp birch (*Betula pumila*), swamp buckthorn (*Rhamnus alnifolia*), hoary willow (*Salix candida*), and autumn willow (*Salix serissima*). These and other wetlands in the calcareous regions are considered critical habitats in Connecticut and inventory and conservation measures are underway.

Other emergent wetlands with a distinctive vegetation include the edges of small sandy ponds and sedge fens. Sandy pond borders contain plants such as munro-grass (*Panicum stipitatum*), umbrella sedges (*Cyperus dentatus*, *C. strigosus*), spike-rush (*Eleocharis acicularis*), rush (*Juncus brevicaudatus*), St. John's-wort (*Hypericum* spp.), and golden-pert (*Gratiola aurea*).

Sedge fens are somewhat different from sandy pond borders with sedges growing out of a saturated mat of peat mosses (*Sphagnum* ssp.). Associated plants include sedges (*Carex rostrata*, *C. stricta*, *C. lasiocarpa*) intermixed with shrubs such as highbush blueberry, swamp azalea (*Rhododendron viscosum*), leatherleaf (*Cassandra calyculata*), and buttonbush. In these wetlands, big cranberry (*Vaccinium macrocarpon*), sundew (*Drosera rotundifolia*, *D. intermedia*), and pitcher-plant are also common.

Along the coast, common reed-dominated emergent wetlands are extensive, particularly where former salt marshes were cut off from tidal influence by dikes and roadways. Many of them have evidence of relict salt marsh species such as salt marsh hay, black grass, sea myrtle, marsh orach, and switchgrass, yet strictly freshwater plants including common elderberry, red maple, willow, horsetail (*Equisetum* spp.), nightshade (*Solanum dulcamara*), poison ivy, and swamp rose may also occur.

Palustrine Scrub-Shrub Wetlands

Scrub-shrub wetlands are dominated by woody vegetation less than 20 feet (6 m) in height. Dominant shrubs in Connecticut include speckled alder (*Alnus rugosa*), smooth alder (*Alnus serrulata*), willows (*Salix* spp.), buttonbush, northern arrow-wood, meadow-sweet, steeplebush, high-bush blueberry, swamp rose, and red maple saplings. Other important shrubs include sweet pepperbush (*Clethra alnifolia*), swamp azalea, winterberry, and poison sumac. Sweet gale (*Myrica gale*) and mountain-holly (*Nemopanthus mucronata*) are locally common in the northwestern corner of the state, and red-osier dogwood, swamp birch, swamp buckthorn, and willows (*Salix serissima* and *S. candida*) are common in the limestone valleys.

Along the coast, red maple, arrow-wood and highbush blueberry are still common dominants, but other woody plants often predominate in shrub wetlands including sweet pepperbush, swamp azalea, fetter-bush (*Leucothoe racemosa*), and sapling trees of Atlantic white cedar (*Chamaecyparis thyoides*). Other shrubs of local importance are chokeberries (*Aronia* spp.), northern wild raisin (*Viburnum cassinoides*), nannyberry (*Viburnum lentago*), and smooth alder. Examples of the community structure of scrub-shrub wetlands are shown in Table 20.

The wettest shrub wetlands may be dominated by buttonbush or by leatherleaf. Buttonbush is characteristic of both semipermanent and seasonal flooding for long duration during the growing season. Buttonbush thickets occur in shallow water on the edges of lake and pond, in wet swales and oxbows on flood plains, and in permanently flooded glacial kettles and upland depressions. These wetlands are flooded for at least most of the growing season, with the water table fluctuating from 3 feet (1 m) above to just slightly below the soil surface (Messier, 1980). Associated species found here include water-pepper (*Polygonum hydropiperoides*, *P. punctatum*), water smartweed (*Polygonum amphibium*), mermaid-weed (*Proserpinaca palustris*), and the moss *Drepanocladus fluitans*.

Leatherleaf predominates in saturated, low shrub bogs throughout the state (Figure 30). Leatherleaf bogs are a complex of micro-habitats with variation in plant dominance due to changes in both microtopography and fertility (Messier, 1980). This wetland type occurs on the margins of acidic ponds or in glacial kettles and deep bedrock depressions, and is characterized by a substrate of peat mosses in various stages of decomposition. The peat surface can be quite acidic, sometimes approaching a pH of 3.8 (Messier, 1980). Characteristic plants include many with a restricted distribution within the state: bog laurel (*Kalmia polifolia*), bog rosemary (*Andromeda glaucophylla*), small cranberry (*Vaccinium oxycoccos*), black spruce (*Picea mariana*), larch, sedges (*Carex trisperma*, *C. limosa*, and *C. canescens*), tawny cotton-grass (*Eriophorum virginicum*), white beakrush (*Rhynchospora alba*), sundews, pitcher plant, and numerous peat mosses (*Sphagnum* spp.). A U.S. Fish and Wildlife Service community profile on bogs of the northeastern U.S. (Damman and French, 1987) presents a detailed account of the ecology of these wetlands and a M.S. thesis on the development of a bog in Connecticut has been prepared by Perry (1989).

Seasonally flooded shrub swamps in Connecticut have the highest diversity of hydrologic conditions and vegetation development. Although most seasonally flooded shrubs and swamps are in transition to forested wetlands

Table 20. Examples of palustrine scrub-shrub wetland communities in Connecticut.

Dominance Type (Water Regime)	Associated Vegetation		Location (County)
Buttonbush (semipermanently flooded)	Shrubs:	Red Maple, Steeplebush	Hartford
	Herbs:	Bur-reed, Tussock Sedge, Rice Cut-grass, Spike Rush, Water Hemlock, Fowl Meadow-grass, Beggers-ticks	
	Others:	Duckweed	
Highbush Blueberry/Swamp Azalea (seasonally flooded/saturated)	Shrubs:	Black Chokeberry, Winterberry Red Maple, Shadbush, Grey Birch	New Haven
	Herbs:	Skunk Cabbage, Tussock Sedge, Blue Flag, Royal Fern, Marsh Fern	
	Others:	Peat Mosses	
Red Maple (seasonally flooded/saturated)	Shrubs:	Steeplebush, Highbush Blueberry, Grey Birch, Northern Arrow-wood, Sweet Pepperbush, Swamp Azalea	Fairfield
	Herbs:	Marsh Fern, Cinnamon Fern, Tussock Sedge, Skunk Cabbage, Fowl Meadow Grass	
	Others:	Peat Moss and other Mosses	
Atlantic White Cedar (seasonally flooded/saturated)	Shrubs:	Leatherleaf, Sheep Laurel, Swamp Azelea	New Haven
	Herbs:	Virginia Chain Fern, Cinnamon Fern, Sundew	
	Others:	Peat Mosses, Liverworts	
Speckled Alder (seasonally flooded)	Shrubs:	Red Maple, Steeplebush, Maleberry, Highbush Blueberry	Windham
	Herbs:	Royal Fern, Wool-grass, Blue Flag, Marsh Fern	
Silky Willow (seasonally flooded)	Shrubs:	Buttonbush, Red-osier Dogwood, Steeplebush Swamp Rose, Other Willows	Litchfield
	Herbs:	Ditch Stonecrop, Marsh Fern, Tussock Sedge, Marsh-purslane	
Northern Arrowwood - Speckled Alder (semipermanent tidal)	Shrubs:	Swamp Rose, False Indigo, Silky Dogwood	Middlesex
	Herbs:	Bog Hemp, Sensitive Fern, Tussock Sedge, Joe-Pye-weed, Smartweed, Marsh Fern, Yellow Iris	
Black Huckleberry (saturated)	Shrubs:	Sheep Laurel, Black Spruce, Pitch Pine	Hartford
	Herbs:	Sedges, Star Flower, Sundew	
	Others:	Peat Mosses, Broom Mosses, Lichens	
Leather Leaf (saturated)	Shrubs:	Bog Laurel, Black Spruce, Sheep Laurel, Bog Rosemary	Litchfield
	Herbs:	Pitcher Plant, Sundews, Sedges	
	Others:	Peat Mosses	

Metzler

Figure 30. Leatherleaf bogs are an uncommon scrub-shrub wetland type in Connecticut.

(e.g., sapling red maple thickets), some natural thickets occur. These are mostly ericaceous shrub, alder, and willow thickets. Alder thickets include some of the driest of these, whereas willow thickets represent the wettest.

Ericaceous shrub thickets occur in shallow, undrained depressions in the uplands or along slow-moving, acidic streams where the water often stagnates and organic material accumulates (Figure 31). Often these wetlands are flooded in the spring, with the water table falling just below the soil surface during the drier summer months. The soils are saturated nearly continuously and therefore, have developed deep organic layers. In these wetlands the surface topography is often mounded and can be very irregular, with standing water between the mounds. Characteristic species include ericaceous shrubs (e.g., highbush blueberry and swamp azalea), and other shrubs such as sweet pepperbush, winterberry, and red chokeberry

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Figure 31. Highbush blueberry is abundant in Connecticut scrub-shrub wetlands.

(*Aronia arbutifolia*). Herbs such as cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), marsh fern, fowl manna-grass (*Glyceria striata*), and sedges may also be present.

Alder thickets occur on the flood plains of small streams, in depressions at the toe of slopes with substantial surface runoff, or on seepage slopes. The hydrology of these wetlands is variable, ranging from temporary to seasonally flooded or periodically saturated conditions. The water table is below the soil surface during most of the growing season, so little organic material generally accumulates. The vegetation is distinctive and includes the following: alders, northern arrow-wood, spice bush, silky dogwood with a variable herbaceous cover of sedges (*Carex bromoides*, *Carex* spp.), skunk cabbage, false hellebore (*Veratrum viride*), and asters.

Willow thickets are similar in their hydrology but can occur on wetter sites adjacent to lakes and ponds. Willow thickets are characterized by the following species: silky willow (*Salix sericea*), pussy willow (*Salix discolor*), other willows, buttonbush, silky dogwood, tussock sedge, ditch stonecrop (*Penthorum sedoides*), and others.

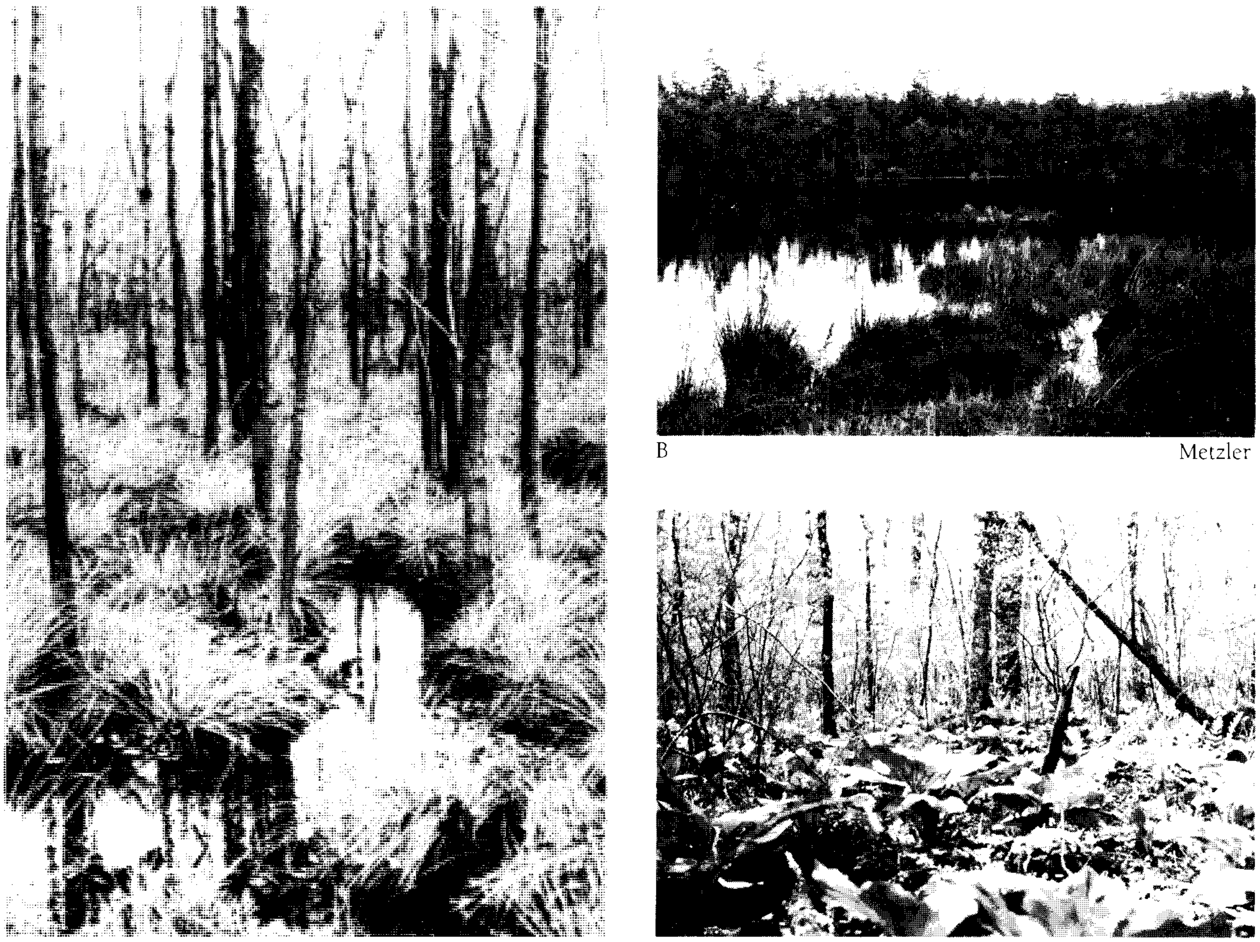
Mixed shrub communities are probably more common throughout the state than pure shrub thickets. Most shrub swamps are either mixed with trees (e.g., red maple, white pine, black gum (*Nyssa sylvatica*), Atlantic white cedar, and black spruce), or with emergent plants. One common mixed shrub/emergent wetland has been called a "tussock sedge-shrub community" (Jervis, 1963). Here sapling red maple and shrubs such as arrow-wood, meadowsweet, steeplebush and silky dogwood grow on top of the sedge tussocks. Although red maple saplings mixed with tussock sedge or bluejoint are common, the composition of these mixed wetlands can be quite variable. Tussock sedge-shrub wetlands generally occur on the edges of ponds and/or lakes with a strongly fluctuating water table or on spring-fed lower slopes where surface water is seasonally present, or in areas where drainage has been modified to create seasonally flooded conditions. In most years surface water is present between the hummocks for most of the spring, with the soil surface exposed by mid- to late-summer. Other conspicuous herbaceous plants in these wetlands include marsh bellflower (*Campanula aparinoides*), rattlesnake grass (*Glyceria canadensis*), marsh fern, and Joe-Pye-weeds (*Eupatorium* spp.).

Palustrine Forested Wetlands

Palustrine forested wetlands are the most abundant and widely distributed wetland type in the state. Most of these wetlands lie along rivers and streams and in upland depressions, while some border salt marshes in coastal areas. Forested wetlands are characterized by the presence of woody vegetation 20 feet (6 m) or taller. The floristic composition of Connecticut's forested wetlands has received little attention from botanists and ecologists, with most studies focused around specific sites (Damman and Kershner, 1977; Niering and Goodwin, 1962; Niering and Egler, 1966; Egler and Niering, 1965, 1967, 1971, 1976; Kershner, 1975), and a regional study of the wetlands of northwestern Connecticut (Messier, 1980). Figure 32 shows examples of these wetlands.

The vast majority of wooded swamps in Connecticut are deciduous forested wetlands, with evergreen forested wetlands scattered throughout the state. Red maple swamps are the predominant type, but in many instances other trees are intermixed and may appear as co-dominants. These trees include yellow birch (*Betula lutea*), American elm (*Ulmus americana*), black ash (*Fraxinus nigra*), and conifers like Eastern hemlock (*Tsuga canadensis*) and Eastern white pine (*Pinus strobus*). Although red maple dominates the majority of forested wetlands, differences in plant community structure exist between individual wetlands due to factors such as soil type, water regime, and historical land-use practices (Table 21). In most red maple forested wetlands,other trees are found in varying numbers, often near the upland transition.

A common type of red maple swamp found in Connecticut occurs along seasonally flooded drainageways or on lower slopes receiving ground-water seepage. In these areas the soils often have shallow organic layers in the



A Williams

B Metzler

C Metzler

Figure 32. Examples of palustrine forested wetlands in Connecticut: (A) red maple-tussock sedge swamp (Plymouth); (B) Atlantic white cedar swamp (Windham); and, (C) red maple-skunk cabbage swamp (Tolland).

upper horizons. During the spring and/or after heavy rains there is often surface water present, especially in small undrained pools and depressions. Red maple, yellow birch, American elm, swamp white oak (*Quercus bicolor*), and pin oak (*Quercus palustris*) are common trees, with a dense shrub understory composed almost entirely of spicebush. In the spring, a dense herbaceous layer of skunk cabbage (*Symplocarpus foetidus*) and false hellebore (*Veratrum viride*) is intermixed with marsh-marigold (*Caltha palustris*), cinnamon fern (*Osmunda cinnamomea*), sensitive fern (*Onoclea sensibilis*), and spinulose wood-fern (*Dryopteris spinulosa*). Other herbaceous plants present include jack-in-the-pulpit (*Arisaema triphyllum*), shining club-moss (*Lycopidium lucidulum*), spotted jewelweed (*Impatiens capensis*), wood reed grass (*Cinna arundinacea*), violets (*Viola cucullata*, *V. pallens*), and sedges (*Carex bromoides*, *C. intumescens*, *C. stricta*).

In areas where water stagnates and organic material accumulates, a somewhat different red maple swamp is found. Even though these areas are also seasonally flooded, ericaceous shrubs such as highbush-blueberry and swamp azalea, and other shrubs including sweet pepperbush, winterberry, and northern wild raisin form a thick shrub layer beneath the tree canopy of red maple, yellow birch, Eastern hemlock and/or Eastern white pine. In these wetlands the surface topography is often very hummocky due to blow-downs of the shallow-rooted trees, and standing water is present between the hummocks in the spring and after heavy rains. In most years, the water table remains close to the soil surface for much of the summer. The soils are either organic or mineral with considerable organic accumulations in the upper horizons. The herbaceous layer is similar to other red maple forested wetlands with turtlehead (*Chelone glabra*), water-horehound (*Lycopus virginicus*, *L. uniflorus*), marsh calla (*Calla palustris*), and dwarf raspberry (*Rubus pubescens*) commonly occurring. Mosses may be locally abundant in these wetlands, especially on the bases of hummocks and in shallow depressions. They include peat mosses, broom mosses (*Dicranum* spp.), delicate-fern moss (*Thuidium delicatulum*) and liverworts. This forested wetland type is common throughout the state in undrained basins and depressions or along slow-moving streams with seasonal flooding and saturated soil conditions.

Table 21. Examples of palustrine forested wetland communities in Connecticut.

Dominance Type (Water Regime)	Associated Vegetation		Location (County)
Red Maple - Highbush Blueberry (seasonally flooded/saturated)	Trees:	Yellow Birch, American Elm	Windham
	Shrubs:	Swamp Azalea, Northern Arrow-wood Black Chokeberry, Winterberry, Sweet Pepperbush	
	Herbs:	Skunk Cabbage, Cinnamon Fern, Royal Fern, Sedges, Marsh Fern, Marsh Violet, Jewelweed, Jack-in-the-pulpit, Goldenrod	
	Others:	Mosses	
Red Maple - Spicebush (seasonally flooded)	Trees:	American Elm, Swamp White Oak, Tulip-tree, Pin Oak, Black Gum	Hartford
	Shrubs:	Winterberry, Northern Arrow-wood	
	Herbs:	Skunk Cabbage, Jewelweed, White Avens, Wood-reedgrass, Sedges, Violets, Goldenrod	
Red Maple - Black Ash (seasonally flooded/saturated)	Trees:	American Elm, Yellow Birch, Swamp White Oak	Litchfield
	Shrubs:	Red-osier Dogwood, Spice Bush, Ironwood, Winterberry	
	Herbs:	Skunk Cabbage, Sensitive Fern, Foam Flower, Northern Swamp Buttercup, Lady Fern, Sedges, Water-avens	
Eastern Hemlock (seasonally flooded/saturated)	Trees:	Red Maple, White Pine	Litchfield
	Shrubs:	Highbush Blueberry, Winterberry, Spice Bush, Mountain Holly	
	Herbs:	Cinnamon Fern, Goldthread, Skunk Cabbage, Partrigeberry, Star Flower	
	Others:	Mosses, Liverworts	
Atlantic White Cedar (seasonally flooded/saturated)	Trees:	Red Maple, White Pine Hemlock	New London
	Shrubs:	Spice Bush, Winterberry, Mountain Laurel, Great Laurel, Sweet Pepperbush	
	Herbs:	Skunk Cabbage, Goldthread, Massachusetts Fern, Sedges, Marsh Fern, Cinnamon Fern	
	Others:	Peat Mosses, Liverworts	
Silver Maple (temporarily flooded)	Trees:	Cottonwood, Green Ash, American Elm	Hartford
	Herbs:	False Nettle, Wood Nettle, Sensitive Fern, Ostrich Fern, Poison Ivy	
Black Spruce (saturated)	Trees:	Red Maple, Eastern Hemlock Larch	Litchfield
	Shrubs:	Black Spruce, Mountain Holly, Highbush Blueberry	
	Herbs:	Cinnamon Fern, Star Flower, Pitcher Plant, Sundew, Sedges	
	Others:	Peat Mosses	

In the limestone valleys red maple swamps take on a different appearance. Black ash and American elm are more conspicuous overstory associates and, with the exception of an occasional highbush-blueberry, ericaceous shrubs are generally lacking throughout the swamp. Poison sumac (*Toxicodendron vernix*), winterberry, dogwoods (*Cornus amomum*, *C. stolonifera*), spice bush, and ironwood (*Carpinus caroliniana*) regularly occur. Skunk cabbage, false hellebore, and sensitive fern are common emergent plants, but species such as water-avens (*Geum rivale*), swamp saxifrage (*Saxifraga pensylvanica*), northern swamp-buttercup (*Ranunculus septentrionalis*), miterwort (*Mitella diphylla*), tufted loosestrife (*Lysimachia thyrsiflora*), swamp thistle (*Cirsium muticum*), and sedges (e.g., *Carex lacustris*) reflect the alkaline nature of the soils.

Other forested wetland types often border major rivers and streams, and occur on the low-lying inner flood plain behind natural levees. Micro-relief determines the duration of flooding, which in turn affects plant community composition. The lowest areas are seasonally flooded, while slightly higher levels are only temporarily flooded.

Along smaller rivers and streams a mixed community characterizes these forested wetlands. Important trees include white ash (*Fraxinus americana*), sycamore (*Platanus occidentalis*), red maple, green ash, pin oak, swamp white oak, black willow (*Salix nigra*), elms, basswood (*Tilia americana*), and ironwood. On temporarily flooded sites bitternut (*Carya cordiformis*), box elder (*Acer negundo*), sugar maple, beech, and red oak (*Quercus rubra*) also occur. On these smaller flood plains spice bush, silky dogwood, elderberry (*Sambucus canadensis*), nannyberry (*Viburnum lentago*), northern arrow-wood, and bladdernut (*Staphylea trifolia*) form a well-developed shrub layer, and cinnamon fern, skunk cabbage, violets, sensitive fern, royal fern, bog hemp (*Boehmeria cylindrica*), and other herbs occupy the forest floor. Often, lianas are predominant, including poison ivy, wild grape (*Vitis labrusca*, *V. riparia*), Virginia creeper (*Parthenocissus quinquefolia*), and Asiatic bittersweet (*Celastrus orbiculatus*). The active flood scouring on many alluvial flood plains forms a complex pattern of ridges and swales formed by lateral channel migration. In addition, where upland seepage or surface water flows onto the flood plain, alluvial wetlands can be quite similar to other wetlands.

Along larger rivers such as the Connecticut, Housatonic and Farmington, pure silver maple (*Acer saccharinum*) forests develop on the inner floodplain. Here, an extended flood duration creates a complex pattern of vegetation. Dominance of the herbaceous cover can change abruptly with seemingly small increases in elevation, and the lack of a predominant shrub layer gives a park-like appearance to the forest. Characteristic species include silver maple, cottonwood (*Populus deltoides*), black willow, poison ivy, bog hemp, wood nettle (*Laportea canadensis*), ostrich fern (*Matteuccia struthiopteris*), sensitive fern, clearweed (*Pilea pumila*), cutgrass (*Leersia virginica*), bur-cucumber (*Sicyos angulatus*), wild cucumber (*Echinocystis lobata*), dodder (*Cuscuta gronovii*), river-grape (*Vitis riparia*), and green dragon (*Arisaema dracontium*).

The vegetation of flood plains often shows a clear pattern of zonation from the riverbank to the upland border. On the Connecticut River flood plain near Hartford (Figure 33) the typical pattern of zonation from the river to the upland is as follows: (1) a narrow border of non-persistent emergent plants or beach vegetation, composed in part of grasses, sedges, and autumn annuals; (2) a narrow belt of black willow shrubs on the levee border; (3) an elevated levee dominated by cottonwood and silver maple; and, (4) an inner flood plain dominate by silver maple trees. The relationships between flooding and the vegetation patterns of the Connecticut River flood plain near Hartford are described in detail by Metzler and Damman (1985).

Evergreen forested wetlands occur throughout the state with black and red spruce (*Picea mariana* and *P. rubens*) forests in northwestern Connecticut, northern white cedar (*Thuja occidentalis*) forests in the northwestern limestone region, Atlantic white cedar swamps in southeast and south-central Connecticut, and Eastern hemlock and/or Eastern white pine swamps scattered throughout the state. In most cases, however, these forested wetlands have a mixture of conifers with hardwoods such as red maple and yellow birch. Where the evergreen canopy creates dense shade, there is a poorly developed herbaceous layer with mosses and liverworts the predominant ground cover. Many evergreen forested wetlands have numerous windthrows, creating difficult access and an extreme hummocky terrain. However, canopy openings favor the regeneration of species such as Atlantic white cedar and Eastern white pine. Common associates of evergreen forested wetlands, excluding the red and black spruce forested bogs, include gold thread (*Coptis groenlandica*), skunk cabbage, cinnamon fern, spice bush, mountain laurel (*Kalmia latifolia*), star-flower (*Trientalis borealis*), peat mosses, and the liverwort *Bazzania trilobata*.

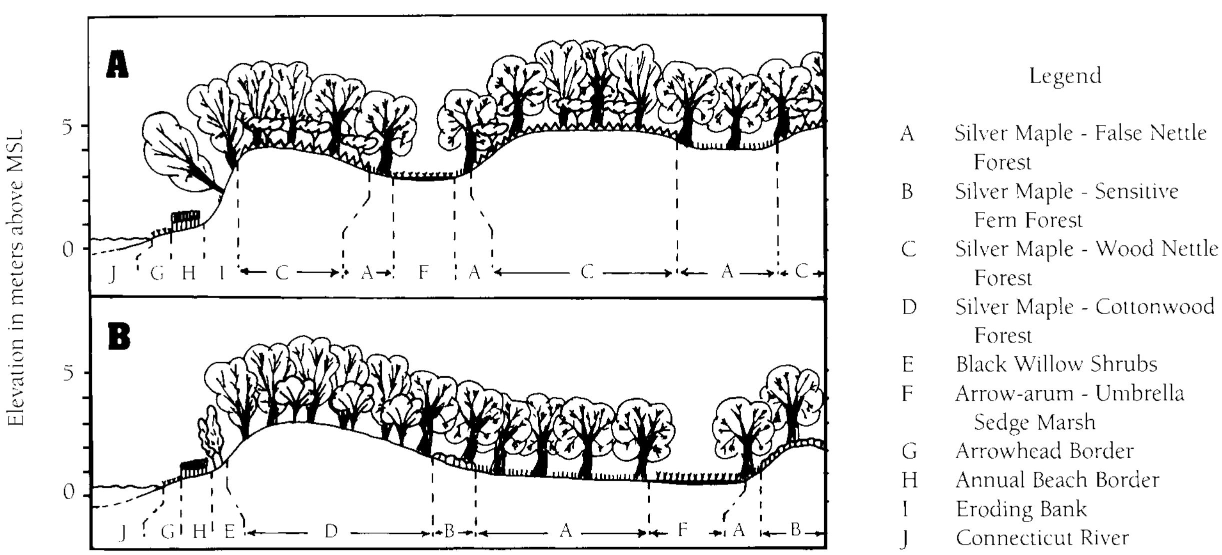


Figure 33. Pattern of vegetation on the Connecticut River flood plain for (A) a stable meander scroll; and, (B) a low levee and a part of the inner flood plain (from Metzler and Damman, 1985).

In addition to these plants, great laurel (*Rhododendron maximum*), fetter-bush (*Leucothoe racemosa*), Massachusetts fern (*Thelypteris simulata*), netted chain-fern (*Woodwardia areolata*), and the liverwort *Pallavicinia lyellii* occur in Atlantic White cedar swamps, while American hornbeam (*Carpinus caroliniana*), foam flower, miterwort, star-flowered false Solomon's seal (*Smilacina stellata*), and tufted loosestrife occur in northern white cedar swamps. Examples of Atlantic white cedar swamps include Pachaug Great Meadow in Voluntown and Chester cedar swamp in Chester, both National Natural Landmarks. A U.S. Fish and Wildlife Service community profile of Atlantic white cedar wetlands has been prepared by Laderman (1989) and several Atlantic white cedar wetlands in Connecticut have been described by Webster (1970).

Forested spruce bogs have species similar to dwarf shrub bogs, but the shrub and herbaceous cover are restricted to openings in the evergreen canopy. Species common in spruce bogs include Eastern hemlock, larch, mountain holly (*Nemopanthus mucronata*), pitcher plants, sedges (e.g., *Carex trisperma*), and numerous peat mosses (*Sphagnum* spp.). Black Spruce Bog in Mohawk State Forest has a boardwalk for access and is an excellent example of a forested bog in Connecticut.

Lacustrine Wetlands

The Lacustrine System is principally a deepwater habitat system of lakes, reservoirs, and deep ponds. Lacustrine wetlands are generally limited to shallow waters and exposed shorelines like those found in the Riverine System. While algae are probably the most abundant species in these waters, the vascular plants are usually more readily observed. A variety of life forms can be recognized, including: (1) free-floating plants; (2) rooted floating-leaved plants; (3) submergent plants; and, (4) emergent plants. The first three groups of vascular plants form aquatic beds, while the latter represents nonpersistent emergent wetlands.

Lacustrine Aquatic Beds

Floating-leaved and free-floating aquatic beds are common in lacustrine shallow waters. Dominant floating-leaved species include spatterdock, white water lily, watershield, and some pondweeds. Duckweeds (*Lemna* spp., *Spirodela polyrhiza*, *Wolffia* spp.) compose the free-floating beds. Bladderworts (*Utricularia* spp.) and hornwort (*Ceratophyllum demersum*) are also free-floating, but are typically submerged. Submergent aquatic beds are less conspicuous and include pondweeds, naiads (*Najas* spp.), tapegrass, and ditch moss (*Elodea candensis*).

Soft-water lakes with a pH between 6.8 and 7.4 may be characterized by pondweeds, naiads, tapegrass, and manna grass (*Glyceria* spp.), with bladderworts, white water lily, bullhead lily, and water milfoils (*Myriophyllum* spp.) also abundant. Aquatic bed species restricted to soft-water lakes include some pondweeds (*Potomageton spirillus*, *P. epihydrus*, *P. gramineus*), naiads (*Najas guadalupensis*), and water-crowfoot (*Ranunculus longirostris*, *R. subrigidus*).

Nonpersistent Emergent Wetlands

Emergent wetlands frequently form along the shorelines of lakes. Common nonpersistent plants include arrowheads, three-way sedge, spike rushes three-square, pipeworts (*Eriocaulon* spp.), bur-reeds, rushes, smartweeds, pickerelweed, and arrow arum. In addition, persistent plants like cattails, water willow, buttonbush, and leatherleaf may compose all or part of the lacustrine boundaries; these persistent wetlands, however, fall within the Palustrine System according to Cowardin *et al.* (1979) as discussed earlier. Along soft-water lakes and ponds the emergents consist of hard-stem bulrush, twig-rush (*Cladium mariscoides*), pickerelweed, and bur-reeds mixed with other species that are more common in more acidic waters.

Endangered and Threatened Wetland Plants

Although Connecticut is the third smallest state in the Union, it contains a remarkable diversity of landscapes and biota. Over a distance of less than 60 miles, from sea-level along the shores of Long Island Sound to the highest elevation of northwestern Connecticut (2,300 ft), there are distinct differences in topographic relief, landscapes, soils, vegetation, and associated fauna. Gradual differences in climate, such as temperature, snowfall, and the length of the frost-free season, are associated with elevation and distance from the ocean. These differences are reflected by the regional distribution of many plant and animal species, particularly those at the northern or southern limits of their range distribution. Dowhan and Craig (1976) stated that several species characteristic of the Atlantic and Gulf Coastal Plains reach their northern range limits in the southeastern corner of the state, a number of boreal species reach their southern range limit in northwestern Connecticut, some Piedmont species reach their northern range limits in southwestern Connecticut, and a number of Appalachian Mountain species are confined to the highland summits and plateaus of extreme northwestern part of the state. Connecticut, therefore, has a number of plant species limited by range or habitat as well as species considered rare, infrequent, or declining throughout their range.

Until recently Connecticut did not have an official state list of endangered and threatened species. In 1989 the State Legislature enacted legislation "Establishing a Program for the Protection of Endangered and Threatened Species." Currently, a draft list contains 135 endangered, threatened, or special concern plant species (or 27 percent of the entire plant list) that grow in wetland or aquatic habitats. Nine of these listed plant species are also currently under review by the U.S. Fish and Wildlife Service as Federally Endangered or Threatened throughout all or a significant part of their ranges (Table 22). These as well as other obligate and facultative wet wetland plants that occur in Connecticut are listed in the Appendix.

Summary

The plant composition of Connecticut's wetlands is diverse and complex. The state's geographic position, with several physiographic regions found within its borders, adds to this natural diversity. At a broad level, major differences can be seen between the estuarine wetlands where salt and brackish emergent marshes predominate, and the palustrine wetlands where forested swamps abound. Even within major wetland vegetation types of wetlands, significant differences in community structure are observed. These variations are largely due to several factors including water regime (hydrology), soil type, local geology, water chemestry, human activities (e.g., drainage, timber harvest, filling, and water pollution), and natural events like fire and beaver activity. Consequently, a wide variety of wetland plant communities exist within Connecticut and they represent an essential part of the state's landscape diversity and natural heritage.

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Table 22. List of Connecticut plants under review for federal listing as endangered or threatened species. Wetland habitats have been identified where applicable.

Scientific Name	Common Name	Occurs in Wetlands	Wetland Habitats
Asplenosorus X *ebenoides*	Scott's Spleenwort	—	N/A
Carex barrattii	Barratt's Sedge	X	peaty and sandy freshwater wetlands
Carex polymorpha	Variable Sedge	—	N/A
Cypripedium arietinum	Ram's-head Lady's-slipper	X	mossy swamps and bogs
Eriocaulon parkeri	Parker's Pipewort	X	shallow freshwater ponds and freshwater tidal flats
Helianthemum dumosum	Bushy Rock-rose	—	N/A
Hydrastis canadensis	Goldenseal	—	N/A
Isoetes eatonii	Eaton's Quillwort	X	shallow freshwater ponds and freshwater tidal flats
Isoetes foveolata	Pitted Quillwort	X	shallow freshwater ponds
Panax quinquefolius	American Ginseng	—	N/A
Platanthera flava	Southern Rein Orchid	X	freshwater wetlands
Potamogeton hillii	Hill's Pondweed	X	shallow freshwater ponds
Potamogeton lateralis	Pondweed	X	freshwater ponds
Prunus alleghaniensis	Alleghany Plum	—	N/A
Prunus maritimus var. *gravesii*	Graves Beach-plum	—	N/A
Trollius laxus ssp. *laxus*	Spreading Globeflower	X	calcareous spring fens

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CHAPTER 7.

Wetland Values

Introduction

Historically, Connecticut's wetlands have been used for hunting, trapping, fishing, native cranberry and blueberry harvest, timber and salt hay production, and livestock grazing. These uses tend to preserve wetland integrity, although the qualitative nature of wetlands may be modified, especially for salt hay and timber harvest. Human uses also include destructive, often irreversible actions such as drainage for agriculture and filling for industrial, commercial, and residential development. In the past most people considered wetlands as wastelands whose best use could only be attained through "reclamation projects." Yet, the contrary, wetlands in their natural state provide a wealth of values to society (Table 23). These benefits can be divided into three basic categories: (1) fish and wildlife values; (2) environmental quality values; and, (3) socio-economic values.

The following discussion emphasizes the more important values of Connecticut's wetlands, while mentioning some particular noteworthy national examples from Tiner (1984). For an in-depth examination of wetland values, the reader is referred to *Wetland Functions and Values: The State of Our Understanding* (Greeson, *et al.*, 1979). In addition, the U.S. Fish and Wildlife Service maintains a wetland values data base which contains abstracts of over 2,000 articles (Stuber, 1983).

Fish and Wildlife Values

Fish and other wildlife use wetlands in a variety of ways. Some species spend their entire lives in wetlands, while others use wetlands primarily for reproduction and nursery grounds. Many fish and other wildlife species frequent marshes and swamps for feeding or feed on organisms produced in wetlands. Wetlands are also essential for survival of numerous endangered animal and plant species.

Fish and Shellfish Habitat

Coastal and inland wetlands in Connecticut are important fish habitat. Approximately two-thirds of the major U.S. commercial fish species depend on estuaries and salt marshes for nursery or spawning grounds (McHugh, 1966). Among the more familiar wetland-dependent fish are menhaden, bluefish, flounder, white perch, weakfish, and striped bass. Forage fish, such as anchovy, killifish, mummichog, and Atlantic silverside, are among the most abundant estuarine fish. Striped bass migrate into Connecticut freshwaters, but there is no reliable evidence that they spawn there (Whitworth *et al.*, 1976).

Coastal wetlands are also important for shellfish such as bay scallops, blue mussels, blue crabs, oysters, and clams. A critical stage of the bay scallop's life cycle requires that larvae attach to eelgrass leaves for about a month (Davenport, 1903). Prior to World War II Long Island Sound supported a major oyster industry which produced more than 3,000 bushels annually. Blue crabs are abundant in tidal creeks of salt marshes. Estuarine aquatic beds also provide important cover for juvenile fish and other estuarine organisms.

Freshwater fish also find wetlands essential for survival. In fact, nearly all freshwater fish can be considered wetland-dependent because: (1) many species feed in wetlands or upon wetland-produced food; (2) many fish

Table 23. List of major wetland values.

Fish and Wildlife Values

- Fish and Shellfish Habitat
- Waterfowl and Other Bird Habitat
- Furbearer and Other Wildlife Habitat

Environmental Quality Values

- Water Quality Maintenance
    - Pollution Filter
    - Sediment Removal
    - Oxygen Production
    - Nutrient Recycling
    - Chemical and Nutrient Absorption
- Aquatic Productivity
- Microclimate Regulator
- World Climate (Ozone layer)

Socio-economic Values

- Flood Control
- Wave Damage Protection
- Erosion Control
- Ground-water Recharge
- Water Supply
- Timber and Other Natural Products
- Energy Source (Peat)
- Livestock Grazing
- Fishing and Shellfishing
- Hunting and Trapping
- Recreation
- Aesthetics
- Education and Scientific Research

use wetlands as nursery grounds; and, (3) almost all important recreational fish spawn in the aquatic portions of wetlands (Peters *et al.*, 1979). Chain and grass pickerel are common throughout Connecticut as are bass, crappie, bluegill, bullhead, and carp (State Board of Fisheries and Game, 1959; Whitworth, *et al.*, 1976). In fact, the use of submerged aquatic beds by pickerel, bass, bluegill, and northern pike is extensive. Alewife and blueback herring use freshwater tidal wetlands as spawning and nursery grounds (Simpson, *et al.*, 1983b). White perch occur in freshwater tidal segments of some of Connecticut's rivers and streams, with some individuals probably permanent residents (Whitworth *et al.*, 1976). The American shad spawns in the lower Housatonic River and in the Connecticut River and its tributaries. Historically, shad were abundant in many other rivers in Connecticut but habitat losses and pollution have restricted their range primarily to the Connecticut.

Waterfowl and Other Bird Habitat

In addition to providing year-round habitat for resident birds, wetlands are particularly important as breeding grounds, overwintering areas, and feeding grounds for migratory waterfowl and numerous other birds (Figure 34). Both coastal and inland wetlands are valuable bird habitats and have been recognized as such for some time (Sage and Bishop, 1913).

Salt marshes along the Atlantic coast are used for nesting by birds such as clapper rail, black duck, blue-winged teal, willet, sharp-tailed sparrow, and seaside sparrow. Smooth cordgrass marshes are principal nesting areas for the clapper rail (Widjeskog and Shoemaker, 1981). Other birds such as marsh wren, pied-billed grebe, herons, glossy ibis, and egrets also feed and nest in and adjacent to Connecticut's coastal wetlands. The U.S. Fish and Wildlife Service has identified and listed nesting colonies of coastal water birds in Connecticut and other northeastern states (Erwin and Korschgen, 1979).

Atlantic coastal marshes are important feeding areas for migrating waterfowl, raptors, shorebirds, and wading birds. Intertidal mudflats are the principal feeding grounds for migratory shorebirds, while swallows can often be seen feeding on flying insects over the marshes.

A DEP-Wildlife

B Fusco

C Fusco

D Fusco

Figure 34. Migratory birds depend on wetlands: (A) young osprey; (B) Canada gosling; (C) black duck; and (D) red winged blackbird.

Connecticut's salt marshes and adjacent bays are also prime wintering grounds for large numbers of waterfowl, with black duck, greater scaup, Canada goose, and mallard the most abundant species. It is estimated that upwards of 8,000 scaup alone overwinter in New Haven Harbor (Connecticut Department of Environmental Protection, 1979). Additional overwintering waterfowl include red-breasted merganser, common goldeneye, bufflehead, scoter, American widgeon, canvasback, oldsquaw, and mute swan, with smaller concentrations of gadwall, pintail, green-winged teal, shovelers, ruddy duck, ring-necked duck, snow goose, and Atlantic brant. Major waterfowl overwintering areas along the Connecticut coast are located in Figure 35.

Coastal beaches are also important habitat for shorebirds feeding during migration and for nesting by piping plover, least tern, and common tern. Rocky shores are used for nesting sites by double-crested cormorants and roseate terns.

Sixteen species of birds nest in Connecticut's freshwater tidal marshes, including red-winged blackbirds, marsh wrens, least bittern, American bittern, swamp sparrow, Virginia rail, mallard, and black duck (Craig, 1990). Many of these marsh nesting birds utilize nontidal wetlands as well.

Connecticut's inland wetlands are used by a variety of birds, including waterfowl, wading birds, rails, and songbirds. Among the more typical species are black duck, wood duck, mallard, green-winged teal, Canada goose, mute swan, green-backed heron, great blue heron, least bittern, American bittern, Virginia rail, sora, common moorhen, spotted sandpiper, marsh wren, red-winged blackbird, tree swallow, Acadian flycatcher, willow flycatcher, eastern kingbird, warbling vireo, swamp sparrow, and woodcock. Most of these species are associated with freshwater wetlands and waterbodies. Wood duck, Acadian flycatcher, barred owl, northern saw-whet owl, northern waterthrush, Louisiana waterthrush, Canada warbler, and white-throated sparrow nest in forested wetlands. Among the birds breeding in shrub swamps are woodcock, willow flycatcher, and common yellowthroat. In a study of eight red maple swamps in western Massachusetts, Swift (1980) found 46 breeding species. The most common included common yellowthroat, veery, Canada warbler, ovenbird, northern waterthrush, and gray catbird. Anderson and Maxfield (1962) studied birdlife in a red maple/Atlantic white cedar swamp in southeastern Massachusetts and found the same species plus ruffed grouse, hairy woodpecker, downy woodpecker, blue jay, black-capped chickadee, American robin, and common grackle.

Wetlands, therefore, are crucial for the existence of many birds, ranging from waterfowl and shorebirds to migratory songbirds. Some spend their entire lives in wetland environments, while others primarily use wetlands for seasonal breeding, feeding, or resting.

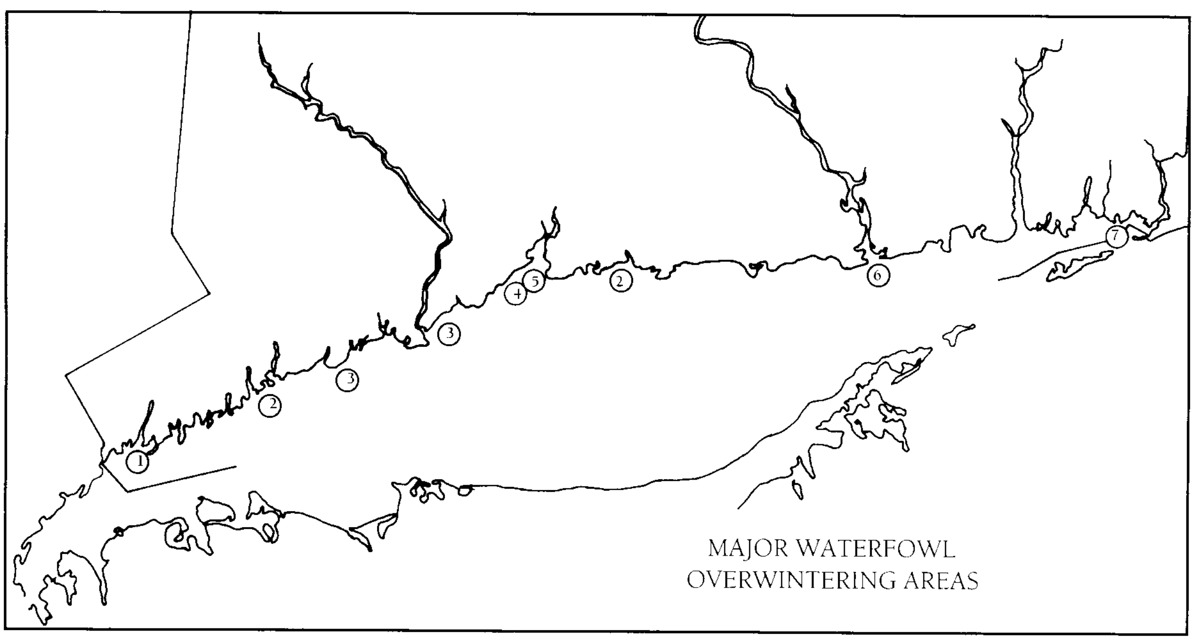


Figure 35. Major waterfowl overwintering areas along the Connecticut coast (redrawn from Connecticut DEP, 1979). 1 = scaup, black ducks, Canada geese; 2 = scaup; 3 = scaup, black ducks; 4 = scaup, canvasback, widgeon; 5 = black ducks; 6 = waterfowl in general; and, 7 = Canada geese, brant.

Furbearer and Other Wildlife Habitat

Muskrat and beaver are the most important commercial furbearers living in Connecticut wetlands. Muskrat are more abundant and wide-ranging, and inhabit both coastal and inland marshes. By contrast, beaver tend to be restricted to inland wetlands and are most abundant in Windham and Litchfield Counties. Other furbearers that use wetlands include river otter, mink, raccoon, skunk, fox, and weasel (Figure 36). Smaller mammals such as star-nosed moles, numerous mice, voles, and shrews frequent wetlands. White-tailed deer depend on white cedar swamps in southeastern Connecticut and other evergreen forested wetlands in northern Connecticut for winter shelter and food.

Besides mammals and birds, other forms of wildlife make their homes in wetlands. Reptiles (turtles and snakes) and amphibians (frogs and salamanders) are important residents in wetlands. DeGraaf and Rudis (1983) described the non-marine reptiles and amphibians of New England including their habitat and natural history. Turtles are most common in freshwater marshes and ponds. In Connecticut, eight turtles may be found: bog, common snapping, eastern box, eastern mud, eastern painted, red spotted, wood turtle, and the diamond-backed terrapin (Lamson, 1935). Of these, the eastern box and the wood turtle use wetlands only for breeding, spending much of their life in upland sites. The uncommon bog turtle depends on freshwater wetlands, especially those within the calcareous valleys of northwestern Connecticut. Along the coast the diamond-backed terrapin is a common denizen of salt marshes. In Connecticut northern water snakes are very abundant, and ribbon snakes also use wetlands with some regularity, hunting frogs, toads, and small fish along the banks of small streams.

Fusco

Figure 36. The river otter is a secretive resident of freshwater marshes.

Amphibians are also native to wetlands, with nearly all of the approximately 190 species of amphibians in North America wetland-dependent, at least for breeding (Clark, 1979). Frogs occur in most freshwater wetlands, and in Connecticut, the bull, green, leopard, pickerel, wood, gray tree, and spring peeper are the most abundant (Babbitt, 1937). Toads and many salamanders use temporary ponds or wetlands for breeding, although they may spend most of the year in uplands. Common Connecticut salamanders include the marbled salamander, the red-backed salamander, and the northern red eft; common toads include both the American and the Fowler's toad. Numbers of amphibians, even in small wetlands, can be astonishing. For example, 1,600 salamanders and 3,800 frogs and toads were found in a small pond (less than 100 feet wide) studied in Georgia (Wharton, 1978).

Endangered and Threatened Animals

Currently, the Connecticut Natural Diversity Data Base is tracking 185 animal species that are endangered, threatened, or are of special concern to the state due to their low numbers. Of this list, 49 percent (90 species) are considered wetland or water dependent for feeding, breeding, or as for fish, existence. The proposed list of wetland-dependent Endangered, Threatened, and Special Concern animals in Connecticut is summarized in Table 24. Among the wetland habitats where most of these species occur include forested wetlands, inland marshes, meadows, beaches and shores, mudflats, tidal marshes, Long Island Sound, and the fresh water of rivers, streams, lakes, and ponds.

Environmental Quality Values

Besides providing habitat for wildlife, wetlands play a less conspicuous but vital role in maintaining environmental quality. They provide a number of valuable functions, including the removal of sediments and man-made pollutants, and food production to support aquatic and other wildlife.

Water Quality Improvement

Wetlands help maintain good water quality and/or improve degraded waters in several ways: (1) nutrient removal and retention; (2) processing chemical and organic wastes; and, (3) reducing the sediment load in rivers and streams. Wetlands are particularly good water filters because they form physical buffers between land and open water. Thus, wetlands can both intercept runoff from the land before it reaches the water and help filter nutrients, wastes and sediment from flooding waters and runoff.

Clean waters are important to people as well as to aquatic life. Wetland vegetation can remove nutrients,

Table 24. Proposed Endangered, Threatened, and Special Concern animal species in Connecticut dependent on wetlands. Species of Special Concern prefaced with an asterisk(*) are considered extirpated.

Name	Common Name
Endangered	
Acipenser brevirostrum	Shortnose Sturgeon
Alasmidonta heterodon	Dwarf Wedge Mussel
Anarta lutcola	Noctuid Moth
Botaurus lentiginosus	American Bittern
Cicindela puritana	Puritan Tiger Beetle
Circus cyaneus	Northern Harrier
Cistothorus platensis	Sedge Wren
Clemmys muhlenbergii	Bog Turtle
Cryptotis parva	Least Shrew
Dermochelys coriacea	Leatherback
Dorocordulia libera	Raquet-tailed Emerald
Elimia virginica	Virginia River Snail
Falco peregrinus	Peregrine Falcon
Grammia speciosa	Bog Tiger Moth
Haliaeetus leucocephalus	Bald Eagle
Hybomitra longiglossa	Horse Fly
Lepidochelys kempii	Atlantic Ridley
Leptodea ochracea	Tidewater Mucket
Mitoura hesseli	Hessel's Hairstreak
Podilymbus podiceps	Pied-billed Grebe
Scaphiopus holbrooki	Eastern Spadefoot
Sterna dougallii	Roseate Tern
Williamsonia lintneri	Banded Bog Skimmer
Threatened	
Acipenser oxyrhynchus	Atlantic Sturgeon
Caretta caretta	Loggerhead
Casmerodius albus	Great Egret
Catoptrophorus semipalmatus	Willet
Charadrius melodus	Piping Plover
Chelonia mydas	Atlantic Green Turtle
Egretta thula	Snowy Egret
Gyrinophilus porphyriticus	Spring Salamander
Hybomitra frosti	Horse Fly
Ixobrychus exilis	Least Bittern
Laterallus jamaicensis	Black Rail
Lycaena epixanthe	Bog Copper
Papaipema appassionata	Pitcher Plant Borer
Phyllonorycter ledella	Labrador Tea Tentiform Leafminer
Plethodon glutinosus	Slimy Salamander
Sterna antillarum	Least Tern
Special Concern	
Alasmidonta varicosa	Brook Floater
Ambystoma jeffersonianum	Jefferson Salamander
Ambystoma laterale	Blue-spotted Salamander
Ammodramus caudacutus	Sharp-tailed Sparrow
Ammodramus maritimus	Seaside Sparrow
Ardea herodias	Great Blue Heron
Bembidion quadratulum	Ground Beetle
Bubulcus ibis	Cattle Egret
**Cicindela dorsalis dorsalis*	Northeastern Beach Tiger Beetle
Crangonyx abarrans	Mystic Valley Amphipod
Egretta caerulea	Little Blue Heron
Egretta tricolor	Tricolored Heron
**Eulamnidia stoningtonensis*	Clam Shrimp
Euphyes dion	Sedge Skipper
Exyra rolandiana	Noctuid Moth
**Fossaria galbana*	Lymnaeid Snail
**Fossaria rustica*	Lymnaeid Snail
Goniops chrysocoma	Horse Fly
Gyraulus circumstriatus	Aquatic Snail
Haematopus palliatus	American Oystercatcher
Halichoerus grypus	Gray Seal
Hybomitra lurida	Horse Fly
Hybomitra trepida	Horse Fly
Hybomitra typhus	Horse Fly
**Hydraecia immanis*	Hop Vine Borer Moth
Lampetra appendix	American Brook Lamprey
**Lampsilis cariosa*	Yellow Lampmussel
Leucorrhinia hudsonica	Hudsonian Whiteface
**Ligumia nasuta*	Eastern Pond Mussel
**Lithophane lemmeri*	Lemmer's Noctuid Moth
Lota lota	Burbot
Margaritifera margaritifera	Eastern Pearl Shell
**Meropleon ambifusca*	Newman's Brocade
Merycomia whitneyi	Tabanid Fly
**Numenius borealis*	Eskimo Curlew
Nyctenassa violacea	Yellow-crowned Night-heron
Nycticorax nycticorax	Black-crowned Night-heron
Pandion haliaetus	Osprey
Papaipema duovata	Goldenrod Stem Borer
**Papaipema maritima*	Borer Moth
Passerculus sandwichensis ssp. *princeps*	Ipswich Sparrow
Phocoena phocoena	Harbor Porpoise
Plegadis falcinellus	Glossy Ibis
Pomatiopsis lapidaria	Slenderwalker
Procambarus acutus	Whiteriver Crayfish
Sargus fasciatus	Soldier Fly
**Speyeria idalia*	Regal Fritillary
Stagnicola catascopium	Lymnaeid Snail
Sterna hirundo	Common Tern
**Stygobromus tenuis*	Piedmont Groundwater Amphipod
Synaptomys cooperi	Southern Bog Lemming
Tabanus fulvicallus	Horse Fly
**Valvata sincera*	Boreal Turret Snail
**Valvata tricarinata*	Turret Snail

especially nitrogen and phosphorus, from surface water runoff and help prevent eutrophication (the over-enrichment of natural waters). It is possible, however, to overload a wetland and thereby reduce its ability to perform this function. Individual wetlands have a finite capacity for natural assimilation of excess nutrients and research is needed to determine this threshold (Good, 1982).

Wetlands have been shown to be excellent removers of waste products from water. Sloey, *et al.*, (1978) summarize the value of freshwater wetlands in removing nitrogen and phosphorus from the water and address management issues. They note that some wetland plants are so efficient at this task that some municipalities employ artificial wetlands as part of their waste water treatment. For example, the Max Planck Institute of Germany has a patent to create one such system, where a bulrush (*Scirpus lacustris*) is the primary waste removal agent. Many scientists have proposed that certain types of wetlands be used to process domestic wastes, and some wetlands are already used for this purpose (Sloey, *et al.*, 1978; Carter, *et al.*, 1979; Kadlec, 1979). Perhaps the best known example of the importance of wetlands for water quality improvement is Tinicum Marsh (Grant and Patrick, 1970). Tinicum Marsh is a 512-acre freshwater tidal marsh lying just south of Philadelphia, Pennsylvania. Three sewage treatment plants currently discharge treated sewage into the marsh. On a daily basis, it was shown that this marsh removes 7.7 tons of biological oxygen demand, 4.9 tons of phosphorus, 4.3 tons of ammonia, and 138 pounds of nitrate. In addition, Tinicum Marsh adds 20 tons of oxygen to the water each day.

Wooded swamps also have the capacity for removing water pollutants. Bottomland forested wetlands along the Alcovy River in Georgia filter impurities from flooding waters. Human and chicken wastes grossly pollute the river upstream, but after passing through less than three miles of swamp, the river's water quality is significantly improved. The value of the 2,300-acre Alcovy River Swamp for water pollution control was estimated at $1 million per year (Wharton, 1970).

Wetlands also play a valuable role in reducing the turbidity of flood and runoff waters. This is especially important for aquatic life and for reducing siltation of ports, harbors, rivers and reservoirs. Removal of sediment load is also valuable because sediments often transport nutrients, pesticides, heavy metals, and other toxins which pollute our nation's waters (Boto and Patrick, 1979). Wetlands in basins should retain all of the sediment entering them (Novitski, 1978). In Wisconsin watersheds with 40 percent coverage by lakes and wetlands had 90 percent less sediment in their waters than watersheds with no lakes or wetlands (Hindall, 1975).

Creekbanks of salt marshes typically support more lush vegetation than the marsh interior. Deposition of silt is accentuated at the water-marsh interface, where vegetation slows the velocity of water, thus causing sediments to drop out of suspension. In addition to improving water quality, this process adds nutrients to the creekside marsh, leading to higher plant density and productivity (DeLaune, *et al.*, 1978).

The U.S. Army Corps of Engineers has investigated the use of marsh vegetation to lower turbidity of runoff from the disposal of dredged material and to remove contaminants. In a 50-acre dredged material disposal impoundment near Georgetown, South Carolina, after passing through about 2,000 feet of marsh vegetation, the effluent turbidity was similar to that of the adjacent river (Lee *et al.*, 1976). Wetlands have also been proven to be good filters of nutrients and heavy metal loads in dredged disposal effluents (Windom, 1977).

Recently, the ability of wetlands to retain heavy metals has been reported (Banus, *et al.*, 1974; Mudroch and Capobianco, 1978; Simpson, *et al.*, 1983c). Wetland soils have been regarded as primary sinks for heavy metals, while wetland plants may play a more limited role. Waters flowing through urban areas often have high concentrations of heavy metals such as cadmium, chromium, copper, nickel, lead, and zinc. The ability of freshwater tidal wetlands along the Delaware River in New Jersey to sequester and hold heavy metals has been documented (Good, *et al.*, 1975; Whigham and Simpson, 1976; Simpson, *et al.*, 1983a, 1983b, 1983c). Additional study is needed to better understand retention mechanisms and capacities in these and other types of wetlands.

Aquatic Productivity

Wetlands can be regarded as the farmlands of the aquatic environment where great volumes of food are produced annually; they are among the most productive ecosystems in the world, rivaling the most intensively cultivated and fertilized croplands (Figure 37). Many wetland plants are particularly efficient converters of solar energy. Through photosynthesis, plants convert sunlight into plant material or biomass and produce oxygen as a by-product. Other materials, such as organic matter, nutrients, heavy metals, and sediment are also captured by wetlands and either stored in the sediment or converted to biomass (Simpson, *et al.*, 1983a). This biomass serves as food for a multitude of animals, both aquatic and terrestrial. For example, many waterfowl depend heavily on the seeds of marsh plants, moose feed on aquatic vegetation (especially water lilies and pond lilies), and muskrat eat cattail tubers and young shoots.

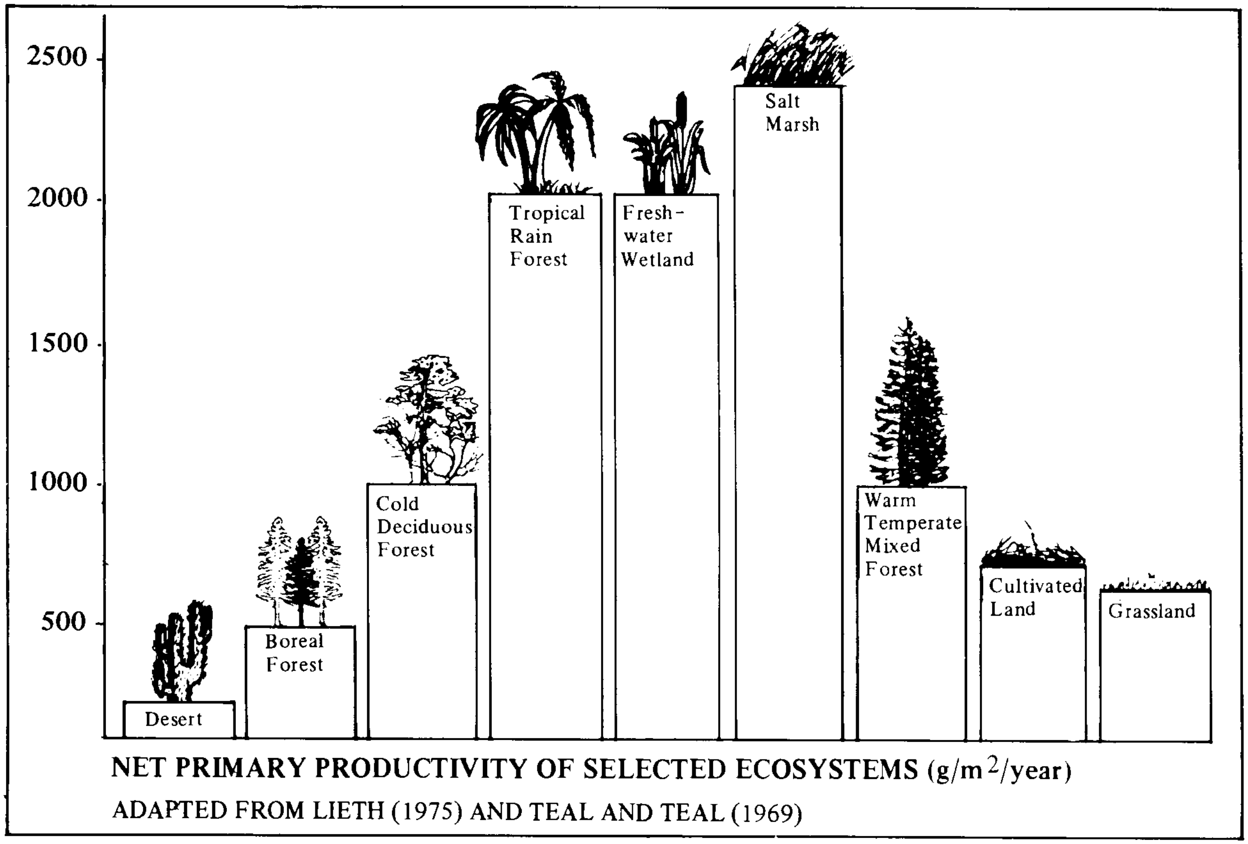


Figure 37. Relative productivity of wetland ecosystems in relation to other ecosystems (redrawn from Newton, 1981). Salt marshes and freshwater wetlands are among the most productive ecosystems.

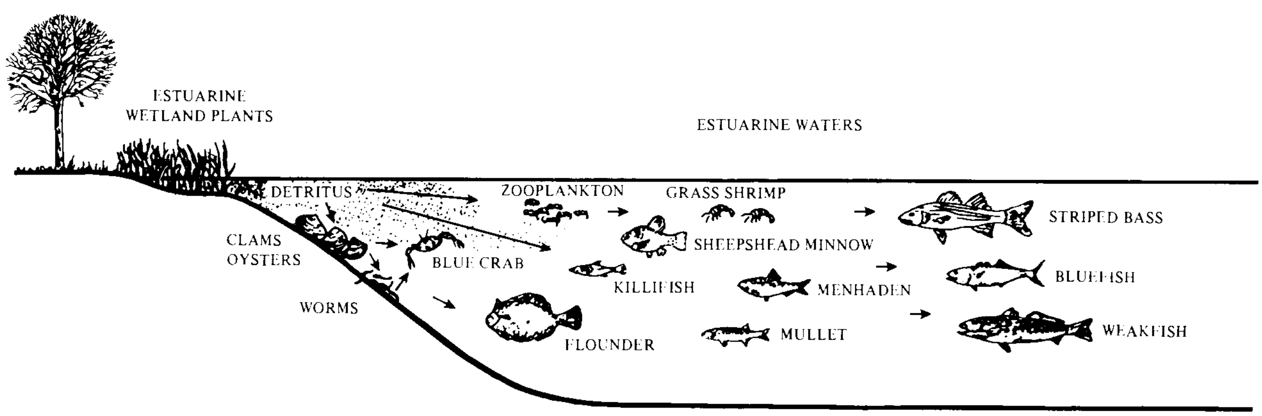


Figure 38. Simplified food pathways from estuarine wetland vegetation to commercial and recreational fishes of importance to humans.

Although direct grazing of wetland plants may be considerable in freshwater marshes, their major food value to most aquatic organisms is reached upon their death when the plants break down to form "detritus." This detritus forms the base of an aquatic food web that supports higher consumers, e.g., commercial fish species. This relationship is especially well-documented for coastal areas. Animals like zooplankton, shrimp, snails, clams, worms, killifish, and mullet eat detritus or graze upon the bacteria, fungi, diatoms, and protozoa growing on its surfaces (Crow and Macdonald, 1979; de la Cruz, 1979). Forage fishes (e.g., anchovy, smelt, killifish, and Atlantic silverside) and grass shrimp are the primary food for commercial and recreational fishes, including bluefish, flounder, weakfish, and white perch (Sugihara, *et al.*, 1979). A simplified estuarine food web for estuaries in the northeastern U.S. is presented as Figure 38. The majority of nonmarine aquatic animals also depend, either directly or indirectly, on this food source.

Socio-economic Values

The more tangible benefits of wetlands to society may be socio-economic and include flood and storm damage protection, erosion control, harvest of natural products, livestock grazing, and recreation. Since these values provide either dollar savings or financial profit, they are more easily understood by most people.

Flood and Storm Damage Protection

In their natural condition, wetlands serve to temporarily store flood waters, protecting downstream property owners from flood damage. After all, such flooding is the driving force creating these wetlands. This flood storage function also helps to slow the velocity of water and lower wave heights, thereby reducing the water's erosive potential. Rather than having all flood waters flowing rapidly downstream and destroying private property and crops, wetlands slow the flow of water, store it for sometime and slowly release the stored waters downstream (Figure 39). This becomes increasingly important in urban areas, where development has increased the rate and volume of surface water runoff and the potential for flood damage.

In 1975, 107 people were killed by flood waters in the U.S., and potential property damage for the year was estimated to be $3.4 billion (U.S. Water Resources Council, 1978). Almost half of all flood damage was suffered by farmers as crops and livestock were destroyed and productive land was covered by water or lost to erosion. Approximately 134 million acres of the conterminous U.S. have severe flooding problems. Of this, 2.8 million acres are urban land and 92.8 million acres are agricultural land (U.S. Water Resources Council, 1977). Many of these flooded farmlands are wetlands. Although regulations and ordinances required by the Federal Insurance

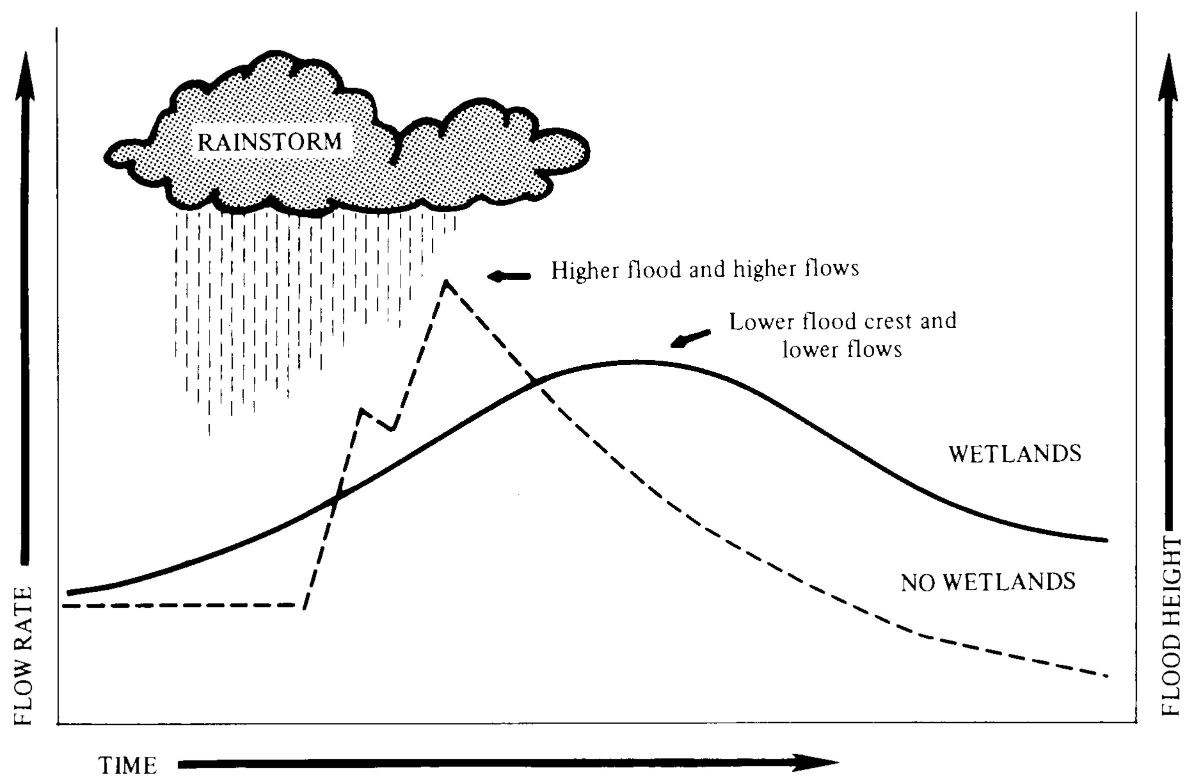


Figure 39. Wetland value in reducing flood crests and flow rates after storms (adapted from Kusler, 1983).

Administration reduce urban flood losses, agricultural losses are expected to remain at present levels or increase as more wetland is put into crop production. Protection of wetlands is, therefore, an important means to minimizing flood damages in the future.

The U.S. Army Corps of Engineers has recognized the value of wetlands for flood storage in Massachusetts. In the early 1970s, they considered various alternatives to providing flood protection in the lower Charles River watershed near Boston, including: (1) a 55,000 acre-foot reservoir; (2) extensive walls and dikes; and, (3) perpetual protection of 8,500 acres of wetland (U.S. Army Corps of Engineers, 1976). If 40 percent of the Charles River wetlands were destroyed, flood damages would increase by at least $3 million annually. Loss of all basin wetlands would cause an average annual flood damage cost of $17 million (Thibodeau and Ostro, 1981). The Corps concluded that wetlands protection - "Natural Valley Storage" - was the "least-cost" solution to future flooding problems. In 1983, they completed acquisition of approximately 8,500 acres of Charles River wetlands for flood protection.

This protective value of wetlands has also been reported for other areas. Undeveloped floodplain wetlands in New Jersey protect against flood damages (Robichaud and Buell, 1973). In the Passaic River watershed annual property losses to flooding approached $50 million in 1978 and the Corps of Engineers is considering wetland acquisition as an option to prevent flood damages from escalating (U.S. Army Corps of Engineers, 1979). A Wisconsin study projected that floods may be lowered as much as 80 percent in watersheds with many wetlands, compared with similar basins with little or no wetlands (Novitski, 1978).

Recent studies at national wildlife refuges in North Dakota and Minnesota have demonstrated the role of wetlands in reducing streamflow. Inflow into the Agassiz National Wildlife Refuge and the Thief River Wildlife Management Area was 5,000 cubic feet per second (cfs), while outflow was only 1,400 cfs. Storage capacity of those areas reduced flood peaks at Crookston, Minnesota by 1.5 feet and at Grand Forks, North Dakota by 0.5 feet (Bernot, 1979). Drainage of wetlands was the most important land-use practice causing flood problems in a North Dakota watershed (Malcolm, 1978; Malcolm, 1979). In the Devils Lake basin of North Dakota it has been shown that pothole wetlands store nearly 75 percent of the total runoff that flows into them (Ludden, *et al.*, 1983). Even northern peat bogs reduce peak rates of streamflow from snow melt and heavy summer rains (Verry and Boelter, 1979). Destruction of wetlands through flood plain development and wetland drainage have been partly responsible for recent major flood disasters throughout the country.

Besides reducing flood levels and potential damage, wetlands may buffer the land from storm wave damage. Salt marshes of smooth cordgrass are considered important shoreline stabilizers because of their wave dampening effect (Knudson, *et al.*, 1982). Forested wetlands along lakes and large rivers may function similarly.

Erosion Control

Located between watercourses and uplands, wetlands help protect uplands from erosion. Wetland vegetation can reduce shoreline erosion in several ways, including: (1) increasing durability of the sediment by binding it with roots; (2) dampening waves through friction; and, (3) reducing current velocity through friction (Dean, 1979). This process also helps reduce turbidity and thereby improves water quality.

Obviously, trees are good stabilizers of riverbanks. Their roots bind the soil, making it more resistant to erosion, while their trunks and branches slow the flow of flooding waters and dampen wave heights. The banks of some rivers have not been eroded for 100 to 200 years due to the presence of trees (Leopold and Wolman, 1957; Wolman and Leopold, 1957; Sigafoos, 1964). Among the grass and grass-like plants, common reed and bulrushes have been regarded as the best at withstanding wave and current action (Kadlec and Wentz, 1974; Seibert, 1968). While most wetland plants need calm or sheltered water for establishment, they will effectively control erosion once established (Kadlec and Wentz, 1974; Garbisch, 1977). Wetland vegetation has been successfully planted to reduce erosion along many U.S. waters. Willows, alders, ashes, cottonwoods, poplars, maples, and elms are particularly good stabilizers (Allen, 1979). Successful emergent plants include reed canary grass, common reed, cattail, and bulrushes in freshwater areas (Hoffman, 1977) and smooth cordgrass along the coast (Woodhouse, *et al.*, 1976).

Water Supply

Most wetlands are areas of ground-water discharge and some may provide sufficient quantities of water for public use. In Massachusetts, 40 to 50 percent of wetlands may be valuable potential sources of drinking water. More than 90 municipalities in Connecticut have public water supply wells in or very near wetlands (Connecticut Department of Environmental Protection, 1982). Prairie pothole wetlands store water which is important for wildlife and may be used for irrigation and livestock watering by farmers during droughts (Leitch, 1981). These situations may hold true for Connecticut and other states, and wetland protection could be instrumental in helping to solve some current and future water supply problems.

Ground-water Recharge

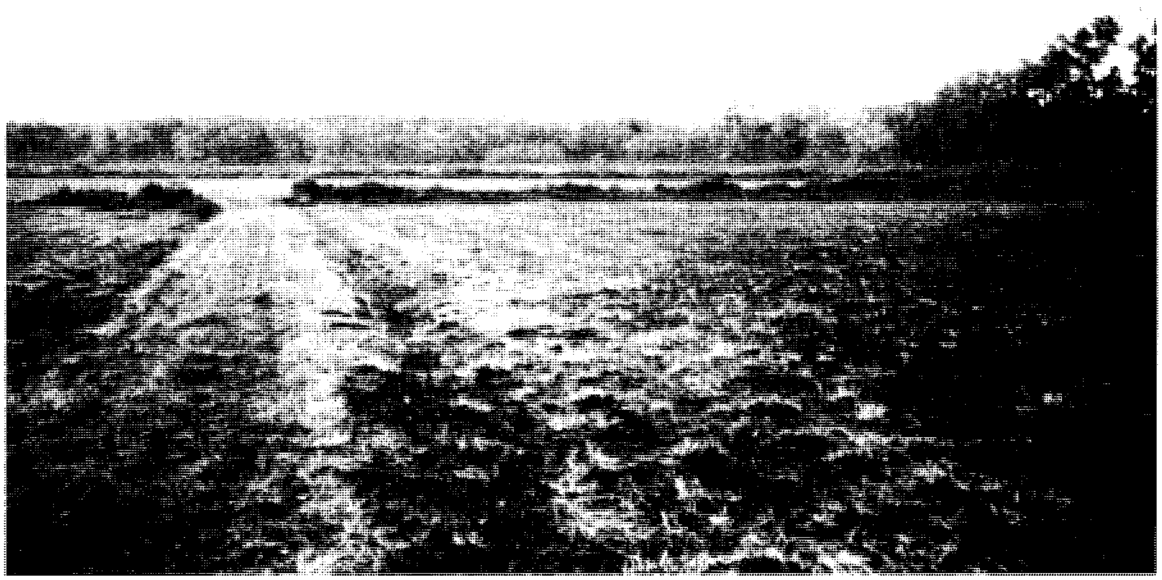
There is considerable debate over the role of wetlands in ground-water recharge, i.e., the ability to add water to the underlying aquifer or water table. Recharge potential of wetlands varies according to numerous factors, including wetland type, geographic location, season, soil type, water table location, and precipitation. Most researchers believe that wetlands do not generally serve as ground-water recharge sites (Carter, *et al.*, 1979). A few studies, however, have shown that certain wetland types may help recharge ground-water supplies. Shrub wetlands in the New Jersey Pine Barrens may contribute to ground-water recharge (Ballard, 1979). Basin wetlands like cypress domes in Florida and prairie potholes in the Dakotas may also contribute to ground-water recharge (Odum, *et al.*, 1975; Stewart and Kantrud, 1972). Flood plain wetlands also may do this through overbank water storage (Mundorff, 1950; Klopatek, 1978). In urban areas where municipal wells pump water from streams and adjacent wetlands, "induced infiltration" may draw in surface water from wetlands into public wells. This type of human-induced recharge has been observed in Burlington, Massachusetts (Mulica, 1977). These studies and others suggest that additional research is needed to better assess the role of wetlands in ground-water recharge.

Harvest of Natural Products

A variety of natural products are produced by wetlands, including timber, fish and shellfish, wildlife, peat moss, cranberries, blueberries, and wild rice. Wetland grasses are cut in many places for winter livestock feed. During other seasons, livestock graze directly in many Connecticut wetlands. Along Long Island Sound, many tidal marshes were historically important for producing salt hay, a practice still carried out in a few marshes today. Salt marsh hay is a most desirable garden mulch, since it is weed-free. These and other products are harvested for human use and provide a livelihood for many people.

In the 49 continental states there are an estimated 82 million acres of commercially forested wetlands (Johnson, 1979). These forests provide timber for such uses as homes, furniture, newspapers and firewood. Most of these forests lie east of the Rockies, where trees like oak, gum, cypress, elm, ash, and cottonwood are most important. The standing value of southern wetland forests is $8 billion. These southern forests have been harvested for over 200 years without noticeable degradation, and unless converted to other uses, can be expected to produce timber for many years to come. Undoubtedly many cords of firewood are harvested from Connecticut's wetlands each year.

Many wetland-dependent fish and wildlife species are also used by society. Commercial fishermen and trappers make a living from these resources. From 1956 to 1975, about 60 percent of the U.S. commercial fishery landings were fish and shellfish that depend on wetlands (Peters, *et al.*, 1979). Nationally, major commercial species associated with wetlands are menhaden, salmon, shrimp, blue crab, and alewife from coastal waters and catfish, carp, and buffalo from inland areas. Recreational fishing and shellfishing in Connecticut is valued annually at more than $130 million. Nationally, furs from beaver, muskrat, mink, and otter yielded roughly $35.5 million in 1976 (Demms and Pursley, 1978). Louisiana harvests more furs than any other state and nearly all furs come from wetland animals. In Connecticut where muskrat dominates the harvest, furbearers produced an annual value of $142,000 in 1978 alone.



Mehrhoff

Figure 40. Cranberry production was once a viable industry in Connecticut, currently reduced to one mostly inactive "bog" in the state.

The production and harvest of blueberries and cranberries is another commercial use of wetlands. Historically, cranberries were cultivated in Connecticut, especially in sandy wet soils near the coast, with most of the commercial production abandoned in the 1930's. Only one cranberry "bog" was in recent cultivation in Connecticut and has now been abandoned (Figure 40). Blueberry production in Connecticut has also been limited with active cultivation scattered throughout the state. Most berry harvest from wetlands, however, is limited to personal consumption.

Although not as important in Connecticut as in some other states such as New York and Michigan, some wetlands are mined for peat which is used mainly for enriching garden soils. For centuries peat has been used as a major fuel source in Europe. Recent shortages in other fuels, particularly oil and gas, have increased attention to wetlands as potential fuel sources. Unfortunately, peat mining destroys natural wetlands and most of their associated values.

Recreation and Aesthetics

Many recreational activities take place in and around wetlands. Hunting and fishing are popular sports. Waterfowl hunting is a major activity in wetlands, but big game hunting is also important locally. In 1980 5.3 million people spent $638 million on hunting waterfowl and other migratory birds (U.S. Department of the Interior and Department of Commerce, 1982). In 1987 90,626 Connecticut residents purchased hunting licenses and they spent nearly 55,000 person-days hunting wildlife generating approximately $5.2 million to the State's economy. About 13 percent of these hunters participated in waterfowl hunting, with an annual contribution of approximately $1 million. Saltwater recreational fishing has increased dramatically over the past 20 years, with one-half of the catch in wetland-associated species. In 1979, nearly 275,000 people fished in Connecticut's coastal waters. Estuarine-dependent fishes, e.g., fluke, bluefish, winter flounder, and weakfish, were the most important species caught. Moreover, nearly all freshwater fishing is dependent on wetlands. In 1975 alone, sport fishermen spent $13.1 billion to catch wetland-dependent fishes in the U.S. (Peters, *et al.*, 1979).

Other recreation in wetlands is largely non-consumptive and involves activities like hiking, nature observation, photography, and canoeing and other boating. Many people simply enjoy the beauty and sounds of nature and spend their leisure time walking or boating in or near wetlands and observing plant and animal life. This aesthetic value is extremely difficult to quantify or evaluate in dollars. It is a very important one, nonetheless, because in 1980, 28.8 million people (17 percent of the U.S. population) took special trips to observe, photograph or feed wildlife. Moreover, about 47 percent of all Americans showed an active interest in wildlife around their homes (U.S. Department of the Interior and Department of Commerce, 1982).

Summary

Marshes, swamps and other wetlands are assets to society in their natural state. They provide numerous products for human use and consumption, protect private property and provide recreational and aesthetic appreciation opportunities. Wetlands may also have other values yet unknown to society. For example, a micro-organism from the New Jersey Pine Barrens swamps has been recently discovered to have great value to the drug industry. In searching for a new source of antibiotics the Squibb Institute examined soils from around the world and found that only one contained microbes suitable for producing a new family of antibiotics. From a Pine Barrens swamp microorganism, scientists at the Squibb Institute have developed a new line of antibiotics which will be used to cure diseases not treatable with present antibiotics (Moore, 1981). This represents a significant medical discovery. If these wetlands were destroyed or grossly polluted, the discovery and its medicinal value may not have been possible.

Destruction or alteration of wetlands eliminates or minimizes their values. Drainage of wetlands, for example, eliminates all the beneficial effects of the marsh on water quality and directly contributes to flooding problems (Lee *et al.*, 1975). While the wetland landowner can derive financial profit from some of the values mentioned, the general public receives the vast majority of wetland benefits through flood and storm damage control, erosion control, water quality improvement, and fish and wildlife resources. It is in the public's best interest to protect wetlands in order to preserve these values for themselves and future generations. This is particularly important to a densely populated state like Connecticut where extensive wetland acreage has already been lost, making the remaining wetlands even more valuable as public resources.

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CHAPTER 8.

Connecticut Wetlands Trends

Introduction

Although conservation-minded government agencies, private groups, and individuals have long recognized the importance of wetlands to fish and wildlife, Connecticut's wetlands have been largely viewed as land best suited for conversion to other uses such as agriculture, landfills, industrial sites, and residential housing. Many of these consumptive uses result in physical destruction of wetlands and the losses of the environmental benefits and conservation values that they naturally provide. Other uses alter the character or quality of a wetland but do not destroy all of its natural values. For example, the diking and other restrictions of tidal flow of water into coastal marshes along Long Island Sound has disrupted their ecology and estuarine productivity, yet these wetlands still provide wildlife habitat and other functions. In addition, certain development activities may indirectly impact the functional capacity of wetland areas by various changes in drainage or nutrient input from adjacent sites. The following discussion addresses factors causing wetland change and presents an estimate of wetland alteration in Connecticut. For information on national wetland trends, the reader is referred to *Wetlands of the United States: Current Status and Recent Trends* (Tiner, 1984).

Forces Changing Wetlands

Wetlands are a dynamic environment subject to change by both natural processes and human action. These forces interact to cause both gains and losses in wetland acreage, as well as changes in the functional values of the wetland areas. In general, the overall effect in Connecticut has been a loss and degradation of wetlands. Table 25 outlines major causes of wetland loss and degradation in the state.

Table 25. Major causes of wetland loss and degradation in Connecticut (adapted from Zinn and Copeland, 1982; Gosselink and Baumann, 1980).

Human Threats

Direct:

1. Discharges of materials (e.g., pesticides, herbicides, other pollutants, nutrient loading from domestic sewage, urban runoff, agricultural runoff, and sediments from dredging and filling, agricultural and other land development) into waters and wetlands.
2. Filling for dredged spoil and other solid disposal, roads and highways, and commercial, residential, and industrial development.
3. Dredging and stream channelization for navigation channels, flood protection, coastal housing developments, and reservoir maintenance.
4. Construction of dikes, dams, levees, and seawalls for flood control, cranberry production, water supply, irrigation, and storm protection.
5. Drainage for crop production, timber production, and mosquito control.
6. Flooding wetlands for creating reservoirs and lakes.
7. Mining of wetland soils for sand, gravel, and other materials.

Indirect:

1. Sediment diversion by dams, deep channels, and other structures.
2. Hydrologic alterations by canals, spoil banks, roads, and other structures.
3. Subsidence due to extraction of ground water.

Natural Threats

1. Subsidence (including natural rise of sea level).
2. Droughts.
3. Hurricanes and other storms.
4. Erosion.
5. Biotic effects, e.g., muskrat and snow goose "eat-outs".

Natural Processes

Natural events influencing wetlands include rising sea level, coastal subsidence, natural changes in vegetation, natural sedimentation and erosion, beaver dam construction, and fire. The rise in sea level (roughly one foot per century) has the potential to both increase wetland acreage by flooding low-lying uplands and decrease wetland acreage by permanent inundation. Natural succession and fire typically change the vegetation of a wetland, usually with no net loss or gain in wetland acreage. Deposition of water-borne sediments along rivers and streams often leads to formation of new wetlands, while erosion removes wetland acreage. The activities of beaver create or alter wetlands by damming stream channels. Thus, natural forces act in a variety of ways to create, modify, or destroy wetlands.

Human Actions

Human actions have a significant impact on wetlands. Unfortunately, many human activities are destructive to natural wetlands, either by direct conversion to agricultural land or to other uses, or indirectly by degrading their quality. Key human impacts in Connecticut are caused by such factors as channelization for flood control; filling for housing, highways, industrial, and commercial development; deposition of material into sanitary landfills; dredging for navigation channels, harbors, and marinas; reservoir construction; timber harvest; groundwater extraction; and various forms of water pollution and waste disposal. A few human actions do, however, create and preserve wetlands. Construction of farm ponds and in some cases reservoirs, may increase wetland acreage, although valuable natural wetlands and their associated functional values may be destroyed in the process. Marsh creation and restoration of previously altered wetlands can also be beneficial. Federal and state fish and wildlife agencies have traditionally managed wetlands in Connecticut to improve their value to waterfowl. Wetland protection efforts, such as federal and state wetland regulatory programs, serve to help maintain and enhance our nation's wetland resources, despite mounting pressures to convert them to other uses.

Wetland Trends

Changes in Connecticut's wetlands can be generally divided into two categories: (1) quantitative changes; and, (2) qualitative changes. The former represent actual increases or decreases in the amount of wetland, while the latter relate to quality changes. Since few data exist as to the historic extent of inland wetlands in Connecticut and their losses over time, the following sections will largely address coastal marsh losses.

Quantitative Changes

While some wetlands are created by reservoir and pond construction, impoundments, and other water control projects, the net effect of these gains is minimal due to the extensive conversion of wetlands to other uses. These include cropland, residential housing, commercial and industrial development, and highways.

Drainage of wetlands for pasture or crop production has altered many of Connecticut's wetlands. Much of the agricultural activity is historic, where the land was either cleared and drained to grow grass hay, or tilled and cultivated after the spring dryout. In 1748 the Reverend Jared Elliot encouraged the drainage of Connecticut's wetlands and the use of muck as fertilizer in his Essays on Field Husbandry, and in the 1880's swamp draining was part of the curriculum at the Storrs Agricultural School. Although most of the wetland draining was restricted to small acreage on family farms, a large area of muck soil was successfully drained to commercially cultivate cabbage, celery, and onions in the town of Branford. Cranberry and blueberry production were also historically important in Connecticut; however, most of the cranberry bogs were abandoned prior to 1930 due to problems with infestations of blackheaded fireworms. Since 1960 most other agriculture in wetlands has been abandoned and these drained and other cultivated wetlands have potential for wetland rehabilitation. Many areas are already reverting naturally to woodland and whether they will become forested wetlands depends on how permanent the drainage is and what restoration efforts are required, if any.

Filling is probably the greatest threat to Connecticut's wetlands. Many municipalities have encouraged filling by zoning wetlands for residential, commercial, or industrial development. Although proposals for wetland encroachment have accelerated throughout the state, filling is not a new threat. For example, in the late 1800s, large tracts of coastal marsh in New Haven and Fairfield counties were drained and filled for industrial and residential development. Stamford, Norwalk, Fairfield, Bridgeport, Stratford, and New Haven all lost substantial tidal marsh acreage prior to the 1950s. As recently as 1956 the state of Connecticut authorized filling of tidal wetlands in Sherwood Island State Park with dredged sand and gravel to stockpile aggregate for the construction of the Connecticut Thruway and to create a parking lot (Darling, 1961). Other coastal areas with considerable industrial and commercial encroachment include tidal marshes in the Stratford Great Meadows and Great Creek Marshes in Silver Sands State Park, and tidal flats in New Haven Harbor for the construction of I-95.

Inland, the filling of wetlands has accelerated as well. It has been estimated that even with a strong inland wetland regulatory program, 1,200 to 1,500 acres of inland wetland continue to be filled each year (Council Environmental Quality, 1986). Although most inland wetland filling occurs on a small scale, the large number of minor driveway crossings and residential house encroachments permitted on an annual basis result in substantial wetland losses. In some cases large acreages of inland wetland have been filled and/or diked for industrial and commercial development, such as on the Connecticut River flood plain in Hartford and East Hartford, the East Haven Industrial Park, the Laurel Lake marshes in Manchester, and many others. In recent times the Connecticut Department of Transportation has also been responsible for filling substantial acreage of inland wetland in highway corridors including the Hockanum River flood plain in Manchester and Vernon for I-84, various wetlands between Waterbury and Winsted for Route 8, and in New Britain, Newington, and Berlin for Route 72. Significant wetland losses and/or fragmentation have been partially responsible for escalating flood damages throughout the more developed portions of Connecticut (Figure 41). With a substantial increase in development activity and land values throughout Connecticut, impacts to inland wetlands are not likely to decrease in the near future.

One mitigating factor to wetland loss along highway corridors is the creation of "artifical" wetlands as required by federal agencies for the "no net loss" policy of the Federal government. Although attempts at wetland cre-

Williams

Figure 41. Increased urban development of wetlands heightened flood damages, especially in south central Connecticut (photo circa, 1980).

ation have largely been unsuccessful, wetlands have been created as compensation for loss due to road construction along the Central Connecticut Expressway, Route 7, I-91, and other federally financed highway projects. Currently, the feasibility and success of these created wetlands and guidelines for future wetland creations is under study by a team of researchers at the University of Connecticut (Lefor, *et al.*, 1990).

Other significant adverse direct impacts on wetlands include reservoir and recreational lake construction, and channel dredging and associated material disposal. Manmade lakes, ponds, and reservoirs throughout the state have been created from wetlands and adjacent upland.

Qualitative Changes

Qualitative changes are often more subtle and more difficult to detect at first glance than the effects of filling, drainage, and impoundment. These quality-related actions include logging operations, direct (point source) discharges of industrial wastes and municipal sewage, and indirect (non-point sources) discharges such as urban and agricultural runoff.

Logging operations in forested wetlands in Connecticut may alter the character or plant composition of wetlands so used. Historically, Atlantic white cedar swamps were widespread in southeastern Connecticut but logging practices have reduced many of the cedar swamps to sparse stands. In other areas where cedar has been selectively cut, these evergreen swamps have changed to hardwood stands, mainly red maple swamps.

Water pollution and disposal of hazardous and other wastes have degraded wetlands and watercourses. Urbanization has increased sedimentation and nutrient levels in streams, thereby affecting wetlands and aquatic plants and animals as well as water quality. In numerous instances, less desirable plants, like common reed and purple loosestrife, have invaded urban wetlands replacing native species.

Coastal Wetland Losses

Coastal wetland losses were tremendous prior to the passage of the Tidal Wetlands Act of 1969, which provided strong control of the uses of tidal wetlands. Although most of the state's remaining tidal marshes are in Middlesex, New Haven, and New London counties, Fairfield County once possessed vast acreage of tidal marsh (Table 26). These wetlands were probably the first of the coastal wetlands to be filled due to their nearness to the New York City metropolitan area, their proximity to harbor waters, and the relative ease of filling them for development (Figure 42). By 1965 it has been estimated that approximately 50 percent of pre-settlement tidal wetlands had been filled or drained (Goodwin and Niering, 1966). In the 11-year period from 1954 to 1965, 2,779 acres of tidal marsh were lost, a 13 percent reduction from the 1954 acreage (Goodwin and Niering, 1966). As previously stated, during this period the largest losses occured in Fairfield County (923 acres, 45 percent) and the smallest in New London County (95 acres, 3 percent), corresponding to historic losses greatest with close proximity to New York City. Currently, the Tidal Wetlands Act of 1969 and the Coastal Area Management Act of 1979 have considerably slowed the filling and drainage of tidal wetlands, with an annual loss of less than one acre since their enactment. However, coastal intertidal flats have not received the same protection, with tens of acres still dredged each year. Although tidal wetland laws have been inacted to "protect" coastal wetlands, even stronger regulations are necessary to preserve all remaining tidal wetlands and mudflats for generations to come.

Statewide Wetland Losses

Other than for coastal marshes, reliable information on state-wide wetland losses does not exist. Although it is largely known that substantial inland wetland losses have and continue to occur, the State of Connecticut has never established a base line to which future losses can be compared. A recent U.S. Fish and Wildlife Service report to Congress on historical wetland losses in the U.S. between the 1790's and the 1980's stated that Connecticut lost 74 percent of its wetlands (Dahl, 1990). It estimated the state's original wetland base at 670,000 acres. According to the National Wetlands Inventory (NWI), the current total is about 172,500 acres. The projected loss of about 400,000 acres seems to be extraordinarily high and, in our opinion, significantly overestimates the loss. We say this for a number of reasons. First, the NWI maps usually do not show the driest wetlands, especially those on gentle slopes or in nonfloodplain positions, since they are not readily identified through aerial photo interpretation. Therefore, many acres of hydric soil series with Aeric subgroups and Aquic suborders are not delineated as wetlands on the NWI maps, even though they may actually be wetlands. This is purely a limitation of the NWI mapping technique, that is, aerial photo interpretation. The NWI maps also do not identify farmed wetlands, except cranberry bogs. In using hydric soil map unit acreages to estimate the state's original wetland acreage, there are also limitations, mainly that hydric soil map units include minor areas of nonhyric soils and dry or drained phase of hydric soils which no longer qualify as wetlands. In other words, simple comparison between acreages of wetlands on the NWI maps and acreages of hydric soil map units on soil surveys to estimate historical wetland losses has serious shortcomings. In reviewing the draft of the 1990 report on historical wetland trends, Connecticut DEP commented that the 74 percent loss figure was misleading and that a more reasonable estimate may be a 40-50 percent loss of freshwater wetlands and up to 65 percent loss of coastal wetlands (Douglas Cooper, Connecticut DEP, personal communication). We believe that statewide, Connecticut has probably lost somewhere between one third and one half of its original wetlands, with urban and coastal areas losing more wetland acreage than rural areas. This is our best guess based on existing data tempered by our observations across the state.

Table 26. Estimated tidal wetland acreage in Connecticut from 1884 to 1980. These figures are estimates and were based upon the consideration of different criteria. Currently, the estimate including all tidal wetlands is 17,500 acres (R. Rozsa, Connecticut Office of Long Island Sound Programs, personal communication).

Date	Acreage	Source
1884	22,264	Shaler (1886)
1914	23,360	Goodwin and Niering (1966)
1925	17,636	Britton (1926)
1953	17,018	Fish and Wildlife Service (1954)
1959	15,927	Fish and Wildlife Service (1959)
1964	14,839	Fish and Wildlife Service (1965)
1972	13,318	Fish and Wildlife Service (1972)
1980	12,070	This Report

Recently the U.S. Fish and Wildlife Service conducted a wetland trend analysis study in central Connecticut using aerial photo intrepretation and selected field study (Tiner, *et al.*, 1989). This study compared the 1980 NWI results with wetlands delineated on 1985/86 aerial photographs, with the major purpose to document wetland changes in central Connecticut since Section 404 of the Clean Water Act came into full effect. Although the 1989 study covered only a small portion of Connecticut, it provides the data upon which future comparisons can be made; Table 27 summarizes some of the 1989 findings. Losses between 1980 and 1985/86 included 117 acres of vegetated wetlands which were converted to nonwetland and 28 acres which were made into ponds. In the study area commercial development and highway/road construction were the most significant causes of wetland loss with substantial changes due to golf courses, home construction, and wetland drainage as well. Pond acreage, however, declined by 24 acres due to sedimentation and,

Table 27. Losses of vegetated wetlands in central Connecticut between 1980 and 1985/86 (Tiner *et al.*, 1989).

Wetland Type	Cause of Loss	Acres Lost	Wetland Type	Cause of Loss	Acres Lost
Palustrine Emergent Wetlands	Pond Construction	15	Palustrine Scrub-Shrub Wetlands	Commercial Development	12
	Highways/Roads	11		Recreational Facilities	5
	Drainage by Ditching	10		Drainage by Opening Condemned Dams	3
	Housing	7		Drainage by Ditching	3
	Unknown	6		Mining	3
	Drainage by Opening Condemned Dams	5		Highways	2
	Mining	4		Pond Construction	2
	Agriculture	1		Industrial Development	2
	Subtotal	59		Subtotal	32
Palustrine Forested Wetlands	Recreational Facilities	11	Estuarine Emergent Wetlands	Housing	1
	Pond Construction	11			
	Commercial Development	9			
	Housing	7			
	Highways/Roads	7	Total		145
	Unknown	4			
	Other	4			
	Subtotal	53			

Mehrhoff

Figure 42. Prior to the 1970's, many estuarine wetlands were filled for residential and commercial development.

presumably, a conversion to emergent and scrub-shrub wetlands.

Future Outlook

While substantial wetland losses have occurred, wetlands remain abundant in the more rural parts of Connecticut. This may be related to the fact that population growth has focused primarily in Hartford, Fairfield, and New Haven Counties. This growth pattern has left wetlands in other parts of the state in a relatively undisturbed state.

There is no reason to believe, however, that the filling and other encroachment on inland wetlands will not continue at its present rate. If the estimate of 1,200 to 1,500 acres per year of wetland encroachment in Connecticut is correct, this represents a 3 to 5 percent loss each year. At this rate most inland wetlands in Connecticut will be negatively impacted within the next 25 years.

Five programs have been enacted by federal and state governments which can slow this degradation:

1) The identification of wetlands of critical concern.;
2) The more active role of the federal government in wetland and water quality protection.;
3) Recent state legislative amendments which furthur strengthen Connecticut's comprehensive freshwater wetlands laws;
4) The more active role of the Connecticut DEP in supporting town wetland protection efforts;
5) Land acquisition efforts of the DEP and private conservation groups.

These programs are discussed in more detail in the following chapter.

It is likely that water quality problems will continue to affect the state's remaining wetlands. Although control of point sources of water pollution, such as industrial effluents and municipal wastewater treatment plants, is improving the quality of many of Connecticut's watercourses, urban and agricultural runoff continues to degrade water quality. Soil erosion from upland development causes sedimentation and water quality problems for streams and adjacent wetlands (Figure 43), a problem which could be mitigated by establishing a buffer zone

DEP-Inland Water Resources

Figure 43. Many freshwater wetlands remain vulnerable to development pressures.

around wetlands and implementing specific erosion control measures on active construction sites. In the New Jersey Pinelands, Roman and Good (1983) have proposed a buffer zone delineation model to accomplish this and the buffer zone concept has been incorporated into New Jersey freshwater wetlands protection legislation. The future of Connecticut's remaining wetlands could be substantially improved by the establishment of a similar buffer zone.

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CHAPTER 9.

Wetland Protection

Introduction

A variety of techniques are available to protect our remaining wetlands, including strict implementation of land-use regulations, direct acquisition, conservation easements, tax incentives, and public education. Kusler (1983) describes these techniques in great detail in *Our National Wetland Heritage - A Protection Guidebook*. Opportunities also exist for private initiatives by individual landowners, groups, and corporations to help in conserving wetlands. Private options for land preservation are reviewed by Rusmore *et al.*, (1982).

Wetland Regulations

Several federal and state laws regulate certain uses of many Connecticut wetlands. The more significant ones include the River and Harbor Act of 1899 and the Clean Water Act of 1977 at the federal level, and the state Tidal Wetlands Act of 1969, the Inland Wetlands and Watercourses Act of 1972, and the Coastal Management Act of 1979. Also, the placement of structures along rivers and streams, and the erection of structures and placement of fill in tidal, coastal, and navigable waters, have been regulated since 1963. In addition, Executive order 11990 - "Protection of Wetlands" - requires federal agencies to develop guidelines to minimize destruction and degradation of wetlands and to preserve and enhance wetland values. Key points of these and other laws are outlined in Table 28.

The foundations of federal wetland regulation are Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Enacted in 1972 as part of the Federal Water Pollution Control Act and amended during reauthorization of the Clean Water Act of 1977, Section 404 regulates the discharge of dredged or fill material into the waters of the United States, including wetlands. The goal of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters." The Section 404 program helps achieve these goals by preventing significant or unnecessary losses of wetlands and other sensitive aquatic areas. By the late 1970s and early 1980s, several important court decisions and an improved understanding of wetland values mandated an enhanced role for Section 404 in wetland protection.

Many construction activities in the waters of the United States involve some discharge of dredged or fill material and thus require a Section 404 permit. Construction of marinas, highways, residential and industrial developments, dams and bulkheads, and stream relocations fall under the purview of the program. "Waters of the United States" reach to the farthest extent permissible under the Commerce Clause of the Constitution and includes rivers, lakes, streams, ponds, and wetlands (e.g., swamps, marshes, sloughs, bogs, and fens).

Section 404 regulates the discharge of dredged or fill material from a point source into waters of the United States. Therefore, three main elements must be present to establish Section 404 jurisdiction: (1) the activity in question must involve a discharge of dredged or fill material; (2) the discharge must be from a point source; and, (3) this discharge must occur in waters of the United States. In many cases determining jurisdiction is straightforward, but in some circumstances, difficulties in delineating the limit of waters of the U.S, or uncertainty about whether a particular activity involves a discharge of dredged or fill material, complicate the task.

The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps) share program responsibilities under Section 404. The Corps administers the program on a day-to-day basis and issues or denies permits. EPA developed the Section 404(b)(1) guidelines, in conjunction with the Corps. These regulations must be applied by the Corps in evaluating permit applications. In addition, the Corps has its own permit regulations which are used to review projects. Furthermore, EPA has authority under Section 404(c) to "veto" Corps-issued permits based on a determination of "unacceptable adverse impacts" to certain environmental resources. Congress also assigned EPA the responsibility for approving assumption of the program by qualified states. Both EPA and the Corps have authority to enforce against unauthorized discharges and violations of permit conditions.

Section 404 contains certain limited exemptions. The CWA exempts normal farming, ranching, and silvicultural activities that are part of an established operation from the requirement to obtain a Section 404 permit, as long as they do not bring wetlands into a new use where the flow of the water would be impaired or the reach reduced. Congress exempted normal ongoing agricultural and silvicultural activities such as plowing and harvesting of crops or timber, and certain types of maintenance activities. However, Congress was careful not to exempt discharges associated with activities causing major disruptions of wetlands or other aquatic resources (e.g., clearing, diking, and leveling a forested wetland for cranberry production).

Section 404(f)(2) provides that "any discharge incidential" to one of the activities listed in Section 404(f)(1) that results in a change in use of the waters of the United States, and which impairs the flow or reduces the reach of waters of the United States requires a permit. Thus, discharges from activities exempted by Section 404(f)(1) can be "recaptured" by Section 404(f)(2) and become subject to permit requirements.

Over the last several years the federal agencies and courts have narrowly construed the Section 404(f)(1) exemption. In several recent cases the courts found that the farming activities either were not part of an established operation or that they were a new use that "reduced the reach of the wetlands" in question. As a result the activiites either were found to be not exempt under Section 404(f)(1) or they were "recaptured" by Section 404(f)(2) and required Section 404 permits.

The Corps of Engineers issues either individual or general permits. Individual permits are processed upon receipt of a complete permit application and are subject to public notice and comments on the proposed work. A number of boilerplate conditions normally apply to all permits. Special conditions may also be included for a specific activity. Nationwide, general permits are granted for a number of activities that the Corps believes have minimal individual and cumulative adverse environmental effects. The District or Division Engineer of the Corps may also issue general permits called "regional permits" within a particular geographic area. This region may encompass a watershed drainage area, a state, or an entire Corps Division. Regional permits may be conditioned to require a case-by-case reporting and acknowledgment system. For Connecticut, a state program general permit is currently in effect with information available from the New England District of the Corps in Waltham, Massachusetts.

The U.S. Fish and Wildlife Service (FWS), the National Marine Fisheries Service (NMFS), and the leading state agency responsible for fish and wildlife resources play important roles in the Section 404 process. The Fish and Wildlife Coordination Act requires that the Corps consults with these agencies whenever an applicant seeks a Section 404 permit. In reviewing Section 404 permits these agencies recommend measures to protect fish and wildlife resources. In addition to implementing their own programs, states have the authority through Section 401 of the Clean Water Act to issue, condition, waive or deny water quality certification for federal permits and licenses. No Section 404 permit may be issued unless the state grants or waives Section 401 certification. Any conditions which the state makes as part of a Section 401 certification must be included in the Section 404 permit. State involvement in the permit program, however, goes beyond Section 401. For example, the Fish and Wildlife Coordination Act requires that the Corps consults with state fish and wildlife departments, as well as FWS and NMFS. The Corps must give "full consideration" to the views of states and minimizing potential project-related impacts to fish and wildlife resources. In addition, the Coastal Zone Management Act requires that the Corps receives a consistency determination from the state coastal zone management program before issuing some permits.

Currently, the Section 404 Regulatory Program in Connecticut is more active and controversial than before. Although there is still interest in the regulation of coastal development and harbor management planning, greater emphasis is now placed on inland wetland development. Unless an applicant is certain that the proposed wetland activity qualifies for a "nationwide permit", the Corps requires a review of all applications in Connecticut, as well as a Section 404 permit for the proposed activity. In addition, the Corps may require or propose alternative use and/or compensation for certain projects. Presently the EPA is conducting "Advanced Identification of Sites" in certain parts of New England to determine guideline standards for wetlands of concern. These changes, coupled with a more active interagency review, have strengthened federal regulation over Connecticut's wetlands.

State laws have generally worked well to protect wetlands in certain areas of the state, especially in tidal waters. Since its passage in 1969 the Tidal Wetlands Act has reduced cumulative losses of tidal wetlands from about 6,000 acres to less than 20 (Ron Rozsa, Connecticut Office of Long Island Sound Programs, personal communication). The Coastal Management Act of 1979 requires a review of the impacts to wetlands in the designated coastal zone to determine "adverse impacts" and to "preserve and enhance coastal resources." Included in this Act are tidal and subtidal habitats and upland areas such as dunes, bluffs, and escarpments within the coastal zone. Areas within the coastal zone are seaward of the contour elevation of the 100 year frequency flood zone, or a 1,000 foot linear setback measured from either the mean high water mark in coastal waters or the inland boundary of tidal wetlands.

Freshwater, nontidal wetlands in Connecticut are regulated through the 1972 Inland Wetlands and Watercourses Act. This act regulates all areas in the state with poorly drained, very poorly drained, alluvial, and flood plain soils, and all standing or flowing bodies of water, both natural and artificial, as well as swamps, marshes, and bogs. The law was designed to prohibit without a permit all activities that affect inland wetlands and watercourses and the quality and quantity of both ground and

Table 28. Summary of primary federal and state laws relating to wetland protection in Connecticut.

Name of Law	Administering Agency	Type of Wetlands Regulated	Regulated Activities
Rivers and Harbor Act of 1899 (Section 10)	U.S. Army Corps of Engineers	Tidal wetlands below the mean high water mark.	Structure and/or work in or affecting navigable waters of the U.S. including dredging and filling.
Clean Water Act Act of 1977 (Section 404)	U.S. Army Corps of Engineers under their regulations and 404(b)(1) guidelines developed by the U.S. Environmental Protection Agency	Wetlands that are contiguous to all waters of the U.S.	Discharge of dredged or fill material.
Act Regulating Dredging and the Erection of Structures and the Placement of Fill in Tidal, Coastal, or Navigable Waters (1963)	Connecticut Department of Environmental Protection	Tidal, coastal, or navigable waters waterward of high tide line.	Dredging or erection of structures, placement of fill, and obstruction or encroachment and/or incidential work.
Act Establishing Stream Channel Encroachment Lines (1963)	Connecticut Department of Environmental Protection	All Wetlands within the designated encroachment lines.	All activities including excavation and filling, erection of structures, and any obstruction.
Tidal Wetlands Act of 1969	Connecticut Department of Environmental Protection		Draining, dredging, excavation, dumping, and filling, and the erection of structures, driving of pilings, and obstructions.
Inland Wetlands and Watercourses Act of 1972	Connecticut Department of Environmental Protection, with local regulation required by each of the 169 municipalities in Connecticut	All "land including submerged land consisting of any soil type designated as poorly-drained, very poorly-drained, alluvial or floodplain by the National Cooperative Survey of the (U.S.D.A.) Soil Conservation Service" and "rivers, streams, brooks, waterways, lakes, ponds, marshes, swamps, bogs, and all other bodies of water".	Removal for deposition of material, or any obstruction, construction, alteration, or pollution of wetlands or watercourses. Sixty percent of Connecticut municipal wetland commissions also regulate certain activities within designated buffer areas ranging from 25 to 300 feet from the wetland or watercourse boundary.

Exemptions	Comments
None specified	July 22, 1982 Regulations: U.S. Fish and Wildlife Service and State Wildlife Agency review permit applications for environmental impacts by authority of Fish and Wildlife Coordination Act.
Normal Farming, silviculture, and ranching activities (including minor drainage); maintenance of existing structures; construction or maintenance of farm ponds or irrigation ditches; construction of temporary sedimentation basins; construction or maintenance of farm roads, forestry roads, or temporary mining roads (within certain specifications).	July 22, 1982 Regulations: U.S. Environmental Protection Agency oversight, U.S. Fish and Wildlife Service, and Connecticut Wildlife Bureau review proposed work for environmental impacts by authority of the Fish and Wildlife Coordination Act. Permits cannot by issued without state certification that proposed discharge meets state water quality standards. Individual permits are required for specific work in many wetlands; regional permits for certain categories of activities in specified geographic areas; nationwide permits for 25 specific activities and for discharges into wetlands above headwaters or those which are not part of surface tributary system to interstate or navigable waters of U.S. State takeover of permit program is encouraged. New regulations were issued in October, 1984.
The establishment, operation and maintenance of stream gauging stations in investigations of water resources in cooperation with the U.S. Geological Survey.	None.
Agriculture or farming including building of fences.	None.
Mosquito control activities by the Connecticut Dept. of Health Services, conservation activities by Connecticut Department of Environmental Protection, construction and maintenance of aids to navigation, and emergency decrees of municipal health officers acting to protect public health.	Coastal Management Act of 1979 required review of proposed impacts to wetlands in the designated coastal zone to determine adverse impacts and to preserve and enhance coastal resources, including intertidal and subtidal habitats and upland areas such as dunes, bluffs, and escarpments, seaward of the contour elevation of the 100 year linear foot setback measured from mean highwater mark or the inland boundary of tidal wetlands.
Grazing, farming, nurseries, gardening and harvest of crops, and farm ponds 3 acres or less, essential to farming activities.	July 1, 1987 Amendments: Major revisions included a tightening up of exemptions, especially agriculture a requirement for weighing of alternatives, a clarification of the State Department of Environmental Protections oversight and intervention powers, and a provision for technical assistance and education for local commissionrs. In addition, the amendments provided each local commission the authority to deny a permit if a "reasonable and prudent" alternative exists for the proposed activity.

surface water. Examples of regulated activities include filling, dredging, building, obstructing, and polluting. For some activities, the DEP has sole regulatory responsibilities: (1) the construction and modification of any dam; (2) construction activities or the placement of fill in established stream channel encroachment lines; (3) the diversion of water for public or domestic use; (4) discharges into waters of the state; and (5) all state initiated projects such as highway construction.

The Inland Wetlands and Watercourses Act was significantly amended in July 1987. Despite the fact that the Act was originally written with the intent of "preserving and protecting" Connecticut's wetlands, losses continued to occur at an alarming rate. Major revisions include tightening up on exemptions, especially for agriculture, a requirement for the analysis of alternatives prior to the issuance of a permit, a clarification of DEP's oversight and intervention powers, and provisions for technical assistance and education for local commissioners. Although it could be argued that these amendments do not go far enough in "preserving and protecting" the state's wetlands, this new legislation has made it clear that each local commission has the authority to deny a permit if a "feasible and prudent alternative" exists for the proposed project. Only time and the courts will test the effectiveness of these amendments in regards to wetland protection in Connecticut.

Wetland Acquisition

Wetlands may also be protected by direct acquisition or by other techniques such as conservation easements. Many wetlands are owned by public agencies or by private environmental organizations, but the majority are privately-owned. The U.S. Fish and Wildlife Service's National Wildlife Refuge (NWR) System was established to preserve important waterfowl wetlands at strategic locations across the country. Two National Wildlife Refuges are located in Connecticut: Salt Meadow NWR (Guilford) and the Stewart B. McKinney NWR (Norwalk and Milford). Although neither of these refuges encompasses much acreage, both contain coastal wetlands and off-shore islands important as both nesting and feeding areas for herons, egrets, shorebirds, and terns. Presently, the U.S. Fish and Wildlife Service is conducting a Southern New England Estuary Study to determine areas of specific wildlife value to help identify possible additions to the refuge system and for protection through other means.

In Connecticut the State DEP owns far more wetland acreage than the federal government. Its wildlife management areas, state parks, and state forests contain numerous wetlands, ponds, lakes, and streams. The actual acreage of wetlands on these state lands, however, is unknown at this time.

Two designated National Natural Landmarks containing wetlands under state ownership are Chester Cedar Swamp in Chester and Pachaug Great Meadows in Voluntown (Figure 44). Other significant wetlands in partial state-ownership include Robbins Swamp (Canaan), Durham Meadows (Durham and Middlefield), Barn Island Hunting Area (Stonington), and Hammonasset State Park (Madison). Many other wetlands are owned by conservation organizations, with The Nature Conservancy (TNC) taking a leading role currently protecting over 1,800 acres of inland and coastal wetland. The Connecticut Audubon and the National Audubon Societies also protect substantial wetland acreage.

Future Actions

Many opportunities are available to both government and the private sector to halt or slow wetland losses. Their joint efforts will determine the future of our nation's wetlands. Major options have been outlined below. For a more detailed discussion the reader is referred to Kusler (1978, 1983), Burke, *et al.* (1989) and Rusmore, *et al.* (1982).

Government Options

1. Develop a consistent public policy to protect wetlands of national and state significance.

2. Strengthen federal, state, and local wetland protection.

3. Ensure proper implementation of existing laws and policies through adequate surveillance and enforcement.

4. Identify wetland areas of significant value and increase wetland acquisition in selected areas.

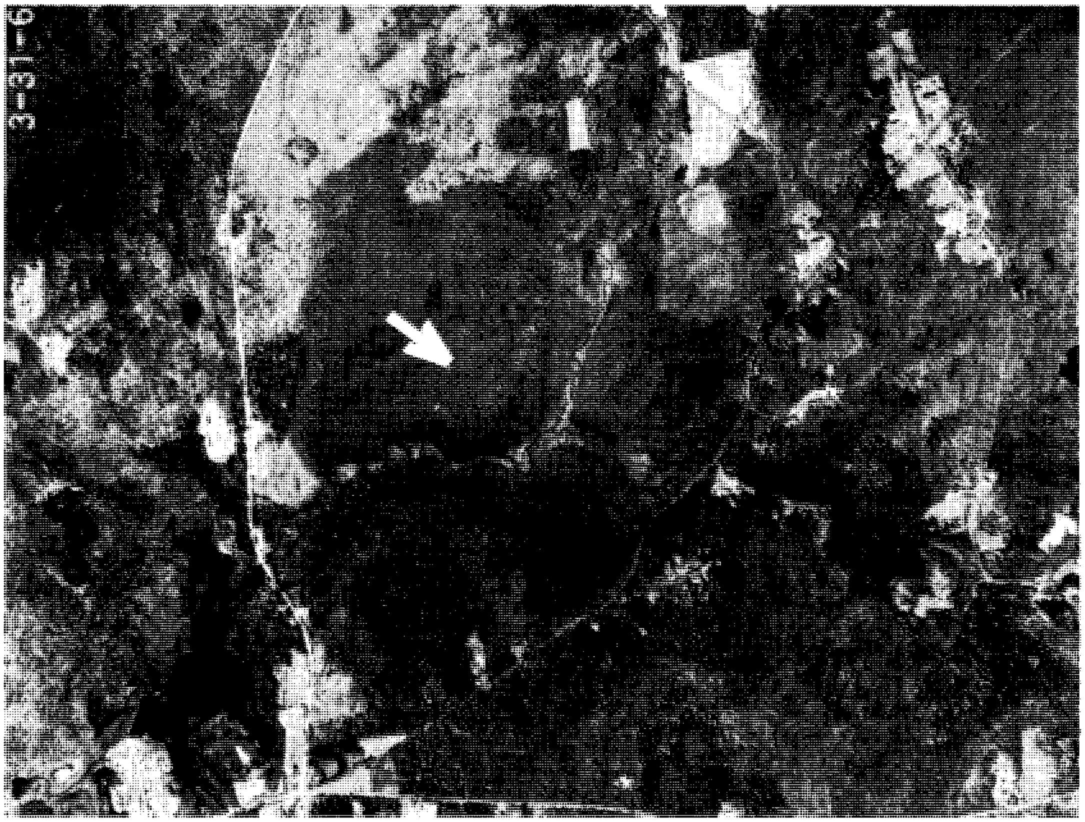
5. Remove government subsidies that encourage wetland drainage or other wetland alterations.

6. Provide tax and other incentives to private landowners and industry to encourage wetland preservation.

7. Scrutinize cost-benefit analyses and justifications for flood control projects that involve channelization of wetlands and watercourses.

8. Improve wetland management in public-owned lands.

9. Increase the number of marsh restoration projects. This should include enhancing existing wetlands



DEP-Natural Resources Center

Figure 44. Pachaug Great Meadow (arrow) is one of the largest and most diverse wetland complexes in Connecticut. This 1965 aerial photograph shows the Pachaug River and associated sedge meadow, and an Atlantic white cedar-red maple swamp complex.

by improving local water quality and by establishing buffer zones.

10. Monitor wetland changes with special attention to the effectiveness of state and federal wetland protection efforts and periodically update wetland inventories in problem areas.

11. Increase public awareness of wetland values and the status of wetlands using the various media.

12. Conduct research to increase our knowledge of wetland values and to identify ways of using wetlands that are least disruptive to their ecological and public values.

Private Options

1. Rather than drain or fill wetlands, seek compatible uses of those areas: timber harvest, waterfowl production, fur harvest, hay and forage, wild rice production, and hunting leases, for example.

2. Donate wetlands or funds to purchase wetlands from private or public conservation agencies.

3. Maintain wetlands as open space.

4. When selling property that includes wetlands, consider incorporating into the master transfer, a deed restriction, or covenant, preventing future alterations and destruction of the wetland, and an appropriate buffer zone.

5. Work in concert with government agencies to inform the public about wetland values.

6. Purchase federal duck stamps to support wetland acquisition.

7. Support various public and private initiatives to protect, enhance, and conserve wetlands.

Robichaud and Buell (1973) raised four basic questions which are central to the fate of the natural environment:

(1) How much future population growth?
(2) What future industrial growth?
(3) How much and what kind of open space?
(4) Who plans and controls land use?

The eventual answers to these questions will determine the future quantity and quality of Connecticut's wetlands. Robichaud and Buell also recognized that people must develop a land ethic - an appreciation for the value of land in its natural state. To reach this endpoint the public must be informed of the impacts associated with different land uses. For example, they must understand that filling and developing wetlands and flood plains leads directly to downstream flooding problems, as well as other losses, like fish and wildlife habitat. Public education is, therefore, vital to protecting wetlands. Private nonprofit organizations like the Connecticut Association of Conservation and Inland Wetland Commissions, the American Littoral Society, the Connecticut Audubon Society, the Connecticut Conservation Association, and others, have made major contributions to educating the public on wetlands and other natural resources.

Public and private cooperation is needed to secure a promising future for our remaining wetlands. In October 1983, the American Telephone and Telegraph Company of New Jersey (AT&T) granted a perpetual easement to the federal government for over 2,400 acres of wetland adjacent to the Forsythe National Wildlife Refuge on the New Jersey coast. The area will be managed for migratory birds as part of the NWR. This is an excellent example of private and public cooperation to achieve wetland protection goals. Perhaps other private corporations will follow this example and begin to seriously consider donating wetland holdings to public or private nonprofit organizations for conservation proposes. In Connecticut, competition for wetlands is particularly intense between developers and environmental agencies and organizations. Ways have to be found to achieve economic growth while minimizing adverse environmental impacts. This is vital to preserving wetland values for future generations.

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Appendix: List of Connecticut Hydrophytes

The following is a list of plants occurring in Connecticut's wetlands with either obligate (OBL) or facultative wet (FACW) indicator status as defined by Reed (1986). This list is based upon the *Preliminary Checklist of the Vascular Flora of Connecticut* (Dowhan 1979) and the *1986 Wetland Plant List, Northeast Region* (Reed 1986), supplemented by the *Catalogue of the Vascular Flora of the Wetlands of Connecticut* (Lefor 1986) and field observations. Nomenclature follows Dowhan (1979), with synonymy to the *National List of Scientific Plant Names* (USDA 1982) in parentheses where appropriate, except *Eleocharis elliptica* Kunth, *Potamogeton X subnitens* Hagstr., *Panicum stipitatum* Nash, and *Vitis novae-angliae* Fern. which have no apparent synonyms in the national list. Proposed Connecticut endangered (E), threatened (T), and special concern (SC) plant species are indicated as such, and species not native to Connecticut are marked with an asterisk (*).

	Scientific Name	Common Name	Indicator Status
	DIVISION I.		
	PTERIDOPHYTA (VASCULAR CRYPTOGRAMS)		
	EQUISETACEAE (HORSETAIL FAMILY)		
	Equisetum fluviatile L.	Water Horsetail	OBL
	Equisetum hyemale L.	Common Scouring-rush	FACW
SC	*Equisetum palustre* L.	Marsh Horsetail	FACW
SC	*Equisetum pratense* Ehrh.	Meadow Horsetail	FACW
	Equistem sylvaticum L.	Wood Horsetail	FACW
	Equisetum variegatum Schleich.	Variegated Horsetail	FACW
	LYCOPODIACEAE (CLUB-MOSS FAMILY)		
	Lycopodium inundatum L.	Bog Club-moss	OBL
	Lycopodium lucidulum Michx.	Shining Club-moss	FACW
	SELAGINELLACEAE (SPIKEMOSS FAMILY)		
	Selaginella apoda (L.) Fern.	Creeping Spikemoss	FACW
	ISOTACEAE (QUILLWORT FAMILY)		
	Isoetes eatonii Dodge = (*I. X eatonii* Dodge)	Quillwort	OBL
	Isoetes engelmannii A. Br.	Quillwort	OBL
SC	*Isoetes foveolata* A. A. Eat. = (*I. X foveolata* A.A. Eat.)	Quillwort	OBL
	Isoetes muricata Dur. = (*I. echinospora* Dur.)	Quillwort	OBL
	Isoetes riparia Engelm.	Quillwort	OBL
	Isoetes saccharata Engelm. = (*I. riparia* Engelm.)	Quillwort	OBL
	Isoetes tuckermanii A. Br.	Quillwort	OBL
	OPHIOGLOSSACEAE (ADDER'S-TONGUE FAMILY)		
	Botrychium lanceolatum (Gmel.) Angstr.	Lance-leaved Grape-fern	FACW
T	*Ophioglossum vulgatum* L.	Adder's-tongue	FACW
	OSMUNDACEAE (FLOWERING FERN FAMILY)		
	Osmunda cinnamomea L.	Cinnamon Fern	FACW
	Osmunda regalis L.	Royal Fern	OBL
	SCHIZAEACEAE (CURLY-GRASS FAMILY)		
SC	*Lygodium palmatum* (Bernh.) Sw.	Hartford Fern	FACW
	POLYPODIACEAE (FERN FAMILY)		
	Dryopteris X boottii (Tuckerm.) Underw.	Boott's Fern	FACW

	Scientific Name	Common Name	Indicator Status
	Dryopteris clintoniana (D.C. Eat.) Dowell	Clinton's Fern	OBL
	Dryopteris cristata (L.) Gray	Crested Wood-fern	OBL
	Matteuccia struthiopteris (L.) Todaro	Ostrich Fern	FACW
	Onoclea sensibilis L.	Sensitive Fern	FACW
	Thelypteris palustris Schott = (*T. thelyperoides* (Michx.) J. Hulub)	Marsh Fern	OBL
	Thelypteris simulata (Davenp.) Nieuwl.	Massachusetts Fern	OBL
	Woodwardia areolata (L.) Moore	Netted Chain-fern	FACW
	Woodwardia virginica (L.) Sm.	Virginia Chain-fern	OBL
	MARSILEACEAE (MARSILEA FAMILY)		
*	*Marsilea quadrifolia* L.	Water Shamrock	OBL

DIVISION II.

SPERMATOPHYTA (SEED PLANTS)

SUBDIVISION I.

GYMNOSPERMAE (GYMNOSPERMS)

	Scientific Name	Common Name	Indicator Status
	PINACEAE (PINE FAMILY)		
	Chamaecyparis thyoides (L.) BSP.	Atlantic White Cedar	OBL
	Larix laricina (DuRoi) K. Koch	Larch	FACW
	Picea mariana (Mill.) BSP.	Black Spruce	FACW
T	*Thuja occidentalis* L.	Northern White Cedar	FACW

SUBDIVISION II.

ANGIOSPERMAE (ANGIOSPERMS)

CLASS I *MONOCOTYLEDONEAE* (MONOCOTS)

	Scientific Name	Common Name	Indicator Status
	TYPHACEAE (CAT-TAIL FAMILY)		
	Typha angustifolia L.	Narrow-leaved Cattail	OBL
	Typha X glauca Godr.	Cattail	OBL
	Typha latifolia L.	Common Cattail	OBL
	SPARGANIACEAE (BUR-REED FAMILY)		
	Sparganium americanum Nutt.	American Bur-reed	OBL
	Sparganium androcladum (Engelm.) Morong	Branching Bur-reed	OBL
	Sparganium angustifolium Michx. = (*S. emersum* Rehm.)	Narrow-leaved Bur-reed	OBL
	Sparganium chlorocarpum Rydr.	Green-fruited Bur-reed	OBL
	Sparganium eurycarpum Engelm.	Giant Bur-reed	OBL
SC	*Sparganium fluctuans* (Morong) Robins.	Floating Bur-reed	OBL
SC	*Sparganium minimum* (Hartm.) Fries	Small Bur-reed	OBL
	ZOSTERACEAE (PONDWEED FAMILY)		
	Potamogeton alpinus Balbis	Pondweed	OB

	Scientific Name	Common Name	Indicator Status
	Potamogeton amplifolius Tuckerm.	Pondweed	OBL
	Potamogeton biculpatus Fern.	Snailseed Pondweed	OBL
SC	*Potamogeton confervoides* Reichenb.	Tuckerman's Pondweed	OBL
	Potamogeton crispus L.	Curly Pondweed	OBL
SC	*Potamogeton diversifolius* Raf.	Waterthread Pondweed	OBL
	Potamogeton epihydrus Raf.	Ribbon-leaved Pondweed	OBL
	Potamogeton foliosus Raf.	Pondweed	OBL
SC	*Potamogeton friesii* Rupr.	Pondweed	OBL
	Potamogeton gramineus L.	Variable Pondweed	OBL
E	*Potamogeton hillii* Morong	Pondweed	OBL
	Potamogeton illinoensis Morong	Pondweed	OBL
	Potamogeton lateralis Morong	Pondweed	OBL
	Potamogeton X longiligulatus Fern.	Pondweed	OBL
	Potamogeton natans L.	Floating Pondweed	OBL
	Potamogeton nodosus Poir.	Pondweed	OBL
	Potamogeton oakesianus Robbins	Pondweed	OBL
	Potamogeton obtusifolius Mert. & Koch	Pondweed	OBL
	Potamogeton pectinatus L.	Sago Pondweed	OBL
	Potamogeton perfoliatus L.	Pondweed	OBL
	Potamogeton praelongus Wulf.	White-stem Pondweed	OBL
	Potamogeton pulcher Tuckerm.	Pondweed	OBL
SC	*Potamogeton pusillus* L.	Pondweed	OBL
	Potamogeton richardsonii (Ar. Benn.) Rydb.	Pondweed	OBL
	Potamogeton robbinsii Oakes	Pondweed	OBL
	Potamogeton spirillus Tuckerm.	Pondweed	OBL
E	*Potamogeton strictifolius* Ar. Benn.	Pondweed	OBL
	Potamogeton X subnitens Hagstr.	Pondweed	OBL
SC	*Potamogeton vaseyi* Robbins	Pondweed	OBL
	Potamogeton zosteriformis Fern.	Pondweed	OBL
	Ruppia maritima L.	Widgeon-grass	OBL
SC	*Zannichellia palustris* L.	Horned Pondweed	OBL
	Zostera marina L.	Eelgrass	OBL
	NAJADACEAE (NAIAD FAMILY)		
	Najas flexilis (Willd.) Rostk. & Schmidt	Naiad	OBL
	Najas gracillima (A. Br.) Magnus	Naiad	OBL
SC	*Najas guadalupensis* (Spreng.) Magnus	Naiad	OBL
	JUNCAGINACEAE (ARROW-GRASS FAMILY)		
E	*Scheuchzeria palustris* L.	Pod-grass	OBL
	Triglochin maritimum L.	Arrow-grass	OBL
	ALISMATACEAE (WATER-PLANTAIN FAMILY)		
	Alisma subcordatum Raf.	Small-flowered Water-plantain	OBL
	Alisma triviale Pursh = (*A. plantago-aquatica* L.)	Mud-plantain	OBL
E	*Echinodorus tenellus* (Mart.) Buchenau	Bur-head	OBL
SC	*Sagittaria cuneata* Sheldon	Wapato	OBL

	Scientific Name	Common Name	Indicator Status
	Sagittaria eatonii J. G. Sm. = (*S. graminea* Michx.)	Arrowhead	OBL
	Sagittaria engelmanniana J. G. Sm.	Arrowhead	OBL
	Sagittaria graminea Michx.	Narrow-leaved Arrowhead	OBL
	Sagittaria latifolia Willd.	Common Arrowhead	OBL
	Sagittaria longirostra (Micheli) J. G. Sm. = (*S. engelmanniana* J.G. Sm.)	Arrowhead	OBL
SC	*Sagittaria montevidensis* C. & S.	Tide-water Arrowhead	OBL
	Sagittaria rigida Pursh	Stiff Wapato	OBL
SC	*Sagittaria subulata* (L.) Buchenau	Arrowhead	OBL
	BUTOMACEAE (FLOWERING RUSH FAMILY)		
*	*Butomus umbellatus* L.	Flowering Rush	OBL
	HYDROCHARITACEAE (FROG'S-BIT FAMILY)		
	Elodea canadensis Michx.	Ditch Moss	OBL
	Elodea nuttallii (Planch.) St. John	Water Weed	OBL
	Vallisneria americana Michx.	Tapegrass	OBL
	GRAMINEAE (GRASS FAMILY)		
	Agrostis semiverticillata (Forsk.) C. Christ.	Water Bent	FACW
	Agrostis stolonifera L.	Creeping Bent	FACW
T	*Alopecurus aequalis* Sobol.	Orange Foxtail	OBL
*	*Alopecurus carolinianus* Walt.	Common Foxtail	FACW
*	*Alopecurus geniculatus* L.	Marsh Foxtail	OBL
*	*Alopecurus pratensis* L.	Meadow Foxtail	FACW
*	*Briza minor* L.	Quaking Grass	FACW
	Bromus altissimus Pursh = (*B. latiglumis* (Shear) Hitch.)	Tall Brome-grass	FACW
	Calamagrostis canadensis (Michx.) Nutt.	Bluejoint Grass	FACW
	Calamagrostis cinnoides (Muhl.) Bart.	Reed Grass	OBL
	Cinna arundinacea L.	Wood-reedgrass	FACW
	Cinna latifolia (Trev.) Griseb.	Drooping Wood-reedgrass	FACW
	Deschampsia caespitosa (L.) Beauv.	Tufted Hairgrass	FACW
E	*Diplachne maritima* Bickn. = (*Leptochloa fascicularis* (Lam.) Gray)	Salt-meadow Grass	FACW
	Distichlis spicata (L.) Greene	Spike-grass	OBL
	Echinochloa muricata (Beauv.) Fern.	Cockspur Grass	FACW
	Echinochloa walteri (Pursh) Heller	Water Millet	OBL
	Elymus riparius Wieg.	Wild Rye	FACW
	Elymus virginicus L.	Terrell Grass	FACW
	Eragrostis frankii C. A. Mey.	Love-grass	FACW
	Eragrostis hypnoides (Lam.) BSP.	Pony Grass	OBL
	Glyceria acutiflora Torr.	Manna-grass	OBL
	Glyceria borealis (Nash) Batchelder	Northern Manna-grass	OBL
	Glyceria canadensis (Michx.) Trin.	Rattlesnake Grass	OBL

	Scientific Name	Common Name	Indicator Status
	Glyceria grandis S. Wats. = (*G. maxima* (Hartm.) Holmb.)	Manna-grass	OBL
	Glyceria laxa Scribn.	Reed Manna-grass	OBL
	Glyceria melicaria (Michx.) F. T. Hubbard	Slender Manna-grass	OBL
	Glyceria obtusa (Muhl.) Trin.	Manna-grass	OBL
	Glyceria septentrionalis Hitchc.	Floating Manna-grass	OBL
	Glyceria striata (Lam.) Hitchc.	Fowl Manna-grass	OBL
	Hierochloe odorata (L.) Beauv.	Sweet Grass	FACW
	Leersia oryzoides (L.) Sw.	Rice Cutgrass	OBL
	Leersia virginica Willd.	Cutgrass	FACW
	Muhlenbergia glomerata (Willd.) Trin.	Muhlenbergia	FACW
	Muhlenbergia mexicana (L.) Trin.	Muhlenbergia	FACW
	Muhlenbergia sylvatica Torr.	Muhlenbergia	FACW
	Muhlenbergia uniflora (Muhl.) Fern.	Muhlenbergia	OBL
	Panicum dichotomiflorum Michx.	Fall Panicum	FACW
	Panicum flexile (Gattinger) Scribn.	Panic-grass	FACW
	Panicum longifolium Torr.	Panic-grass	OBL
	Panicum rigidulum Nees	Monro Grass	FACW
	Panicum stipitatum Nash	Panic-grass	FACW
	Panicum tuckermanii Fern.	Panic-grass	FACW
	Panicum verrucosum Muhl.	Panic-grass	FACW
	Phalaris arundinacea L.	Reed Canary-grass	FACW
	Phragmites australis (Cav.) Trin. ex Steud.	Common Reed	FACW
	Poa alsodes Gray	Woodland Bluegrass	FACW
	Poa palustris L.	Fowl Meadow-grass	FACW
*	*Poa trivialis* L.	Rough-stalked Meadow-grass	FACW
*	*Polypogon monspeliensis* (L.) Desf.	Rabbit-foot Grass	FACW
*	*Puccinellia distans* (L.) Parl.	Alkali-grass	OBL
	Puccinellia fasciculata (Torr.) Bickn.	Alkali-grass	OBL
SC	*Puccinellia paupercula* (Holm) Fern. & Weath.	Alkali-grass	FACW
	Spartina alterniflora Loisel.	Salt-marsh Cordgrass	OBL
	Spartina X *caespitosa* A. A. Eat. = (*S. caespitosa* A.A. Eat.)	Cord-grass	OBL
	Spartina cynosuroides (L.)	Big Cord-grass	OBL
	Spartina patens (Ait.) Muhl.	Salt-meadow Cord-grass	FACW
	Spartina pectinata Link	Fresh-water Cord-grass	OBL
	Torreyochloa pallida (Torr.) Church = (*Puccinellia pallida* (Torr.) R.T. Clausen)	Pale Manna-grass	OBL
	Trisetum pensylvanicum (L.) Beauv. = (*Sphenopholis pensylvanica* (L.) A. Hitchc.)	Swamp Oats	OBL
	Zizania aquatica L.	Wild Rice	OBL
	CYPERACEAE (SEDGE FAMILY)		
*	*Carex acutiformis* Ehrh.	Swamp Sedge	OBL
	Carex albolutescens Schwein.	Sedge	FACW
SC	*Carex alopecoidea* Tuckerm.	Sedge	FACW
	Carex annectens Bickn.	Sedge	FACW
SC	*Carex aquatilis* Wahlenb.	Sedge	OBL
	Carex atlantica Bailey	Sedge	FACW
	Carex aurea Nutt.	Golden Sedge	FACW
SC	*Carex baileyi* Britt.	Sedge	OBL

	Scientific Name	Common Name	Indicator Status
SC	*Carex barrattii* Schwein. & Torr.	Sedge	OBL
	Carex bebbii (Bailey) Fern.	Sedge	OBL
	Carex bicknellii Britt.	Sedge	FACW
	Carex blanda	Sedge	FACW?
	Carex bromoides Schkuhr	Sedge	FACW
	Carex brunnescens (Pers.) Poir.	Sedge	FACW
	Carex bullata Schkuhr	Sedge	OBL
	Carex bushii Mackenz.	Sedge	FACW
E	*Carex buxbaumii* Wahlenb.	Sedge	OBL
	Carex canescens L.	Sedge	OBL
T	*Carex castanea* Wahlenb.	Sedge	OBL
SC	*Carex collinsii* Nutt.	Sedge	OBL
	Carex comosa Boott	Sedge	OBL
	Carex conoidea Schkuhr	Sedge	FACW
E	*Carex crawei* Dew.	Sedge	FACW
	Carex crinata Lam.	Sedge	OBL
	Carex cristatella Britt.	Sedge	FACW
	Carex debilis Michx.	Sedge	FACW
	Carex diandra Schrank	Sedge	OBL
	Carex disperma Dew.	Sedge	FACW
	Carex flava L.	Yellow Sedge	OBL
	Carex folliculata L.	Sedge	FACW
T	*Carex formosa* Dew.	Sedge	FACW
	Carex granularis Muhl.	Sedge	FACW
	Carex grayi Carey	Sedge	FACW
	Carex haydenii Dew.	Sedge	OBL
	Carex hormathodes Fern.	Sedge	OBL
	Carex howei Mackenz.	Sedge	OBL
	Carex hystericina Willd.	Sedge	OBL
	Carex interior Bailey	Sedge	OBL
	Carex intumescens Rudge	Bladder Sedge	FACW
	Carex lacustris Willd.	Lake-bank Sedge	OBL
	Carex laevivaginata (Kukenth.) Mackenz.	Sedge	OBL
	Carex lanuginosa Michx.	Sedge	OBL
	Carex lasiocarpa Ehrh.	Wool-fruit Sedge	OBL
	Carex leptalea Wahlenb.	Sedge	OBL
	Carex leptonervia Fern.	Sedge	FACW
E	*Carex limosa* L.	Mud Sedge	OBL
	Carex livida (Wahlenb.) Willd.	Sedge	OBL
	Carex longii Mackenz.	Sedge	OBL
SC	*Carex lupuliformis* Sartwell	Sedge	FACW
	Carex lupulina Muhl.	Sedge	OBL
	Carex lurida Wahlenb.	Sedge	OBL
SC	*Carex nigromarginata* Schwein.	Sedge	OBL
SC	*Carex oligosperma* Michx.	Sedge	OBL
SC	*Carex pauciflora* Lightf.	Sedge	OBL
SC	*Carex paupercula* Michx.	Sedge	OBL
T	*Carex prairea* Dew.	Sedge	FACW
	Carex prasina Wahlenb.	Sedge	OBL
	Carex projecta Mackenz.	Sedge	FACW
E	*Carex pseudo-cyperus* L.	Sedge	OBL
	Carex retrorsa Schwein.	Sedge	FACW
	Carex rostrata Stokes	Sedge	OBL
	Carex scabrata Schwein.	Sedge	OBL
T	*Carex schweinitzii* Dew.	Sedge	OBL
	Carex scoparia Schkuhr	Sedge	FACW
	Carex seorsa Howe	Sedge	FACW

	Scientific Name	Common Name	Indicator Status
	Carex squarrosa L.	Sedge	FACW
SC	*Carex sterilis* Willd.	Sedge	OBL
	Carex stipata Muhl.	Sedge	OBL
	Carex straminea Willd.	Sedge	OBL
	Carex stricta Lam.	Tussock Sedge	OBL
	Carex styloflexa Buckl.	Sedge	FACW
SC	*Carex tetanica* Schkuhr	Sedge	FACW
	Carex torta Boott	Sedge	FACW
	Carex tribuloides Wahlenb.	Sedge	FACW
	Carex trichocarpa Muhl.	Sedge	OBL
	Carex trisperma Dew.	Sedge	OBL
	Carex tuckermanii Boott	Sedge	OBL
	Carex typhina Michx.	Sedge	FACW
	Carex vesicaria L.	Sedge	OBL
E	*Carex viridula* Michx.	Sedge	OBL
	Carex vulpinoidea Michx.	Sedge	OBL
	Cladium mariscoides (Muhl.) Torr.	Twig-rush	OBL
*	*Cyperus brevifolius* (Rottb.) Hassk.	Galingale	FACW
	Cyperus dentatus Torr.	Galingale	FACW
	Cyperus diandrus Torr.	Galingale	FACW
	Cyperus erythrorhizos Muhl.	Galingale	FACW
	Cyperus esculentus L.	Yellow Nut-grass	FACW
	Cyperus filicinus Vahl	Galingale	OBL
	Cyperus odoratus L.	Galingale	FACW
	Cyperus rivularis Kunth	Galingale	FACW
	Cyperus strigosus L.	Galingale	FACW
	Dulichium arundinaceum (L.) Britt.	Three-way Sedge	OBL
	Eleocharis acicularis (L.) R. & S.	Spike-rush	OBL
	Eleocharis diandra C. Wright = (*E. ovata* (Roth) R. & S.)	Spike-rush	OBL
	Eleocharis elliptica Kunth	Spike-rush	FACW
E	*Eleocharis equisetoides* (Ell.) Torr.	Spike-rush	OBL
	Eleocharis erythropoda Steud.	Spike-rush	OBL
	Eleocharis halophila Fern. & Brack.	Spike-rush	OBL
	Eleocharis intermedia (Muhl.) Schultes	Spike-rush	FACW
SC	*Eleocharis microcarpa* Torr.	Spike-rush	OBL
	Eleocharis obtusa (Willd.) Schultes	Spike-rush	OBL
	Eleocharis olivacea Torr.	Spike-rush	OBL
	Eleocharis parvula (R. & S.) Link	Spike-rush	OBL
E	*Eleocharis quadrangulata* (Michx.) R. & S.	Spike-rush	OBL
	Eleocharis robbinsii Oakes	Spike-rush	OBL
	Eleocharis rostellata Torr.	Spike-rush	OBL
	Eleocharis smallii Britt.	Spike-rush	OBL
	Eleocharis tenuis (Willd.) Schultes	Spike-rush	FACW
	Eleocharis tuberculosa (Michx.) R. & S.	Spike-rush	OBL
	Eriophorum gracile W. D. J. Koch *ex* Roth	Slender Cotton-grass	OBL
T	*Eriophorum spissum* Fern.	Hare's Tail	OBL
	Eriophorum tenellum Nutt.	Rough Cotton-grass	OBL
	Eriophorum virginicum L.	Tawny Cotton-grass	OBL
	Eriophorum viridi-carinatum (Englem.) Fern.	Cotton-grass	OBL

Scientific Name		Common Name	Indicator Status
	Fimbristylis autumnalis (L.) R. & S.	Fimbristylis	FACW
	Fuirena pumila Torr.	Umbrella-grass	OBL
E	*Hemicarpha micrantha* (Vahl) Pax	Hemicarpa	FACW
E	*Psilocarya scirpoides* Torr.	Bald-rush	OBL
	Rhynchospora alba (L.) Vahl	White Beak-rush	OBL
	Rhynchospora capillacea Torr.	Capillary Beak-rush	OBL
	Rhynchospora capitellata (Michx.) Vahl	Beak-rush	OBL
	Rhynchospora fusca (L.) Ait. f.	Beak-rush	OBL
E	*Rhynchospora macrostachya* Torr.	Horned Rush	OBL
T	*Scirpus acutus* Muhl. *ex* Bigel.	Hardstem Bulrush	OBL
	Scirpus americanus Pers.	Olney's Three-square	OBL
	Scirpus atrocinctus Fern.	Bulrush	FACW
	Scirpus atrovirens Willd.	Bulrush	OBL
	Scirpus cyperinus (L.) Kunth	Wool-grass	FACW
	Scirpus expansus Fern.	Bulrush	OBL
	Scirpus fluviatilis (Torr.) Gray	River Bulrush	OBL
SC	*Scirpus georgianus* Harper	Bulrush	OBL
SC	*Scirpus hudsonianus* (Michx.) Fern. = (*Eriophorum alpinum* L.)	Bulrush	OBL
SC	*Scirpus longii* Fern.	Bulrush	OBL
	Scirpus maritimus L.	Saltmarsh Bulrush	OBL
	Scirpus microcarpus Presl	Bulrush	OBL
SC	*Scirpus paludosus* Nels. = (*S. maritimus* L.)	Bayonet-grass	OBL
	Scirpus X *peckii* Britt.	Bulrush	OBL
	Scirpus pedicellatus Fern.	Bulrush	OBL
	Scirpus pendulus Muhl.	Bulrush	OBL
	Scirpus polyphyllus Vahl	Bulrush	OBL
	Scirpus pungens Vahl	Common Three-square	FACW
	Scirpus purshianus Fern.	Bulrush	OBL
	Scirpus robustus Pursh	Salt Marsh Bulrush	OBL
	Scirpus smithii Gray	Bulrush	OBL
	Scirpus subterminalis Torr.	Water Club-rush	OBL
T	*Scirpus torreyi* Olney	Bulrush	OBL
	Scirpus validus Vahl	Softstem Bulrush	OBL
SC	*Scleria pauciflora* Muhl.	Nut-rush	FACW
E	*Scleria reticularis* Michx.	Nut-rush	OBL
SC	*Scleria verticillata* Muhl. *ex* Willd.	Nut-rush	OBL
	ARACEAE (ARUM FAMILY)		
	Acorus calamus L.	Sweet Flag	OBL
SC	*Arisaema dracontium* (L.) Schott	Green Dragon	FACW
	Arisaema triphyllum (L.) Schott	Jack-in-the-pulpit	FACW
	Calla palustris L.	Marsh Calla	OBL
SC	*Orontium aquaticum* L.	Golden Club	OBL
	Peltandra virginica (L.) Kunth	Arrow-arum	OBL
	Symplocarpus foetidus (L.) Nutt.	Skunk-cabbage	OBL
	LEMNACEAE (DUCKWEED FAMILY)		
	Lemna minor L.	Lesser Duckweed	OBL
	Lemna trisulca L.	Star Duckweed	OBL
	Lemna valdiviana Phil.	Duckweed	OBL
	Spirodela polyrhiza (L.) Schleid.	Greater Duckweed	OBL
	Wolffia columbiana Karst.	Water-meal	OBL

	Scientific Name	Common Name	Indicator Status
	Wolffia papulifera C. H. Thompson	Water-meal	OBL
	Wolffia punctata Griseb.	Water-meal	OBL
	XYRIDACEAE (YELLOW-EYED GRASS FAMILY)		
	Xyris difformis Chapm.	Common Yellow-eyed Grass	OBL
E	*Xyris montana* Ries	Northern Yellow-eyed Grass	OBL
E	*Xyris smalliana* Nash	Small's Yellow-eyed Grass	OBL
	Xyris torta Sm.	Twisted Yellow-eyed Grass	OBL
	ERIOCAULACEAE (PIPEWORT FAMILY)		
E	*Eriocaulon parkeri* Robins.	Pipewort	OBL
	Eriocaulon septangulare With.	White Buttons	OBL
	PONTEDERIACEAE (PICKERELWEED FAMILY)		
	Heteranthera dubia (Jacq.) MacM.	Water Stargrass	OBL
E	*Heteranthera reniformis* R. & P.	Mud-plantain	OBL
	Pontederia cordata L.	Pickerelweed	OBL
	JUNCACEAE (RUSH FAMILY)		
	Juncus acuminatus Michx.	Rush	OBL
	Juncus articulatus L.	Rush	OBL
	Juncus brachycarpus Engelm.	Rush	FACW
	Juncus brachycephalus (Engelm.) Buchenau	Rush	OBL
	Juncus brevicaudatus (Englem.) Fern.	Rush	OBL
	Juncus bufonius L.	Toad Rush	FACW
	Juncus canadensis J. Gay	Marsh Rush	OBL
SC	*Juncus debilis* Gray	Rush	OBL
	Juncus dichotomus Ell.	Forked Rush	FACW
	Juncus effusus L.	Soft Rush	FACW
	Juncus gerardii Loisel.	Black Grass	FACW
	Juncus marginatus Rostk.	Rush	FACW
	Juncus militaris Bigel.	Bayonet Rush	OBL
	Juncus nodosus L.	Rush	OBL
	Juncus pelocarpus Mey.	Bog Rush	OBL
	Juncus subcaudatus (Engelm.) Coville & Blake	Rush	OBL
	LILIACEAE (LILY FAMILY)		
	Aletris farinosa L.	Coli-croot	FACW
	Lilium superbum L.	Turk's-cap Lily	FACW
	Smilacina stellata (L.) Desf.	Star-flowered False Solomon's Seal	FACW
T	*Smilacina trifolia* (L.) Desf.	Three-leaved False Solomon's-seal	OBL
	Streptopus roseus Michx.	Rose Twisted-stalk	FACW
	Trillium cernuum L.	Nodding Trillium	FACW
	Veratrum viride Ait.	False Hellebore	FACW
	HAEMODORACEAE (BLOODWORT FAMILY)		
E	*Lachnanthes caroliana* (Lam.) Dandy	Redroot	OBL
	IRIDACEAE (IRIS FAMILY)		
	Iris prismatica Pursh	Slender Blue Flag	OBL
*	*Iris pseudacorus* L.	Yellow Iris	OBL
	Iris versicolor L.	Blue Flag	OBL
	Sisyrinchium atlanticum Bickn.	Eastern Blue-eyed Grass	FACW
	ORCHIDACEAE (ORCHID FAMILY)		
E	*Arethusa bulbosa* L.	Dragon's-mouth	OBL
	Calopogon tuberosus (L.) BSP.	Grass-pink	OBL

	Scientific Name	Common Name	Indicator Status
T	*Corallorhiza trifida* Chatelain.	Early Coral-root	FACW
SC	*Cypripedium arietinum* R. Br.	Ram's-head Lady's-slipper	FACW
E	*Cypripedium reginae* Walt.	Showy Lady's-slipper	FACW
	Liparis loeselii (L.) Rich.	Bog Twayblade	FACW
E	*Malaxis monophyllos* (L.) Sw.	White Adder's-mouth	FACW
E	*Platanthera blephariglottis* (Willd.) Lindl.	White Fringed Orchid	OBL
T	*Platanthera ciliaris* (L.) Lindl.	Yellow Fringed Orchid	FACW
SC	*Platanthera dilatata* (Pursh) Lindl. *ex* Beck	Tall White Bog Orchid	FACW
SC	*Platanthera flava* (L.) Lindl.	Pale Green Orchid	FACW
	Platanthera grandiflora (Bigel.) Lindl.	Large Purple Fringed Orchid	FACW
	Platanthera hyperborea (L.) Lindl.	Tall Northern Green Orchid	FACW
	Platanthera lacera (Michx.) G. Don	Ragged Fringed Orchid	FACW
	Platanthera psycodes (L.) Lindl.	Small Purple Fringed Orchid	OBL
	Pogonia ophioglossoides (L.) Juss.	Rose Pogonia	OBL
	Spiranthes cernua (L.) Rich.	Nodding Ladies'-tresses	FACW
	Spiranthes lucida (H. H. Eat.) Ames	Broad-leaved Ladies-tresses	FACW
	Spiranthes romanzoffiana Cham.	Hooded Ladies-tresses	OBL

CLASS II DICOTYLEDONEAE (DICOTS)

	Scientific Name	Common Name	Indicator Status
	SAURURACEAE (LIZARD'S TAIL FAMILY)		
E	*Saururus cernuus* L.	Lizard's Tail	OBL
	SALICACEAE (WILLOW FAMILY)		
E	*Populus heterophylla* L.	Swamp Cottonwood	FACW
*	*Salix alba* L.	White Willow	FACW
	Salix bebbiana Sarg.	Beaked Willow	FACW
*	*Salix babylonica* L.	Weeping Willow	FACW
	Salix candida Flugge	Hoary Willow	OBL
	Salix discolor Muhl.	Pussy Willow	FACW
T	*Salix interior* Rowlee = (*S. exigua* Nutt.)	Sandbar Willow	OBL
	Salix lucida Muhl.	Shining Willow	FACW
	Salix nigra Marsh.	Black Willow	FACW
E	*Salix pedicellaris* Pursh	Bog Willow	OBL
	Salix rigida Muhl.	Stiff Willow	OBL
	Salix sericea Marsh.	Silky Willow	OBL
	Salix serissima (Bailey) Fern.	Autumn Willow	OBL
	Salix X *subsericea* (Anderss.) Schneid.	False Silky Willow	FACW
	MYRICACEAE (WAX-MYRTLE FAMILY)		
	Myrica gale L.	Sweet Gale	FACW
	CORYLACEAE (HAZEL FAMILY)		
	Alnus rugosa (DuRoi) Spreng.	Specked Alder	FACW
	Alnus serrulata (Ait.) Willd.	Smooth Alder	OBL
SC	*Betula pumila* L.	Swamp Birch	OBL
	FAGACEAE (BEECH FAMILY)		
	Quercus bicolor Willd.	Swamp White Oak	FACW
	Quercus palustris Muenchh.	Pin Oak	FACW
	ULMACEAE (ELM FAMILY)		
	Ulmus americana L.	American Elm	FACW

	Scientific Name	Common Name	Indicator Status
	URTICACEAE (NETTLE FAMILY)		
	Boehmeria cylindrica (L.) Sw.	Bog Hemp	FACW
	Laportea canadensis (L.) Wedd.	Wood-nettle	FACW
	Pilea pumila (L.) Gray	Clearweed	FACW
	POLYGONACEAE (BUCKWHEAT FAMILY)		
	Polygonum amphibium L.	Water Smartweed	OBL
	Polygonum arifolium L.	Halberd-leaved Tearthumb	OBL
	Polygonum careyi Olney	Knotweed	FACW
	Polygonum cespitosum Blume	Knotweed	OBL
	Polygonum erectum L.	Erect Knotweed	OBL
	Polygonum hydropiper L.	Water-pepper	OBL
	Polygonum hydropiperoides Michx.	Mild Water-pepper	OBL
	Polygonum lapathifolium L.	Pale Smartweed	FACW
	Polygonum opelousanum Riddell	Knotweed	OBL
	Polygonum pensylvanicum L.	Pinkweed	FACW
*	*Polygonum persicaria* L.	Lady's Thumb	FACW
	Polygonum punctatum Ell.	Water Smartweed	OBL
	Polygonum robustius (Small) Fern.	Stout Smartweed	OBL
	Polygonum sagittatum L.	Arrow-leaved Tearthumb	OBL
	Rumex altissimus Wood	Tall Dock	FACW
SC	*Rumex maritimus* L.	Golden Dock	FACW
	Rumex orbiculatis Gray	Great Water Dock	OBL
*	*Rumex triangulivalvis* (Danser.) Rech. f.	Dock	FACW
	Rumex verticillatus L.	Swamp Dock	OBL
	CHENOPODIACEAE (GOOSEFOOT FAMILY)		
	Atriplex patula L.	Seabeach Orach	FACW
*	*Bassia hirsuta* (L.) Aschers.	Hairy Smotherweed	OBL
*	*Chenopodium glaucum* L.	Oak-leaved Goosefoot	FACW
	Chenopodium rubrum L.	Coast Blite	FACW
*	*Cycloma atriplicifolium* (Spreng.) Coult.	Winged Pigweed	FACW
	Salicornia bigelovii Torr.	Dwarf Saltwort	OBL
	Salicornia europaea L.	Glasswort	OBL
	Salicornia virginica L.	Woody Glasswort	OBL
	Suaeda linearis (Ell.) Moq.	Tall Sea-blite	OBL
	Suaeda maritima (L.) Dumort.	Low Sea-blite	OBL
	AMARANTHACEAE (AMARANTH FAMILY)		
	Amaranthus cannabinus (L.) Sauer	Salt-marsh Hemp	OBL
*	*Amaranthus tuberculatus* (Moq.) Saver	Water Hemp	OBL
	CARYOPHYLLACEAE (PINK FAMILY)		
*	*Myosoton aquaticum* (L.) Moench	Giant Chickweed	FACW
	Sagina procumbens L.	Pearlwort	OBL
*	*Spergularia canadensis* (Pers.) D. Don	Northern Sand-spurrey	OBL
	Spergularia marina (L.) Griseb.	Salt Marsh Sand-spurrey	OBL
	Stellaria longifolia Muhl.	Long-leaved Stitchwort	FACW
	CERATOPHYLLACEAE (HORNWORT FAMILY)		
	Ceratophyllum demersum L.	Hornwort	OBL
	Ceratophyllum echinatum Gray = (*C. muricatum* Cham.)	Hornwort	OBL

	Scientific Name	Common Name	Indicator Status
	NYMPHAEACEAE (WATER-LILY FAMILY)		
	Brasenia schreberi Gmel.	Water-shield	OBL
*	*Cabomba caroliniana* Gray	Fanwort	OBL
SC	*Nelumbo lutea* (Willd.) Pers.	American Lotus	OBL
	Nuphar advena (Ait.) Ait. f. = (*N. luteum* (L.) Sibth. & J.E. Smith)	Large Yellow Pond-lily	OBL
	Nuphar microphyllum (Pers.) Fern. = (*N. luteum* (L.) Sibth. & J.E. Smith)	Small Yellow Pond-lily	OBL
	Nuphar X rubrodiscum Morong = (*N. luteum* (L.).Sibth. & J.E. Smith)	Red Cow-lily	OBL
	Nuphar variegatum Engelm. = (*N. luteum* (L.) Sibth. & J.E. Smith)	Bullhead-lily	OBL
	Nymphaea odorata Ait.	Fragrant White Water-lily	OBL
	Nymphaea tuberosa Paine	Tuberous White Water-lily	OBL
	RANUNCULACEAE (CROWFOOT FAMILY)		
E	*Anemone canadensis* L.	Canada Anemone	FACW
	Caltha palustris L.	Marsh-marigold	OBL
	Coptis groenlandica (Oeder) Fern. = (*C. trifolia* (L.) Salisb.)	Goldthread	FACW
	Ranunculus abortivus L.	Small-flowered Crowfoot	FACW
E	*Ranunculus ambigens* S. Wats.	Spearwort	OBL
E	*Ranunculus cymbalaria* Pursh	Seaside Crowfoot	OBL
	Ranunculus flabellaris Raf.	Yellow Water-crowfoot	OBL
	Ranunculus laxicaulis (T. & G.) Darby	Crowfoot	OBL
	Ranunculus longirostris Godr.	White Water-crowfoot	OBL
	Ranunculus pensylvanicus L. f.	Bristly Buttercup	OBL
	Ranunculus recurvatus Poir.	Hooked Buttercup	FACW
SC	*Ranunculus reptans* L. =(*R. flammula* L.)	Creeping Spearwort	FACW
SC	*Ranunculus sceleratus* L.	Cursed Crowfoot	OBL
	Ranunculus septentrionalis Poir.	Northern Swamp-buttercup	OBL
	Ranunculus subrigidus Drew	Stiff White Water-crowfoot	OBL
	Ranunculus trichophyllus Chaix = (*R. aquatilis* L.)	Common White Water-crowfoot	OBL
	Thalictrum dasycarpum Fishc. & Lall.	Purple Meadow-rue	FACW
	Thalictrum polygamum Muhl. = (*T. pubescens* Pursh)	Tall Meadow-rue	FACW
E	*Trollius laxus* Salisb.	Spreading Globe-flower	OBL
*	*Xanthorhiza simplicissima* Marsh.	Yellowroot	FACW
	LAURACEAE (LAUREL FAMILY)		
	Lindera benzoin (L.) Blume	Spice Bush	FACW
	CRUCIFERAE (MUSTARD FAMILY)		
	Cardamine bulbosa (Schreb.) BSP.	Spring Cress	OBL
SC	*Cardamine douglassii* (Torr.) Britt.	Purple Cress	FACW
	Cardamine longii Fern.	Bitter Cress	OBL
	Cardamine pensylvanica Muhl.	Bitter Cress	OBL
*	*Cardamine pratensis* L.	Cuckoo-flower	OBL
	Iodanthus pinnatifidus (Michx.) Steud.	Purple Rocket	FACW
*	*Nasturtium officinale* R. Br.	Watercress	OBL
*	*Rorippa amphibia* (L.) Bess.	Yellow Cress	FACW

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	Rorippa palustris (L.) Bess.	Marsh Cress	OBL
*	*Rorippa prostrata* (Bergeret) Schinz & Thell.	Yellow Cress	OBL
*	*Rorippa sylvestris* (L.) Bess.	Creeping Yellow Cress	OBL
	SARRACENIACEAE (PITCHER-PLANT FAMILY)		
	Sarracenia purpurea L.	Pitcher-plant	OBL
	DROSERACEAE (SUNDEW FAMILY)		
SC	*Drosera filiformis* Raf.	Thread-leaved Sundew	OBL
	Drosera intermedia Hayne	Spatulate-leaved Sundew	OBL
	Drosera rotundifolia L.	Round-leaved Sundew	OBL
	PODOSTEMACEAE (RIVERWEED FAMILY)		
SC	*Podostemum ceratophyllum* Michx.	Riverweed	OBL
	CRASSULACEAE (ORPINE FAMILY)		
SC	*Tillaea aquatica* L. = (*Crassula aquatica* (L.) Schoeln.)	Pigmyweed	OBL
	SAXIFRAGACEAE (SAXIFRAGE FAMILY)		
	Chrysosplenium americanum Schwein.	Water Carpet	OBL
*	*Hydrangea paniculata* Sieb.	Hydrangea	OBL
	Mitella nuda L.	Naked Miterwort	FACW
	Parnassia glauca Raf.	Grass-of-Parnassus	OBL
	Penthorum sedoides L.	Ditch-stonecrop	OBL
	Ribes americanum Mill.	Wild Black Currant	FACW
SC	*Ribes glandulosum* Grauer	Skunk Currant	FACW
SC	*Ribes lacustre* (Pers.) Poir.	Swamp Black Currant	FACW
SC	*Ribes triste* Pall.	Wild Red Currant	OBL
	Saxifraga pensylvanica L.	Swamp Saxifrage	OBL
	PLATANACEAE (PLANE-TREE FAMILY)		
	Platanus occidentalis L.	American Sycamore	FACW
	ROSACEAE (ROSE FAMILY)		
	Amelanchier intermedia Spach = (*A.* X *intermedia*)	Swamp Shadbush	FACW
	Aronia arbutifolia (L.) Ell.	Red Chokeberry	FACW
	Aronia prunifolia (Marsh.) Rehd.	Purple Chokeberry	FACW
*	*Filipendula rubra* (Hill) Robins.	Queen-of-the-prairie	FACW
	Geum laciniatum Murray	Rough Avens	FACW
	Geum rivale L.	Water-avens	OBL
*	*Physocarpus opulifolius* (L.) Maxim.	Ninebark	FACW
	Potentilla anserina L.	Silverweed	OBL
	Potentilla fruticosa L.	Shrubby Cinquefoil	FACW
	Potentilla palustris (L.) Scop.	Marsh Cinquefoil	OBL
SC	*Rosa nitida* Willd.	Northeastern Rose	FACW
	Rosa palustris Marsh.	Swamp Rose	OBL
	Rubus flagellaris Willd.	Northern Dewberry	FACW
	Rubus hispidus L.	Bristly Dewberry	FACW
	Rubus pubescens Raf.	Dwarf Raspberry	FACW
	Rubus semisetosus Blanch.	Blackberry	FACW
	Rubus setosus Bigel.	Bog Blackberry	FACW
	Sanguisorba canadensis L.	Canadian Burnet	FACW
	Spiraea latifolia (Ait.) Borkh. = (*S. alba* DuRoi)	Meadow-sweet	FACW
	Spiraea tomentosa L.	Steeplebush	FACW

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	LEGUMINOSAE (PULSE FAMILY)		
*	*Amorpha fruticosa* L.	False Indigo	FACW
	Amphicarpa bracteata (L.) Fern.	Hog-peanut	FACW
	Apios americana Medic.	Ground-nut	FACW
	Lathyrus palustris L.	Marsh Pea	FACW
	LINACEAE (FLAX FAMILY)		
	Linum striatum Walt.	Ridge Yellow Flax	FACW
	Linum virginianum L.	Wild Yellow Flax	FACW
	POLYGALACEAE (MILKWORT FAMILY)		
	Polygala cruciata L.	Cross-leaved Milkwort	FACW
	CALLITRICHACEAE (WATER-STARWORT FAMILY)		
	Callitriche heterophylla Pursh	Water-starwort	OBL
	Callitriche terrestris Raf.	Water-starwort	FACW
	Callitriche verna L.	Water-starwort	OBL
	LIMNANTHACEAE (FALSE MERMAID FAMILY)		
E	*Floerkea proserpinacoides* Willd.	False Mermaid	FACW
	ANACARDIACEAE (CASHEW FAMILY)		
	Toxicodendron vernix (L.) Ktze.	Poison Sumac	OBL
	AQUIFOLIACEAE (HOLLY FAMILY)		
T	*Ilex glabra* (L.) Gray	Inkberry	FACW
	Ilex laevigata (Pursh) Gray	Smooth Winterberry	OBL
	Ilex verticillata (L.) Gray	Winterberry	FACW
	Nemopanthus mucronata (L.) Trel.	Mountain-holly	OBL
	ACERACEAE (MAPLE FAMILY)		
	Acer saccharinum L.	Silver Maple	FACW
	BALSAMINACEAE (TOUCH-ME-NOT FAMILY)		
	Impatiens capensis Meerb.	Spotted Jewelweed	FACW
	Impatiens pallida Nutt.	Pale Jewelweed	FACW
	RHAMNACEAE (BUCKTHORN FAMILY)		
	Rhamnus alnifolia L'Her.	Swamp Buckthorn	OBL
	VITACEAE (GRAPE FAMILY)		
SC	*Vitis novae-angliae* Fern.	New England Grape	FACW
	Vitis riparia Michx.	Riverbank Grape	FACW
	MALVACEAE (MALLOW FAMILY)		
*	*Althaea officinalis* L.	Marsh-mallow	FACW
	Hibiscus palustris L. = (*H. moscheutos* L.)	Rose-mallow	OBL
	GUTTIFERAE (ST. JOHN'S-WORT FAMILY)		
SC	*Hypericum adpressum* Bart.	Creeping St. John's-wort	OBL
	Hypericum boreale (Britt.) Bickn.	Northern St. John's-wort	OBL
	Hypericum canadense L.	Narrow-leaved St. John's-wort	FACW
	Hypericum dissimulatum Bickn.	St. John's-wort	FACW
	Hypericum ellipticum Hook.	Pale St. John's-wort	OBL
	Hypericum majus (Gray) Britt.	Greater St. John's-wort	FACW
	Hypericum mutilum L.	Dwarf St. John's-wort	FACW
	Triadenum fraseri (Spach) Gl.	Marsh-St. John's-wort	OBL

	Scientific Name	Common Name	Indicator Status
	Triadenum virginicum (L.) Raf.	Marsh-St. John's-wort	OBL
	ELATINACEAE (WATERWORT FAMILY)		
	Elatine americana (Pursh) Arn.	Water Purslane	OBL
	Elatine minima (Nutt.) Fisch. & Mey.	Mud Purslane	OBL
	TAMARICACEAE (TAMARISK FAMILY)		
*	*Tamarix gallica* L.	Tamarisk	FACW
	VIOLACEAE (VIOLET FAMILY)		
	Viola affinis LeConte	LeConte's Violet	FACW
	Viola blanda Willd.	Sweet White Violet	FACW
	Viola conspersa Reichenb.	American Dog-violet	FACW
	Viola cucullata Ait.	Marsh Blue Violet	FACW
	Viola incognita Brainerd	Large-leaved White Violet	FACW
	Viola lanceolata L.	Lance-leaved Violet	OBL
	Viola macloskeyi Lloyd = (*V. pallens* (Banks) Brainard)	White Violet	OBL
SC	*Viola renifolia* Gray	Kidney-leaved Violet	FACW
	Viola sagittata Ait.	Arrow-leaved Violet	FACW
SC	*Viola striata* Ait.	Cream Violet	FACW
	LYTHRACEAE (LOOSESTRIFE FAMILY)		
	Decodon verticillatus (L.) Ell.	Water-willow	OBL
*	*Lythrum alatum* Pursh	Winged Loosestrife	FACW
SC	*Lythrum lineare* L.	Narrow-leaved Loosestrife	OBL
*	*Lythrum salicaria* L.	Purple Loosestrife	FACW
E	*Rotala ramosior* (L.) Koehne	Toothcup	OBL
	NYSSACEAE (SOURGUM FAMILY)		
	Nyssa sylvatica Marsh.	Black Gum	FACW
	MELASTOMATACEAE (MELASTOMA FAMILY)		
	Rhexia virginica L.	Common Meadow-beauty	OBL
	ONAGRACEAE (EVENING-PRIMROSE FAMILY)		
	Circaea alpina L.	Small Enchanter's Nightshade	FACW
	Epilobium coloratum Biehler	Purple-leaved Willow-herb	OBL
*	*Epilobium hirsutum* L.	Hairy Willow-herb	FACW
	Epilobium leptophyllum Raf.	Narrow-leaved Willow-herb	OBL
	Epilobium palustre L.	Marsh Willow-herb	OBL
	Epilobium strictum Muhl.	Downy Willow-herb	OBL
	Ludwigia alternifolia L.	Seedbox	FACW
	Ludwigia X *lacustris* Eames	False Loosestrife	OBL
	Ludwigia palustris (L.) Ell.	Marsh-purslane	OBL
SC	*Ludwigia polycarpa* Short & Peter	Many-fruited False Loosestrife	OBL
E	*Ludwigia sphaerocarpa* Ell.	False Loosestrife	OBL
	HALORAGACEAE (WATER-MILFOIL FAMILY)		
SC	*Myriophyllum alterniflorum* DC.	Slender Water-milfoil	OBL
	Myriophyllum exalbescens Fern.	Parrot-feather	OBL
*	*Myriophyllum heterophyllum* Michx.	Various-leaved Water-milfoil	OBL
	Myriophyllum humile (Raf.) Morong	Low Water-milfoil	OBL
SC	*Myriophyllum pinnatum* (Walt.) BSP.	Pinnate Water-milfoil	OBL
SC	*Myriophyllum tenellum* Bigel.	Leafless Water-milfoil	OBL
	Myriophyllum verticillatum L.	Whorled Water-milfoil	OBL
	Proserpinaca palustris L.	Mermaid-Weed	OBL

	Scientific Name	Common Name	Indicator Status
	UMBELLIFERAE (PARSLEY FAMILY)		
*	*Aegopodium podagraria* L.	Goutweed	FACW
	Angelica atropurpurea L.	Purple Angelica	OBL
	Cicuta bulbifera L.	Water-hemlock	OBL
	Cicuta maculata L.	Spotted Cowbane	OBL
	Conioselinum chinense (L.) BSP.	Hemlock-parsley	FACW
*	*Conium maculatum* L.	Poison Hemlock	FACW
	Hydrocotyle americana L.	Marsh-pennywort	OBL
	Hydrocotyle umbellata L.	Water-pennywort	OBL
SC	*Lilaeopsis chinensis* (L.) Ktze.	Lilaeopsis	OBL
	Ptilimnium capillaceum (Michx.) Raf.	Mock Bishop's-weed	OBL
	Sium suave Walt.	Water-parsnip	OBL
	CORNACEAE (DOGWOOD FAMILY)		
	Cornus amomum Mill.	Silky Dogwood	FACW
	Cornus obliqua Raf. = (*C. amomum* Mill.)	Narrowleafed Dogwood	FACW
	Cornus stolonifera Michx.	Red Osier	FACW
	CLETHRACEAE (WHITE ALDER FAMILY)		
	Clethra alnifolia L.	Sweet Pepperbush	FACW
	ERICACEAE (HEATH FAMILY)		
E	*Andromeda glaucophylla* Link	Bog-rosemary	OBL
	Cassandra calyculata (L.) D. Don = (*Chamaedaphne calyculata* (L.) Moench)	Leather-leaf	OBL
T	*Gaultheria hispidula* (L.) Bigel.	Creeping Snowberry	FACW
T	*Gaylussacia dumosa* (Andr.) T & G	Dwarf Huckleberry	OBL
	Kalmia polifolia Wang.	Bog-laurel	OBL
T	*Ledum groenlandicum* Oeder	Labrador-tea	OBL
	Leucothoe racemosa (L.) Gray	Fetter-bush	FACW
	Lyonia ligustrina (L.) DC.	Maleberry	FACW
	Rhododendron canadense (L.) Torr.	Rhodora	FACW
	Rhododendron viscosum (L.) Torr.	Swamp Azalea	FACW
	Vaccinium atrococcum (Gray) Heller = (*V. corymbosum* L.)	Black Highbush-blueberry	FACW
	Vaccinium corymbosum L.	Highbush-blueberry	FACW
	Vaccinium macrocarpon Ait.	Large Cranberry	OBL
	Vaccinium oxycoccos L.	Small Cranberry	OBL
	PRIMULACEAE (PRIMROSE FAMILY)		
	Hottonia inflata Ell.	Featherfoil	OBL
	Lysimachia ciliata L.	Fringed Loosetrife	FACW
	Lysimachia hybrida Michx.	Lance-leaved Loosestrife	OBL
	Lysimachia nummularia L.	Moneywort	OBL
	Lysimachia punctata L.	Spotted Loosestrife	OBL
	Lysimachia terrestris (L.) BSP.	Swamp-candles	OBL
	Lysimachia thyrsiflora L.	Tufted Loosestrife	OBL
	Samolus parviflorus Raf.	Water-pimpernel	OBL
	PLUMBAGINACEAE (LEADWORT FAMILY)		
	Limonium nashii Small	Sea-lavender	OBL
	OLEACEAE (OLIVE FAMILY)		
	Fraxinus nigra Marsh.	Black Ash	FACW
	Fraxinus pennsylvanica Marsh.	Green Ash	FACW

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	GENTIANACEAE (GENTIAN FAMILY)		
	Bartonia paniculata (Michx.) Muhl.	Screwstem	OBL
	Bartonia virginica (L.) BSP.	Bartonia	FACW
	Gentiana andrewsii Griseb.	Closed Gentian	FACW
	Gentiana clausa Raf.	Bottle-gentian	FACW
	Gentiana crinata Froel. = (*Gentianopsis crinita* (Froel.) Ma)	Fringed Gentian	OBL
	Menyanthes trifoliata L.	Buckbean	OBL
	Nymphoides cordata (Ell.) Fern.	Floating-heart	OBL
SC	*Sabatia dodecandra* (L.) BSP.	Large Marsh-pink	OBL
	Sabatia stellaris Pursh	Marsh-pink	FACW
	ASCLEPIADACEAE (MILKWEED FAMILY)		
	Asclepias incarnata L.	Swamp Milkweed	OBL
	POLEMONIACEAE (PHLOX FAMILY)		
*	*Phlox maculata* L.	Wild Sweet William	FACW
	BORAGINACEAE (BORAGE FAMILY)		
	Myosotis laxa Lehm.	Smaller Forget-me-not	OBL
*	*Myosotis scorpioides* L.	Forget-me-not	OBL
	VERBENACEAE (VERVAIN FAMILY)		
	Verbena hastata L.	Blue Vervain	FACW
	LABIATAE (MINT FAMILY)		
	Lycopus americanus Muhl.	Cut-leaved Water-horehound	OBL
	Lycopus amplectens Raf.	Clasping Water-horehound	OBL
	Lycopus rubellus Moench	Gypsywort	OBL
	Lycopus uniflorus Michx.	Common Water-horehound	OBL
	Lycopus virginicus L.	Virginia Water-horehound	OBL
*	*Mentha aquatica* L.	Water-mint	OBL
	Mentha arvensis L.	Field Mint	FACW
*	*Physostegia virginiana* (L.) Benth.	Obedient Plant	FACW
	Pycnanthemum muticum (Michx.) Pers.	Short-toothed Mountain-mint	FACW
	Pycnanthemum tenuifolium Schrad.	Narrow-leaved Mountain-mint	FACW
	Scutellaria epilobiifolia A. Hamilt. = (*S. galericulata* L.)	Marsh Skullcap	OBL
SC	*Scutellaria integrifolia* L.	Hyssop Skullcap	FACW
	Scutellaria lateriflora L.	Mad-dog Skullcap	FACW
E	*Stachys hyssopifolia* Michx.	Hyssop Hedge-nettle	FACW
*	*Stachys palustris* L.	Woundwort	OBL
SC	*Stachys tenuifolia* Willd.	Rough Hedge-nettle	FACW
	Teucrium canadense L.	Seaside Germander	FACW
	Teucrium occidentale Gray = (*T. canadensis* L.)	Hairy Germander	FACW
	SCROPHULARIACEAE (FIGWORT FAMILY)		
	Agalinis maritima (Raf.) Raf.	Seaside Gerardia	FACW
	Agalinis paupercula (Gray) Britt.	Small-flowered Gerardia	FACW
	Agalinis purpurea (L.) Pennell	Purple Gerardia	FACW
	Chelone glabra L.	Turtlehead	OBL
*	*Chelone lyonii* Pursh	Red Turtlehead	FACW
	Gratiola aurea Muhl.	Golden-pert	OBL
	Gratiola neglecta Torr.	Clammy Hedge-hyssop	OBL
SC	*Limosella subulata* Ives	Mudwort	OBL
	Lindernia anagallidea (Michx.) Pennell	False Pimpernel	OBL
	Lindernia dubia (L.) Pennell	False Pimpernel	OBL
	Mimulus alatus Ait.	Winged Monkey-flower	OBL

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*	*Mimulus guttatus* DC.	Yellow Monkey-flower	OBL
*	*Mimulus moschatus* Dougl.	Muskflower	OBL
	Mimulus ringens L.	Square-stemmed Monkey-flower	OBL
	Pedicularis lanceolata Michx.	Swamp Lousewort	FACW
	Veronica americana (Raf.) Schwein.	American Brooklime	OBL
*	*Veronica anagallis-aquatica* L.	Water-pimpernel	OBL
	Veronica peregrina L.	Purslane-speedwell	FACW
	Veronica scutellata L.	Marsh-speedwell	OBL
	LENTIBULARIACEAE (BLADDERWORT FAMILY)		
SC	*Utricularia biflora* Lam.	Two-flowered Bladderwort	OBL
	Utricularia cornuta Michx.	Horned Bladderwort	OBL
SC	*Utricularia fibrosa* Walt.	Fibrous Bladderwort	OBL
	Utricularia geminiscapa Benj.	Bladderwort	OBL
	Utricularia gibba L.	Humped Bladderwort	OBL
	Utricularia inflata Walt.	Small Inflated Bladderwort	OBL
	Utricularia intermedia Hayne	Milfoil Bladderwort	OBL
	Utricularia minor L.	Small Bladderwort	OBL
	Utricularia purpurea Walt.	Purple Bladderwort	OBL
SC	*Utricularia resupinata* B. D. Greene	Bladderwort	OBL
	Utricularia vulgaris L. = (*U. macrorhiza* Leconte)	Common Bladderwort	OBL
	PLANTAGINACEAE (PLANTAIN FAMILY)		
	Plantago juncoides Lam. = (*P. maritima* L.)	Seaside Plantain	FACW
	Plantago oliganthos R. & S. = (*P. maritima* L.)	Salt-marsh Plantain	FACW
	RUBIACEAE (MADDER FAMILY)		
	Cephalanthus occidentalis L.	Buttonbush	OBL
	Diodia virginiana L.	Large Buttonweed	FACW
	Galium asprellum Michx.	Rough Bedstraw	OBL
SC	*Galium labradoricum* Wieg.	Northern Marsh Bedstraw	OBL
	Galium obtusum Bigel.	Large Marsh Bedstraw	FACW
*	*Galium palustre* L.	Marsh Bedstraw	OBL
	Galium tinctorium L.	Clayton's Bedstraw	OBL
	Galium trifidum L.	Small Bedstraw	FACW
	CAPRIFOLIACEAE (HONEYSUCKLE FAMILY)		
	Sambucus canadensis L.	Common Elderberry	FACW
	Viburnum cassinoides L.	Northern Wild Raisin	FACW
SC	*Viburnum nudum* L.	Possum Haw	OBL
	Viburnum recognitum Fern.	Northern Arrow-wood	FACW
	Viburnum trilobum Marsh.	Highbush-cranberry	FACW
	CAMPANULACEAE (BLUEBELL FAMILY)		
	Campanula aparinoides Pursh	Marsh Bellflower	OBL
	Campanula uliginosum Rydb. = (*C. aparinoides* Pursh)	Blue Marsh Bellflower	OBL
	Lobelia cardinalis L.	Cardinal-flower	FACW
	Lobelia dortmanna L.	Water Lobelia	OBL
	Lobelia kalmii L.	Kalm's Lobelia	OBL
	Lobelia siphilitica L.	Great Lobelia	FACW
	COMPOSITAE (COMPOSITE FAMILY)		
	Aster lateriflorus (L.) Britt.	Calico Aster	FACW
T	*Aster nemoralis* Ait.	Bog-aster	FACW
	Aster novae-angliae L.	New England Aster	FACW

Scientific Name		Common Name	Indicator Status
	Aster novi-belgii L.	New York Aster	FACW
	Aster praealtus Poir.	Willow Aster	FACW
	Aster puniceus L.	Purple-stemmed Aster	OBL
E	*Aster radula* Ait.	Rough-leaved Aster	OBL
	Aster simplex Willd.	Tall White Aster	FACW
	Aster subulatus Michx.	Salt Marsh Aster	OBL
	Aster tenuifolius L.	Salt Marsh Aster	OBL
	Aster umbellatus Mill.	Flat-topped White Aster	FACW
	Bidens aristosa (Michx.) Britt.	Tickseed-sunflower	FACW
	Bidens cernua L.	Nodding Beggar's-ticks	OBL
	Bidens comosa (Gray) Wieg.	Leafy-Bracted Beggar's-ticks	FACW
	Bidens connata Muhl. ex Willd.	Swamp Beggar's-ticks	FACW
	Bidens coronata (L.) Britt.	Tall Tickseed-sunflower	OBL
	Bidens discoidea (T. & G.) Britt.	Small Beggar's-ticks	FACW
SC	*Bidens eatonii* Fern.	Eaton's Beggar's-ticks	OBL
	Bidens frondosa L.	Common Beggar's-ticks	FACW
	Bidens heterodoxa (Fern.) Fern. & St. John	Beggar's-ticks	FACW
	Bidens laevis (L.) BSP.	Smooth Bur-marigold	OBL
*	*Bidens pilosa* L.	White-flowered Bur-marigold	FACW
*	*Bidens polylepis* Blake	Beggars-ticks	FACW
*	*Boltonia asteroides* (L.) L'Her.	Boltonia	FACW
	Cirsium muticum Michx.	Swamp-thistle	OBL
	Eupatorium dubium Willd. = (*Eupatoriadelphus dubius* (Willd. *ex* Poir.) R.M. King & H. Rob.)	Joe-Pye-weed	FACW
	Eupatorium fistulosum Barratt = (*Eupatoriadelphus fistulosus* (Barratt *ex.* Hook.) R.M. King & H. Rob.)	Hollow Joe-Pye-weed	FACW
	Eupatorium maculatum L. = (*Eupatoriadelphus maculatus* (L.) R.M. King &. H. Rob.)	Spotted Joe-Pye-weed	FACW
	Eupatorium perfoliatum L.	Boneset	FACW
	Eupatorium pilosum Walt.	Rough Thoroughwort	FACW
	Helenium autumnale L.	Common Sneezeweed	FACW
	Helianthus giganteus L.	Tall Sunflower	FACW
	Iva frutescens L.	High-tide Bush	FACW
	Megalodonta beckii (Torr.) Greene	Water-marigold	OBL
	Mikania scandens (L.) Willd.	Climbing Hempweed	FACW
T	*Petasites palmatus* (Ait.) Gray = (*P. frigidus* (L.) Fr.)	Palmate-leaved Sweet Coltsfoot	FACW
	Pluchea purpurascens (Sw.) DC	Salt Marsh Fleabane	OBL
	Rudbeckia laciniata L.	Tall Cone-flower	FACW
	Senecio aureus L.	Golden Ragwort	FACW
	Solidago X *asperula* Desf.	Goldenrod	OBL
	Solidago elliottii T. & G.	Elliott's Goldenrod	OBL
	Solidago gigantea Ait.	Late Goldenrod	FACW
	Solidago patula Muhl.	Rough-leaved Goldenrod	OBL
	Solidago sempervirens L.	Seaside Goldenrod	FACW
	Solidago tenuifolia Pursh = (*Euthamia tenuifolia* (Pursh) Greene)	Narrow-leaved Goldenrod	OBL
	Solidago uliginosa Nutt.	Bog Goldenrod	OBL
	Vernonia noveboracensis (L.) Michx.	New York Ironweed	FACW